An In-Depth Analysis of the Intersection Located at United States Highway 53 and County Trunk Highway V

by

Dexter R. Covey

A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
in

Risk Control

Approved: 3 Semester Credits

Bryan Beamer, PhD, PE, CSP

The Graduate School

University of Wisconsin-Stout

April, 2009

The Graduate School
University of Wisconsin-Stout
Menomonie, WI

Author: **Covey, Dexter R.**

Title: **An in-depth Analysis of the Intersection Located at United States Highway 53 and County Trunk Highway V**

Graduate Degree/ Major: MS Risk Control

Research Adviser: **Bryan Beamer, PhD, PE, CSP**

Month/Year: **April, 2009**

Number of Pages: **57**

Style Manual Used: **American Psychological Association, 5th edition**

ABSTRACT

It is probable that the residents of Northern Barron County are aware of an expressway intersection which has been known to be the site of numerous crashes. This particular location exists at the intersection of United States Highways 53 and Barron County Trunk V. The current design of this intersection poses a continuous threat to the safety of drivers/passengers who use this intersection. The purpose of this study is to analyze various aspects of this intersection, US Hwy 53 and CT Hwy V, in order to identify risk factors which may be contributing to motor vehicle crashes. 72% of the accidents that occur at the intersection of US Hwy 53 and CT Hwy V cross over or access the far lanes of US Hwy 53. This research shows that this is likely due to a combination of drivers performing rolling stops and obstructed view caused by the construction of vehicles.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Chapter I: Introduction/Problem Statement

Overview

While it may be a significant pleasure for people to travel in some type of vehicle on our nation's highways, there is a strong potential that some individuals may underestimate the amount of risk that this activity presents. The interstate system, as part of the National Highway System (NHS) in the United States, was modeled after the German autobahns. The purpose of the interstate is to support military operations in case of a national emergency and facilitate the effective transportation of goods according to the US Department of Transportation Federal Highway Administration (2006). Additionally, the interstate system was designed to make travel safer for vehicle occupants and pedestrians. Although the concept of freeways and toll roads were discussed since 1939, it was President Eisenhower who signed the Federal-Aid Highway Act in 1956 which provided federal funding to make the interstate highway system a reality. According to Jose, Tye, and Winston (1999) the interstate system only comprises 1% of the United States, National Highway System roadway. However, this 1% carries over 50% of all heavy truck transportation and 21% of all traffic in this country. Interstates offer a high-speed, relatively safe way to travel over long distances with minimal chances for traffic interference, except at specially designed entrances and exit ramps. These ramps are designed with long sweeping approaches allowing for smooth entrance and exit.

The cost to construct an average mile of standard interstate is expensive. Interstate standards of construction are not considered cost effective for NHS routes that have less traffic flow than the major road networks. However, in many situations there are still

requirements to carry heavier traffic loads between major cities and ports. Expressways are the cost-effective method for constructing high speed roadways for routes that have less traffic than required for interstate construction, but have more traffic than a standard two-lane highway.

In 2005, according to the National Safety Council (NSC), 45,800 people died as a result of motor vehicle crashes in the United States. According to the Wisconsin Department of Transportation (Wis DOT), *2006 Wisconsin Traffic Crash Facts* (2008) there is one traffic crash every 4.5 minutes. These resulted in one property damage occurrence every 6.4 minutes, one injury every 14.6 minutes, and one person killed every 12.3 hours. In 2006 this resulted in 659 fatalities, 35,296 personal injuries, and 117,877 reportable crashes due to automobile accidents. These lagging indicators are down slightly over the last few years; however, they are consistent with the 15 year average of 667 fatalities in Wisconsin due to automobile accidents (Wis DOT, 2008).

In addition to the cost in human suffering and property loss to the individuals involved in the accident, each accident scene poses potential personal risk to emergency response personnel. These individuals respond to the scene in efforts to limit the potential hazards to others, care for the victims, and reduce pain and suffering. There is significant risk to police officers as they attempt to gather evidence and investigate the accident scene while maintaining safe traffic flow. After gathering the initial evidence, law enforcement officers often support road maintenance personnel and tow truck operators while the accident scene is being cleared, cleaned, and repaired. This allows the normal traffic flow to be restored. If accidents continue to occur at the same locations over and

over again, there could be a significant risk to the environment due to the loss of fluids from vehicles involved.

Intersection of US Highway 53 and County Trunk Highway V

It is probable that the residents of Northern Barron County are aware of an expressway intersection which has been known to be the site of numerous fatalities, injuries, and property damage related crashes. This particular location exists at the intersection of United States Highways (US Hwy) 53 and Barron County Trunk (CT Hwy) V. Since this four lane expressway (i.e., US Hwy 53) and two lane (i.e., CT Hwy V) intersection was constructed in 1988 there has been a relatively high rate of crashes occurring at this intersection which have resulted in a very high severity level. According to Marc Bowker P.E., Wis DOT (personal communication, March 26, 2009) the severity of these crashes is extremely high because of the high speeds at which vehicles travel on the expressway portion of this intersection. According to Wis DOT, from 1994 to 2007 there were a total of 51 reported crashes at this intersection, recorded on accident reports, and tracked for research provided by Woodman, T. Engineering Technician. These crashes resulted in property damage to 101 vehicles, with 102 people sustaining personal injuries, and six fatalities occurred due to the severity of injuries. It should be noted the results of these losses do not represent the uncalculated emergency response costs and potential risk to emergency response personnel, which Barron County citizens typically must bear.

According to a Wis DOT memorandum, provided by Woodman, (personal communication, November 5, 2008), in the summer of 2000 Barron, Washburn, and Douglas Counties requested Wis DOT to conduct a study on the six major intersections

of US Hwy 53 from Rice Lake to Superior. Committee recommendations included a three pronged approach of education, engineering, and enforcement implemented in 2001 and 2002. Modifications to the intersection on CT Hwy V included rumble strips on the approach to the stop sign, additional informational signage, flashing stop signs, and additional area lighting. On US Hwy 53 the modification was an intersection warning sign in each direction. Since these modifications were made in 2001, 26 accidents have occurred from 2001 to 2007, resulting in three fatalities, 47 incidents of personal injuries and 42 claims of property damage have occurred at the intersection of US Hwy 53 and CT Hwy V.

According to R.J. Anderson, P.E., Project Engineer with the Wisconsin DOT Northwest Region, a detailed traffic use and intersection design analysis was performed in 2005, although no further road design-related modifications have been made at this location to this date, (personal communication, October 25, 2008). Therefore, the current design of the intersection of US Hwy 53 and CT Hwy V is posing a continuous threat to the safety of people, vehicular/property, and the environment in the vicinity of this intersection.

Purpose of the Study

The purpose of this study is to analyze various aspects of this intersection, US Hwy 53 and CT Hwy V, in order to identify risk factors, which may be contributing to the occurrence of motor vehicle crashes. As a result, recommendations will be made regarding how to best protect the public at this intersection.

Methods of Identifying Risk Factors

The following methods will be used to identify risk factors at the intersection:

- Analysis of traffic usage reports
- Personal observation of driver behavior
- Analysis of specific data about accidents that have occurred at this intersection
- Physical measurements to determine the visual distances at key points of the intersection

Assumptions

- Accuracy of traffic accident report filled out by law enforcement officers.
- The 2006 Wisconsin Traffic Crash Facts report accident information is consistent with averages of accident that have occurred at the intersection of US Hwy 53 and CT Hwy V from 1994 to 2007.
- Accuracy of communication between subjects while conducting start and stop measurements using the Nu-metrics measuring device.

Definition of Terms

Interstate Highway System. A network of highways in the United States with full control access and no cross traffic.

Expressway. A divided highway for high-speed traffic with at least partial control of access.

Cross-Traffic. Vehicular traffic at an at-grade intersection normally requires a traffic control device such as a stop sign or traffic light to manage conflicting traffic

National Highway System. A system of roadways in the United States which are important to the nation's economy, defense, and mobility.

Chapter II: Literature Review

Introduction

The intersection of US Hwy 53 and CT Hwy V is considered one of the most dangerous expressway intersections in the state of Wisconsin. The purpose of this study is to analyze various aspects of this intersection in order to identify the risk factors contributing to the number of accidents and high level of severity in crashes at this location. This chapter presents a review of literature related to the history and cost of road construction, as well as the economic loss due to automobile accidents. It reviews the contributing factors of automobile crashes in Wisconsin by describing, analyzing, comparing, and contrasting the collected data on accidents that have occurred at this intersection.

There are many contributing factors to automobile accidents, such as weather conditions, month of year, day of the week, and time of day. These conditions all have relevance and may be contributing factors to frequency and severity of automobile accidents. Completed studies detailed the percentage of drivers that were involved in accidents based on age and gender. Prior studies were conducted on vehicle color and likelihood that certain color vehicles tend to be involved in accidents more often than others. The design of the road and the speed in which vehicles are allowed to travel are a determining factor in the types, occurrences, and severity of accidents on our highways. Multiple facets and contributing factors must be investigated at every accident scene to clearly determine the root cause. Additionally, this information can be analyzed in an attempt to eliminate contributing risk factors in the future.

Cost of Highway Construction

The cost to construct interstate highway is estimated at $1,500,000 per lane/per mile in 2008, according to R. J. Anderson, Project Engineer with Wis DOT (personal communication, November 25, 2008). This would equate to $6 million per mile of four lane interstate. Interstate construction standards are required for the NHS between major metropolitan areas and military facilities. Expressway cost is estimated at $800,000 per lane/per mile or approximately $3.2 million per mile of four lane expressway. This estimate is slightly more than half the cost of a mile of interstate.

History of US Hwy 53 and CT Hwy V

According to the Wisconsin Highway Organization (2008), US Hwy 53 was designated as part of the United States highway system in 1926 along the route formerly named State Highway 11. This roadway starts La Crosse and ends in Superior, Wisconsin. Between 1927 and 1966 it was redesigned and reconstructed between some smaller towns along the route to make it straighter and more efficient to travel on. In 1966 it was engineered to US interstate standards between Eau Claire and Superior. From 1972 to 1976 US Hwy 53 was constructed to interstate standards from Eau Claire to just north of Rice Lake. Due to the expense of interstate construction, in 1988 the portion of US Hwy 53, from just south of Haugan to Trego, was constructed to expressway standards. This created the existing intersection that is in use today at US Hwy 53 and CT Hwy V, which is ½ mile to the east of Haugan. (See Appendix A for current layout of intersection at US Hwy 53 and CT Hwy V and pictures of approaches to the intersection.)

Economic Cost of Automobile Accidents

According to Clifford (2008), the cost of accidents in the United States is an estimated $162,200,000,000 annually (as cited in American Automobile Association, 2008). This equates to approximately $1,250 per person

Month of Year, Day of Week, and Time of Day

The month of year, day of the week, and time of day are all contributing factors to the number of crashes on our nation's roadways. There are certain months, days, and hours when there is more traffic on the roadways to accommodate the needs of our society. There are certain times, days, and months when social interaction and the consumption of alcohol is considered possibly socially acceptable; therefore, vehicle accidents, due to impaired driving, may be more prevalent.

Month of the year. The following table documents the month of the year in 2006 when fatalities and personal injury crashes occurred in the rural areas of Wisconsin.

Table 1

Accident Rate Fatalities and Personal Injuries by Month

Month	Fatalities	Personal Injury	Total	Percentage
January	40	1,192	1,232	8.1%
February	33	1,026	21,059	6.9%
March	43	1,025	1,068	7.0%
April	35	1,022	1,057	6.9%
May	41	1,263	1,304	8.5%
June	39	1,390	1,429	9.4%
July	55	1,352	1,407	9.2%
August	39	1,298	1,337	8.8%
September	45	1,259	1,304	8.5%
October	50	1,173	1,223	8.0%
November	42	1,237	1,297	8.5%
December	40	1,489	1,529	10.0%
Total	502	14,726	15,264	99.8%

Note. From *2006 Wisconsin Traffic Crash Facts*, Prepared by the Wisconsin Department of Transportation, 2008, p. 18.

Day of the week. Traffic usage varies on different days of the week. Some roadways are used primarily for commuting to work, transporting of goods and services, while others may be used primarily for recreational travel. These roads do not carry the same traffic loads from day to day during each day of the week.

Table 2

Accident Rate Fatalities, Personal Injury, and Property Damage by Day of the Week, 2006 Wis Traffic Crash Facts

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total
Fatal	136	85	68	70	82	96	122	659
Personal Injury	4,481	4,785	4,712	4,869	5,144	6,193	5,115	35,296
Property Damage	10,104	11,051	10,820	11,240	12,108	15,164	11,435	81,922
Total	14,721	15,918	15,600	16,179	17,334	21,453	16,672	117,877

Note. From *2006 Wisconsin Traffic Crash Facts*, Prepared by the Wisconsin Department of Transportation, 2008, p. 19.

This table shows Friday is the most likely day to be involved in a crash and will result in serious injury or property damage. Saturday and Sunday have the highest likelihood of having fatal accidents. This occurrence may be explained by the propensity or anxiety of people to want to complete the work week and travel to social or recreational settings. Increased fatalities on the weekends may be contributed to the increased amount of alcohol consumed on weekends.

Time of day. There are certain hours in the day that lend to higher crash incidences. According to a study conducted by Dr. Noyce (2004) in the state of Wisconsin from 2001 to 2003, 58% of all cross over median crashes occurred during day light hours. During periods of darkness, 37% of all crashes occurred, while 5% of automobile accidents happened during the periods of dawn and dusk.

The following table is a computation of accidents and the time of day they occurred, as taken from *2006 Wisconsin Traffic Crash Facts.*

Table 3

Accident Rates Fatalities, Personal Injury, and Property Damage by Time Period, 2006 Wis Traffic Crash Facts

Time period of day	12-6 a.m.	6 a.m.-12 p.m.	12-6 p.m.	6 p.m.-12 a.m.	Total
Fatal	163	110	186	168	627
Injury	3,958	8,752	14,913	8,441	36,064
Property Damage	10,166	19,574	29,288	21,137	80,165
Total	14,287	28,436	44,387	29,746	116.856

Note. * 9.6% unknown. **Does not include unknown and under 16. From *2006 Wisconsin Traffic Crash Facts*, Prepared by the Wisconsin Department of Transportation, 2008, p. 19

The table indicates the frequency of accidents that occur throughout the day. During the main work commute time frame of 6 a.m. - 12 p.m., there is less interference from commercial transportation, making it potentially safer from a frequency rating than the rest of the day to travel. During the periods of 12 p.m. - 6 p.m. there is a heavy combination of commuter traffic intertwined with larger commercial transportation which increases the number and sizes of vehicles on the road with an increase in the frequency of accidents. During periods of high traffic volume, the likelihood increases of having a reportable accident. In comparing the time periods of 6 p.m. - 12 a.m. and 12 a.m. - 6 a.m., there are twice as many reportable accidents in the later time period. However, the earlier time period with a reduced frequency of accident rate, has approximately three times the chance of having fatal accidents, when comparing both time periods. Hour by hour, data gathered by the Wisconsin DOT shows that one hour

between 2 a.m. - 3 a.m. on Saturday and Sunday mornings has the highest rates of fatalities over any other one hour time period during the rest of the week.

Color of Vehicles in Accidents

In 1990, while on a training exercise with the Wisconsin Army National Guard, a camouflage painted military vehicle was driven on Highway 63 north of Hayward, Wisconsin. The vehicle drove around a slight curve, which was designated as a passing zone, and was approached by two vehicles in the south bound lane. Both vehicles traveling south were clearly visible by the occupants of the military vehicle. The rear vehicle traveling south suddenly moved into the north bound passing lane and headed straight for the military vehicle. The driver of the military vehicle "stomped" on the brakes while holding the steering wheel straight. The driver performing the passing maneuver, took his/her vehicle onto the opposite shoulder of the road and passed the military vehicle on the right side. The other south bounded vehicle passed at the same time on the left. The reactions of all drivers involved just averted a head on collision at the last second.

Most people would look at this story and assume this was just another crazy driver trying to get to his grave a little faster. However, in an evaluation of the situation afterward, it is believed the passing vehicle did not see or recognize the hazard of the camouflage military vehicle until he was clearly in the passing lane. The camouflage pattern of the military vehicle was green, brown, and black, causing it to blend in with the natural foliage behind the vehicle on the shoulders of the curve. As a result of this situation and other similar reports, the Wisconsin Army National Guard made it a

requirement that all military vehicles operate with headlights on during all hours of the day.

According to a study conducted between April 1998 to June 1999, Furness et al.(2003), the color of the vehicle resulted in the likelihood of an accident which resulted in serious injuries or death. Brown, black, and green vehicles have 1.0 to 4.2 times the odds ratio of being more likely to be involved in a serious accident. Grey, red, blue, yellow, and white vehicles fell into the mid range of 0.3 to 2.3 odds, when relating these colors to serious injury or death in automobile accidents. Silver vehicles were least likely to be in an accident which caused serious injury or death, and fell into a 0.4 to 0.9 odds ratio. Darker cars are harder to see in low light conditions and shadows. Lighter cars are more likely to be overseen in times of bright sunlight, glare at dawn or dusk, and foggy conditions.

According to *DuPont Automotives* (2003) the percentage of new cars sold in the United States are in the following table:

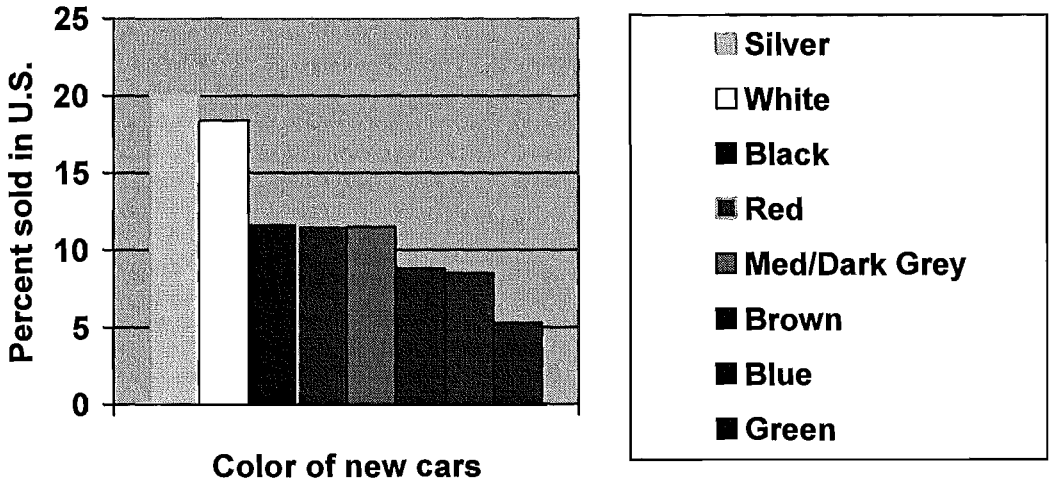


Figure 1. Percentage of new cars sold in the United States by color.

Age and Gender of Drivers

Age of drivers involved in accidents. If you were to ask any age group of drivers about the cost of auto insurance, you would hear the most complaints from the driver (or their parents) that fall between the ages of 16 to 24 years old. Drivers in this age category tend to have the most accidents with more severity. The contributing factors are less driving experience and more risky behavior. Younger drivers often drive older cars that may have maintenance issues. They also may lack the experience in maintaining an automobile or do not have the monetary assets to pay for required maintenance.

Table 4

Accident Rates by Age, 2006 Wis Traffic Crash Facts

Age of drivers	No. of licensed drivers	% of total drivers	% of drivers in crashes	% of drivers in crashes	No. of drivers involved in crashes	Drivers in fatal crashes	Drivers in injury crashes	Drivers in property damage crashes
16-24	573,910	14.2%	22.5%	9.1%	49,656	268	18,916	32,276
25-34	686,677	16.9%	17.5%	5%	34,061	189	11,453	22,419
35-44	764,754	18.8%	16.5%	4.2%	32,009	173	10,758	21,078
45-54	823,152	20.2%	14.8%	3.5%	28,686	157	9,229	19,300
55-64	586,602	14.4%	8.8%	2.9%	17,041	91	5,555.	11,395
65 +	631,178	15.4%	7.3%	2.2	14,291	99	4,830	9,362
Total	4,066,273	100.0%	*90.4%	N/A	**175,744	**967	**58,947	**115830

Note. * 9.6% unknown. **Does not include unknown and under 16. From *2006 Wisconsin Traffic Crash Facts*, Prepared by the Wisconsin Department of Transportation, 2008, p. 42.

The data presented shows the age group of 16 to 24 years old has one less demographic year in their group and the fewest percentage of licensed drivers. They have a higher percentage and number of drivers involved in crashes. This age group also leads in number of fatalities, injuries, and property damage relating to automobile accidents

compared to all other age groups. However, according to the Mayhew, Simpson, & Ferguson (2006), older drives over the age of 70 are involved in 40% of the automobile accidents, resulting in fatalities at intersections (as cited in Insurance Institute for Highway Safety Status Report, 2007). The primary reason for accidents is failure to yield after coming to a stop, versus of running the stop signal or sign. This is compared to 23% of the drivers in the age group between 35 to 54 years old in which 26% of the drivers failed to yield.

Gender of drivers involved in accident. In 2006 there were approximately the same numbers of licensed male and female drivers in the state of Wisconsin *(Wis DOT Traffic Crash Facts 2008)*. There were 2,019,800 (49.67%) female drives and 2,046,473 (50.32%) male drivers; however, this is where the parity ends. Male drivers are accountable for 58.62% of the total accidents. Males account for 59.63% of property damage accidents, 56.38% of accidents causing personal injuries, and 74% of the fatal accidents. When combining categories of gender and age, male ages 16-24 make up approximately 7.2% of the driving population in the State of Wisconsin and account for 19.4% of the fatal accidents in the state.

Intersection Issues

According to the Retting (2002), the problem with intersections controlled by stop signs is not drivers running the stop signs, but it is drivers who stop and fail to yield the right of way (as cited in Insurance Institute for Highway Safety Status Report, 2002). This is reinforced by an eight state rural intersection study conducted by Preston, Storm, Donath, Shankwitz, & Crowson (2008), who found that 62% of drivers involved in accidents who were required to stop at intersections did not see or recognize the hazard of

the other vehicle approaching. The other 38% of drivers was divided between misjudging speed or distance of other vehicles, obstructed view, or weather. Some drivers may be distracted and not paying attention to traffic that has the right of way. Drivers may perceive they are coming to a complete stop, yet they are still rolling forward slowly. This is known as the rolling stop.

The rolling stop may be particularly hazardous due to blind spots created by vehicular construction. These blind spots may include but are not limited to the roof support post on a vehicle, such as the post between the windshield and the front door, or large side view mirrors. One issue with a rolling stop is when the "stopping" vehicle, rolling at two to five miles per hour, may result in the matching the visual angel speed of a vehicle traveling perpendicular toward an intersection at 65-70 m.p.h. As the "stopped" vehicle proceeds forward, increasing in speed, the visual angle decreases and may match the highway speed of the oncoming vehicle. When the driver enters the intersection and identifies the hazard it is too late to avoid the impending accident. The driver who has the right of way may not identify the hazard because cross traffic often crosses an expressway in two steps, yielding or stopping for cross traffic in the median.

Summary

There are a number of highway construction standards used to build the NHS according to the amount of traffic and the cost of construction. There are many factors that are evaluated when determining the root cause of accidents, such as environment, vehicle construction, and human characteristics. Both highway construction and the accident factors may lead directly to the quantity and severity of vehicle crashes at any given location.

Chapter III: Methodology

Since 1988 when the intersection of US Hwy 53 and CT Hwy V was open to traffic in Northern Barron County, there has been an increased risk to all motorist travel through this area. However, not all the motorist who uses this particular intersection may know the history or the risk they are facing when approaching the area. The purpose of this study is to conduct and in-depth analysis on all pertinent data related to the construction, use, and crash history of this intersection in order to provide recommendations for future improvements that will lend to safer conditions.

Subject Selection and Description

Subjects selected for analysis in this study were determined by individuals who previously had been involved in an accident at the intersection of US Hwy 53 and CT Hwy V. These consolidated records were recorded and maintained by Wis DOT at the University of Wisconsin, Madison TOPS lab since 1994. These accident reports are available through the Wisconsin Department of Transportation and are considered public domain. Information used for this study is limited to gender and age categories that will be compared to the State averages. During the analysis, no personal information was documented and all copies of accident reports used were destroyed at the conclusion of the study. If copies of these reports must be obtained for future studies, they can be obtained through the Wisconsin Department of Transportation. The year, make, model, and color of automobile were ascertained from the accident reports. However, no identifying numbers such as license plates or vehicle identification numbers are displayed or used in this report.

Data Required

Data required for this study included: 1) A compilation of accident reports that occurred at the intersection of US Hwy 53 and CT Hwy V from 1994 to 2007, provided by the Wisconsin Department of Transportation; 2) a compilation of traffic usage reports at the intersection of US Hwy 53 and CT Hwy V as determined by the Wisconsin Department of Transportation; 3) an evaluation of the physical measurements of the intersection to determine if drivers can safely cross over or enter the traffic stream based on time, distance, and speed factors; 4) a compilation of personal observation data of driver behavior while traveling through the intersection; 5) a literature review of existing crash data for comparison to the crash data compiled at the intersection.

Data Collection Procedures

Accident reports. A reportable automobile accident is defined by statute in the State of Wisconsin. According to the Wisconsin Statues data base (2009), Chapter 346, Subchapter XI, Statute 346.70 an automobile accident is reportable when a person is killed or injured, or damage to government property exceeds $200, and for property of other and government vehicles is over $1,000. According to the University of Wisconsin-Madison Traffic Operations and Safety Laboratory (TOPS), in 1996 these levels increased from $500 to $1,000 for property damage to personal or government owned vehicles and remained at $200 for other government property.

Once an accident occurs it is a requirement by statute for the parties involved to contact a law enforcement officer in the jurisdiction where the accident occurred and report the accident. The law enforcement agency then dispatches an officer to the scene who conducts an accident investigation and submits a *Wisconsin Motor Vehicle Accident*

Report. Depending on the location of the accident, the investigation and report may be completed by a city police officer, a county sheriff deputy, or a state highway patrol officer. These different law enforcement organizations are required to provide all accident reports to the Wis DOT. The Wis DOT works with the University of Wisconsin-Madison TOPS lab to provide a electronic database on all reportable accidents in the state of Wisconsin from 1994 to the current date.

Both paper and electronic copies of all automobile accident data pertaining to the intersection of US Hwy 53 and CT Hwy V, since the construction in 1988, were requested through the state of Wisconsin DOT. A total of 51 reportable accidents for this intersection are on record with the University of Wisconsin-Madison TOPS lab from 1994 to 2007. The pertinent data is recorded on a spreadsheet by the TOPS lab staff and a *Crash Data Users Guide* provided for interpretation. The data present for analysis provides age and gender of drivers, number of people and vehicles involved, and type of accident. It also provides weather conditions, direction of vehicular travel, property damage, injury, and fatality data for each accident. In addition to the electronic database spreadsheet, paper copies of original accident reports were requested and provided by the TOPS lab for 46 of the 51 automobile accidents that have occurred at this intersection. The detailed reports provide additional information for an in-depth analysis of the time of day, make, model, and color of vehicle involved. In addition, an analysis on the direction of travel for each vehicle involved in accidents at the intersection was determined.

Traffic forecast reports. Traffic forecast reports are routinely estimated by the Wis DOT on State and Federal Highways. They are determined by counting the current traffic use on particular segments of the roadway. Then estimates are established to

determine future funding, maintenance, and construction effort required to maintain the roadways in safe working conditions.

Personal observation. In order to understand the traffic pattern and drivers behavior at an intersection it is important to conduct personal observation. During observation, data was gathered on the vehicles traveling on CT Hwy V and the drivers' actions as they negotiated the intersection. Data gathered consisted of time of day, road conditions, and number of vehicles traveling trough the intersection. The vehicles' direction of travel was recorded coming into and exiting the intersection. The general type of vehicle being driven was noted such as a car, truck, mini van, SUV, and semi trucks. Actions at the stop sign, as to whether the driver performed a complete stop or rolling stop, were recorded. If the vehicle crossed the first lanes of traffic on US Hwy 53, the actions in the median were recorded as stop, go, or yield. If there was cross traffic on US Hwy 53 while the vehicles on CT Hwy V were at the stop sign or median, this was recorded. Additionally, any unusual driver behaviors were recorded. This information was input into a spreadsheet to determine if drivers exhibited good, risky, or extremely risky driving behaviors.

Personal observation of the intersection at US Hwy 53 and CT Hwy V was conducted from an unobtrusive parking lot which was located adjacent to the intersection belonging to the Schmelke Pool Cue Factory. Permission was requested and granted by the plant manager of the Schmelke Pool Cue Factory for conducting and recording observations from their premises.

V*isual angles from stop signs.* Physical measurements were taken from the east and west bound stop sign on CT Hwy V, looking north and south on US HWY 53, using

a Nu-Metrics measuring device (model Night Star 50), of the distance a driver can identify a vehicle driving on US Hwy 53. These measurements assist in determining if the driver who is required to stop has the time and distance to safely cross or enter the stream of traffic on US Hwy 53.

Blind Spot measurements created by the aspects of vehicle construction were obtained while sitting in the control vehicle (1999 Dodge Ram 1500) at the stop signs on CT Hwy V. This procedure was completed while observing the north and south bound lanes of US HWY 53.

A measurement was taken from the driver to the post between the windshield and the passenger door. The width of the post was also recorded. These two measurements create the blind spot in question limiting the drivers' visibility. The driver of the subject vehicle used a Bushnell laser range finder (model number 200400) to acquire the average distance to the near and far side of the blind spot created by this post. The average was determined by using three measurement readings. These readings determined the average distance to the intersection once a vehicle traveling on US Hwy 53 clears the blind spot created by this post. This procedure was used four times to determine:

1. The distance of the blind spot created while stopped at the east bound stop sign observing the north bound traffic lanes looking toward the south.
2. The distance of the blind spot created while stopped in the east bound median observing the north bound traffic lanes looking toward the south.
3. The distance of the blind spot created while stopped at the west bound stop sign observing the south bound traffic lanes looking toward the north.

4. The distance of the blind spot created while stopped in the west bound median observing the south bound traffic lanes looking toward the north.

Data Analysis

The information obtained though the review of exiting traffic accident reports and the traffic usage reports were evaluated against the State of Wisconsin averages as determined in the review of literature. Information collected through personal observation of the intersection was evaluated and analyzed based on trends and computations which compared or contrasted the driving habits of the public using this intersection.

Limitations of the Study

1. Observation of the intersection cannot be conducted during the same conditions when the majority of the accidents occurred.
2. Five of the 51 accident reports were not available through the Wisconsin DOT for complete evaluation.
3. The analysis of the accident reports is based on the thoroughness of the investigation and the accuracy of the officer reporting the information.
4. Observations of an individual driver behavior at the intersection of US Hwy 53 and CT Hwy V were limited to time, direction of travel, type of vehicle, actions at the stop sign, actions in the median (if the vehicle entered the median), cross traffic present on US Hwy 53, and remarks of unusual drivers behavior. There was not enough time to ascertain or determine the drivers' estimated age, gender, and if they were distracted.

Summary

The methodology used to gather data for this study from the accident reports, existing documents, and intersections measurement is objective. Data gathered in observations of drivers' actions in vehicles while they negotiate the intersection from CT Hwy V may be subjective. When combining the objective and subjective data gathered, this research may determine if there are any unusual factors about the intersection located at US Hwy 53 and CT Hwy V that lead to the increased severity of crashes at this location.

Chapter IV: Results

Motorist traveling north on US Hwy 53 for recreational purposes or south on their way home after a weekend away may not know the potential hazard as they approach the intersection of CT Hwy V in Barron County, Wisconsin. However, it is well known to residents in the area. There have been numerous occurrences of severe accidents at this intersection which resulted in property damage, injury, or death to commuters. While conducting this study an analysis of accident data, intersection observations, and interviews with Wisconsin DOT officials were conducted. This study provides data to help determine the potential root cause of the accidents. The goal of this research is to provide a safer travel corridor through the intersection at US Hwy 53 and CT Hwy V. Additionally, this research may be expanded to provide safer commuting through any expressway intersection that have similar conditions.

Month of Year, Day of Week, and Time of Day

Month of the year. The month of the year comparison is comprised of data gathered on 51 accidents involving fatalities or personal injuries, at the intersection of US Hwy 53 and CT Hwy V from 1994 to 2007. This data is compared as a percentage against the Wisconsin 2006 fatality and personal injury data, provided by the annual report consolidated by the Wisconsin DOT. This is published annually as the *Wisconsin Traffic Crash Facts*. The *2006 Wisconsin Traffic Crash Facts* is representative as a base of comparison to the 14 years of accident data on US HWY 53 and CT HWY V used in this study.

Accidents that occurred at the intersection were twice as high as the state average for the months of May. In addition, they were two to three percent higher for June, July,

and October, as shown in Table 5. They were significantly lower in January, February, and March.

Table 5

Accident Rate Comparison of the Intersection of US Hwy 53 and CT Hwy V to the Wisconsin 2006 by Month

Month	Fatal	Personal injury	Total	HWY 53 and V percentage	State total	State percentage
January	1	3	4	3.70%	1,232	8.1%
February	0	3	3	2.77%	21,059	6.9%
March	0	5	5	4.63%	1,068	7.0%
April	1	5	6	5.56%	1,057	6.9%
May	1	17	18	16.67%	1,304	8.5%
June	1	11	12	11.11%	1,429	9.4%
July	0	13	13	12.04%	1,407	9.2%
August	2	8	10	9.26%	1,337	8.8%
September	0	8	8	7.41%	1,304	8.5%
October	0	11	11	10.19%	1,223	8.0%
November	0	7	7	6.48%	1,297	8.5%
December	0	11	11	10.19%	1,529	10.0%
Total	6	102	108	100.1%	15,264	99.8%

Note. The data in columns "State total and State percentage" from *2006 Wisconsin Traffic Crash Facts*, Prepared by the Wisconsin Department of Transportation, 2008, p. 18.

Day of the week. The following day of the week comparison is comprised of data gathered on 51 accidents that have occurred at the intersection of US Hwy 53 and CT Hwy V from 1994 to 2007. The data is expressed as percentage against the 117,877 accidents that occurred in Wisconsin in 2006, as provided by the Wisconsin DOT 2006 Wisconsin Traffic Crash Facts (2008).

Accidents that occurred at the intersection were significantly higher than state averages on the Wednesday, Thursday and Saturday. They were significantly lower Sunday, as shown in Table 6.

Table 6

Accident Rate Comparison of the Intersection of US Hwy 53 and CT Hwy V to the Wisconsin 2006 by Day of the Week

	Sun	Mon	Tues	Wend	Thurs	Fri	Sat	Total
US 53 and V total	4	7	7	5	3	10	15	51
US 53 and V percentage	7.8%	13.7%	13.7%	9.8%	5.9%	19.6%	29.4%	99.9%
State total	14,721	15,918	15,600	16,179	17,334	21,453	16,672	117,877
State percentage	12.5%	13.5%	13.2%	13.7%	14.7%	18.2%	14.1%	99.9%

Note. The data in rows "State Total and State Percentage" from *2006 Wisconsin Traffic Crash Facts*, Prepared by the Wisconsin Department of Transportation, 2008, p. 19.

Time of day. The following time of day analysis, which listed time of accident, was taken from 28 accident reports at the intersection of US HWY 53 and CTHY V that listed time of accident. The following table is a computation of accidents and the time of day they occurred, as determined from accident reports obtained from the TOPS Lab, University of Wisconsin-Madison. The table provides a comparison to the 2006 Wisconsin State average expressed in the *Wisconsin Traffic Crash Facts 2006*.

Table 7

Accident Rate Comparison of the Intersection of US Hwy 53 and CT Hwy V to the Wisconsin 2006 by Time Period of the Day

Time period of day	12 a.m.-6 a.m.	6 a.m.-12 p.m.	12 p.m.-6 p.m.	6 p.m.-12 a.m.
US 53 and V total	0	7	16	5
US 53 and V percentage	0.0%	25.0%	57.1%	17.9%
State total	14,287	28,436	44,387	29,746
State percentage	12.2%	24.3%	38.0%	25.5%

Note. The Data in Rows "State Total and State Percentage" from *2006 Wisconsin Traffic Crash Facts*, Prepared by the Wisconsin Department of Transportation, 2008, p. 19.

Table 7 shows that there have been no accidents at this intersection from 12 a.m. - 6 a.m. According to accident reports at this intersection, 90.2% of the accidents occurred during the day light conditions with clear visibility on dry pavement, as compared to 58% State wide. Only 9.8% of the vehicle accidents at the intersection of US Hwy 53 and CT Hwy V happened during times of darkness or limited visibility due to weather, as compared to 42% of all crashes that occurred in Wisconsin during 2002 to 2003.

Color of Vehicle in Accidents

The following table illustrates the percentage of the color of cars involved in accidents at the intersection of US Hwy 53 and CT Hwy V. This was determined by a total of 51 vehicle with identified colors of accident reports obtained from the Wisconsin DOT.

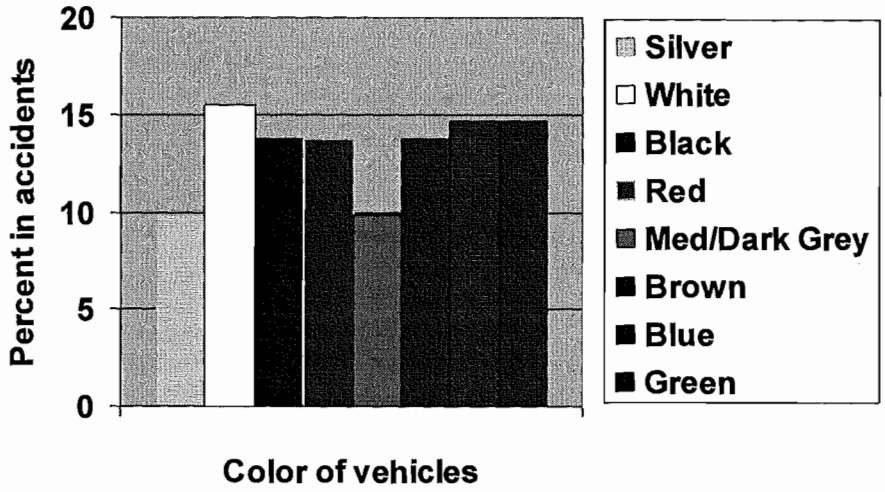


Figure 2. Percent of vehicles involved in accidents at the intersection of US Hwy 53 and CT Hwy V by color

Color of car comparison. Comparison of color of cars involved in accidents at the intersection of US Hwy 53 and CT Hwy V(51 subject car colors obtained through accident reports).

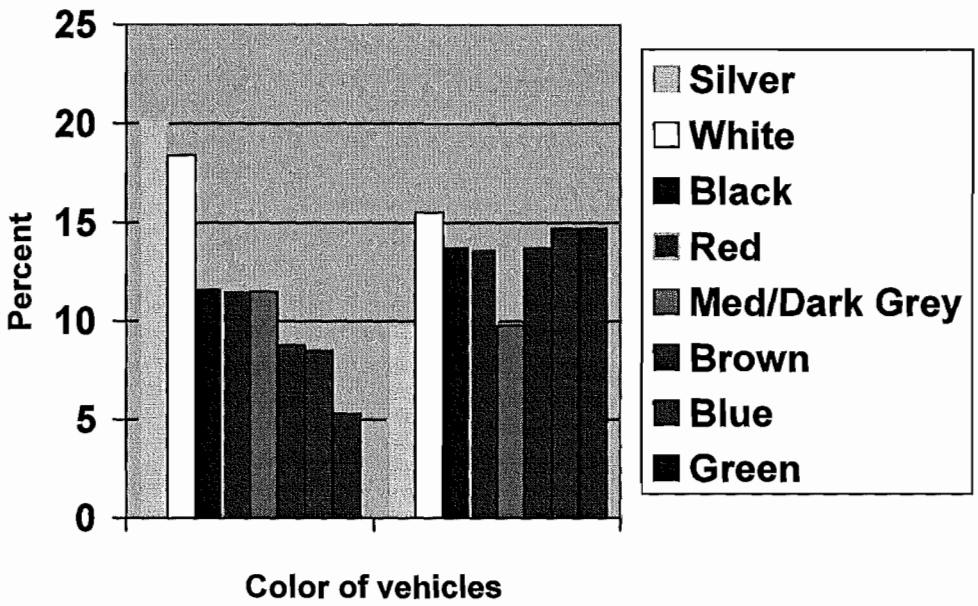


Figure 3. Color comparison of the percentage of new cars sold in the United States to the percentage of the color of vehicles involved in accidents at the intersection of US Hwy 53 and CT Hwy V.

The data indicates that brown, blue, and green vehicles are in a higher percentage of accidents at this intersection than the average number of those same colors sold in the United States. Additionally, silver, white, and grey vehicles are less likely than the average sold to be in accidents at this intersection. This is consistent with the study conducted by Furness in 2003.

Age of Drivers Involved in Accidents

The following data is a representation of the age of drivers involved in accidents, at the intersection of US HWY 53 and CT HWY V, as compared to the 2006 Wisconsin.

Table 8

Accident Rate Comparison of the Intersection of US Hwy 53 and CT Hwy V to the Wisconsin 2006 by the Age of people Drivers Involved

Age of drivers	At fault driver on CT Hwy V	Drivers on US Hwy 53	Total accidents	% at US Hwy 53 and CT Hwy V	Wis. %	No. of Wis. drivers in crashes
16-24	12	7	19	18.4%	28.3%	49,656
25-34	6	12	18	17.7%	19.4%	34,061
35-44	8	12	20	19.4%	18.2%	32,009
45-54	8	10	18	17.7%	16.3%	28,686
55-64	1	4	5	4.9%	9.7%	17,041
65Plus	14	9	23	22.3%	8.1%	14,291
Total	49	54	103	100.4%	100.0%	175,744*

Note. *Does not include unknown and under 16. The data in columns "Wis. % and No. of drivers involved in crashes" from *2006 Wisconsin Traffic Crash Facts*, prepared by the Wisconsin Department of Transportation, 2008, p. 42.

The data presented in Table 8 indicates that the age groups of 65 plus have a significantly higher risk of being involved at this intersection than other age groups. In addition, the age group of 16-24, which has the highest percentage of accidents in the state, is significantly lower and in the same average as the age groups between 25 and 55.

Gender of Drivers Involved in Accidents

In reviewing accident reports with regards to the gender of the individual involved accidents at the intersection of US Hwy 53 and CT Hwy V, there were 103 samples. Of these 67 (65%) were males and 36 (35%) were females. Male drivers account for 65% of the accidents at this intersection as compared to 58% statewide.

Traffic Use Reports

The intersection located at the junction of US Hwy 53 and CT Hwy V just east of Haugan, Wisconsin is considered high use for a rural intersection. This is based on the most recent traffic forecast report conducted by the Wisconsin DOT, November 2008, (Appendix B) provided by Mr. Robert Anderson, Wisconsin, DOT (personal communication November 25, 2008). In 2003, average daily use of CT Hwy V was estimated at 940 vehicles crossing or entering the traffic stream on US Hwy 53. US Hwy 53 has had average daily vehicle use of approximately 10,000 in 2003. The estimated use of this intersection for 2011 is 1400 vehicles on CT Hwy V and 11,000 on US Hwy 53.

Accidents Angle Statistics

Out of the XX accidents that occurred at the intersection located at US Hwy 53 and CT Hwy V located in Barron County, the following information is available from the Wisconsin DOT on the directions vehicle were traveling and the angles of impact when accidents occurred.

Direction of travel. Out of the data gathered on 96 vehicles involved in accidents that occurred, at the intersection located at US Hwy 53 and CT Hwy V between 1994 and 2007, these vehicles were traveling in the following directions prior to the accidents

occurring: 20 were traveling toward the north; 31 were traveling toward the south; 22 were traveling toward the east; 23 were traveling toward the west.

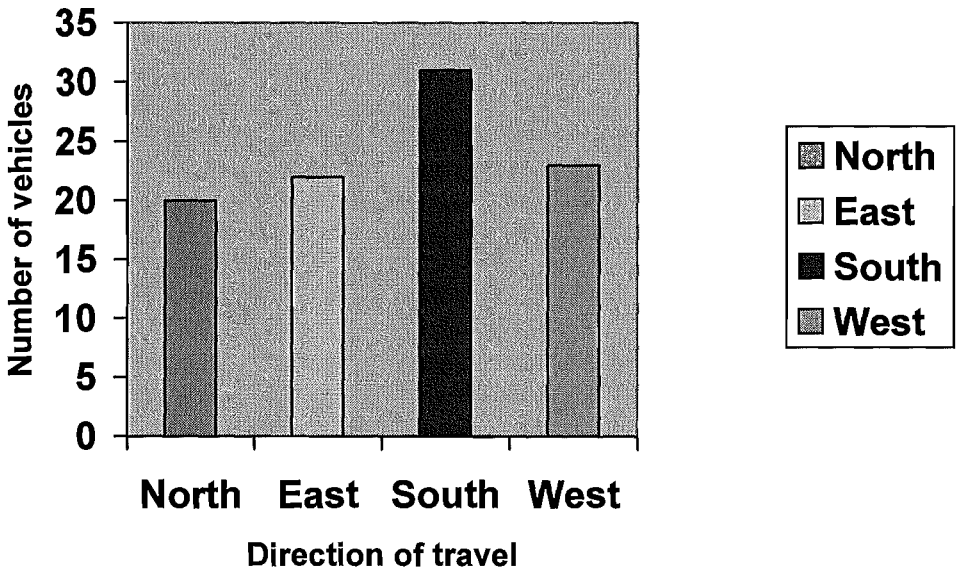


Figure 4. Direction of travel prior to being involved in an accident at the intersection of US Hwy 53 and CT Hwy V.

Out of the 48 accidents when the impacts occurred the following is the combination of directions both vehicles were traveling:

- 20 occurred when a vehicle traveling west on CT Hwy V stuck or was struck by a vehicle traveling south on US Hwy 53
- 15 occurred when a vehicle traveling east on CT Hwy V struck or was struck by a vehicle traveling north on US Hwy 53
- 7 occurred when a vehicle traveling east on CT Hwy V struck or was struck by a vehicle traveling south on Us Hwy 53
- 3 occurred when a vehicle traveling west on CT Hwy V struck or was struck by a vehicle traveling north on US Hwy 53

- 2 occurred while both vehicles were traveling south
- 1 occurred while both vehicles were traveling north

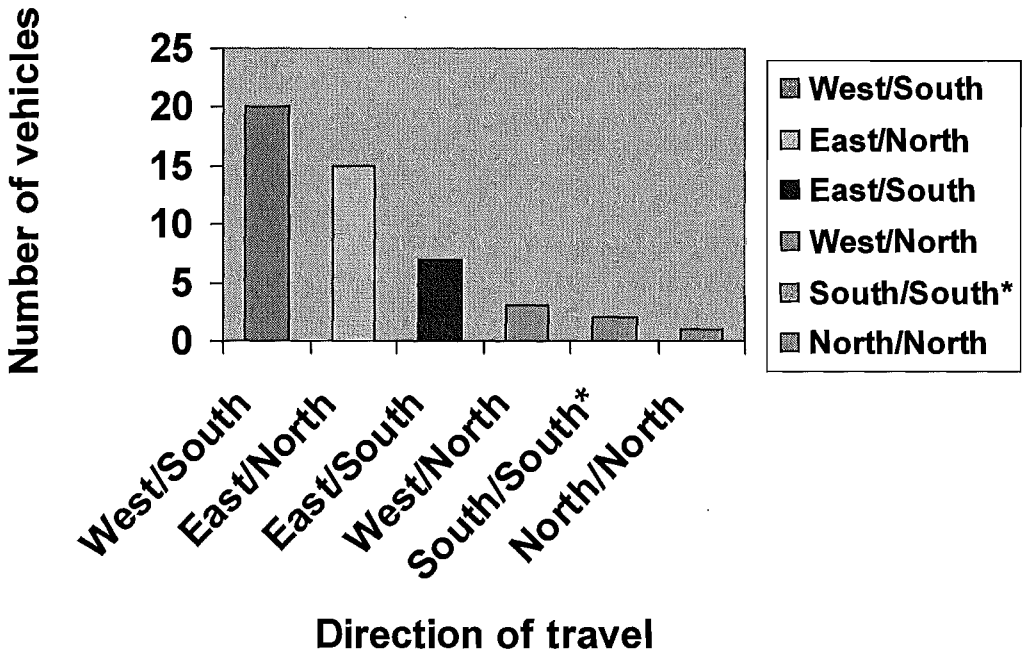


Figure 5. Direction of both vehicles involved in an accident at time of impact. *Two of the South to South accidents occurred immediately following an east bound vehicle turning south on US Hwy 53.

Accident Data

This data clearly indicates that 37 of the accidents occurred when vehicles traveling east or west on CT Hwy V struck (or were struck by) vehicles on US Hwy 53 approaching from the passenger side. Ten of the accidents occurred while vehicles traveling east or west on CT Hwy V struck (or were struck by) vehicles traveling on US Hwy 53 approaching from the drives' side. Three occurred on US Hwy 53 while vehicles were traveling in the same direction.

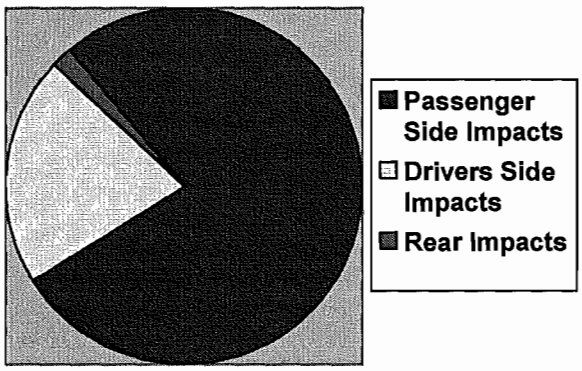


Figure 6. Impact area of vehicles involved in accidents that occurred at the intersection of US Hwy 53 and CT Hwy V.

Observation of Driver Behavior

Over a two week period, data was collected by observing drivers' behavior at the intersection of US HWY 53 and CT HWY V. Observations were conducted at this intersection which occurred during the main work commuting hours, in the morning and evening, Monday thru Friday. Morning observations were conducted from approximately 7:00 a.m. - 8:00 a.m. Monday thru Friday. Evening observations were conducted between 3:50 p.m. - 5:20 p.m., Monday thru Thursday. There was a total of 10 hours of observation during workday commuting times. The priority of observation effort was to the traffic driving from the east or west on CT Hwy V. This traffic was required to stop and then cross over or enter the traffic stream on US Hwy 53. A total of 758 vehicles were observed during these periods. An additional two hours of observation was conducted on Sunday from 8:00 a.m. - 10:00 a.m., which were the main commuting hours at the intersection due to transportation to religious services. A total of 144 vehicles were observed during this two hour period.

Observations were conducted from the parking lot of the Schmelke Pool Cue Factory, which is located approximately 30 yards from the southeast corner of the

intersection. This vantage point provided excellent visibility of both the east and west approaches to the intersection on CT Hwy V and did not interfere with traffic patterns. While recording data the observer, on nine occasions, was in a 1999 Dodge Ram pickup truck and on one occasion was in a 1986 Chevrolet Caprice Classic. These vehicles were not out of the ordinary in the Schmelke Pool Cue Factory parking lot and did not draw the attention of drivers commuting through the intersection.

A total of 902 vehicles were observed as they entered the intersection from CT Hwy V. On the first day of observation it became apparent, fairly quickly, that the observer could not gather all the data that was listed in Chapter III. The data was then limited to time and direction of travel while entering and exiting the intersection. The type of vehicles being driven was broken down into categories which consisted of car, truck, SUV, minivan, van, panel truck, semi truck, and bus. Drivers' actions at the stop signs were recorded by whether a vehicle made a complete stop or rolling stop. If the vehicle proceeded through the intersection into the median, the action at the median was recorded as a complete stop, yield, or go. In addition, if there was cross traffic on US Hwy 53 when the drivers on CT Hwy V were negotiating the intersection, this was also recorded. Finally, if there were out of the ordinary driver behaviors this was recorded in a remarks column.

The data collected was entered into an excel spreadsheet and separated into columns by direction of travel, actions at the stop sign and median. These were combined to establish patterns of drivers' behavior.

Table 9

Driver Behavioral Observation at the Intersection of US Hwy 53 and CT Hwy V

Direction of Travel	Number of Vehicles	Stop Sign Complete Stop	Stop Sign Rolling Stop	Median Complete Stop	Median Yield	Median Go	Cross Traffic US HWY 53
East to East	168	107	61	22	57	86	120
East to South	137	67	70	N/A	N/A	N/A	58
East to North	31	16	15	3	13	13	19
West to West	232	135	97	42	61	119	151
West to South	246	135	111	43	78	121	180
West to North	88	44	44	N/A	N/A	N/A	41
Total	902	504	398	110	209	339	569

Drivers' behavior observation conclusions. Out of 902 total vehicles observed negotiating the intersection from CT Hwy V onto or crossing US Hwy 53, the drivers exhibited the following driving behaviors:

Drivers exhibiting good behavior	504 (55.9%)
Drivers exhibiting risky behavior	114 (12.6%)
Drivers exhibiting extremely risky behavior	284 (31.4%)

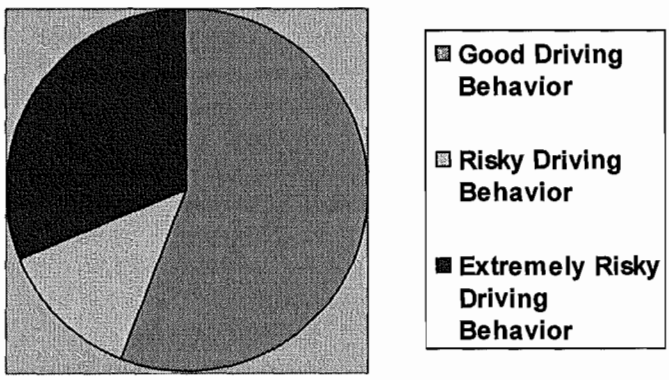


Figure 7. Classification of drivers' behaviors at CT Hwy V considering all vehicles observed.

Out of 902 total vehicles observed 521 drivers had to negotiate the intersection from CT Hwy V on to or crossing US Hwy 53 while there was cross traffic driving at speeds averaging 65 MPH. The following conclusions form the observations were made:

Drivers exhibiting good behavior with cross traffic	348 (73.7%)
Drivers exhibiting risky behavior with cross traffic	23 (4.4%)
Drivers exhibiting extremely risky behavior with cross traffic	150 (28.8%)

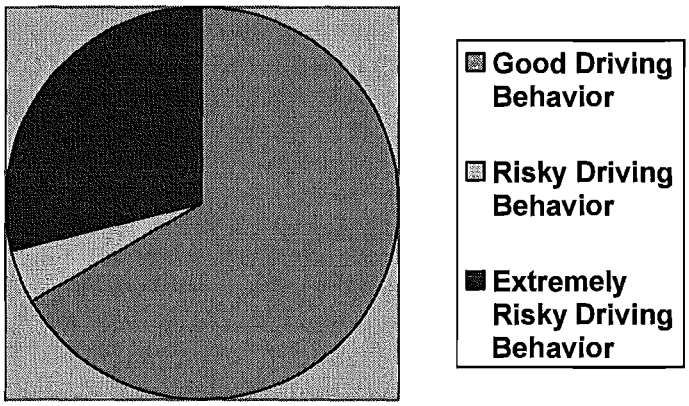


Figure 8. Classification of drivers' behavior at CT Hwy V when cross traffic was present on US Hwy 53.

Out of 902 total vehicles observed 381 drivers had to negotiating the intersection from CT Hwy V onto or crossing US Hwy 53 while there was no apparent cross traffic. The following conclusions form the observations were made:

Drivers exhibiting good behavior without cross traffic	156 (40.9%)
Drivers exhibiting risky behavior without cross traffic	91 (23.9%)
Drivers exhibiting extremely risky behavior without cross traffic	134 (35.2%)

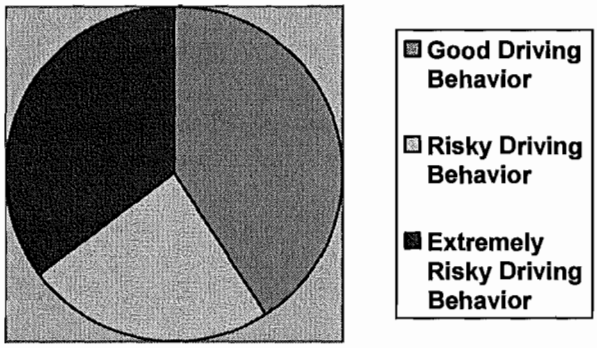


Figure 9. Classification of drivers' behaviors at CT Hwy V when there was no perceived cross traffic on US Hwy 53.

The data indicates when drivers perceive there is no cross traffic they display the riskiest driving behavior. This is potentially the most dangerous time to negotiate the intersection.

Physical Measurements

Visual distance from intersection. While stopped at the stop sign on the east and west bound lanes of CT Hwy V observing the north bound lanes to the south, a driver can see proximately 3,168 feet ($6/10^{th}$ of a mile). Observing the south bound lanes, to the north of the intersection a driver on CT Hwy V can see a vehicle clearly approaching over the hill at 1,568 feet ($3/10^{th}$ of a mile). This was determined by using Nu-Metrics measuring device when the windshield of a test vehicle traveling south could clearly be seen coming over the hill by the driver stopped on CT Hwy V.

Blind spot measurements. The blind spot created to the north, by a 1999 Dodge Ram pickup, facing west while stopped at the stop sign at the intersection of US HWY 53 and CT HWY V is approximately 187 feet from an average of 556 feet to 369 feet. It takes a car traveling on US HWY 53 approximately 1.67 seconds to cross through the blind spot if the Dodge is at a complete stop.

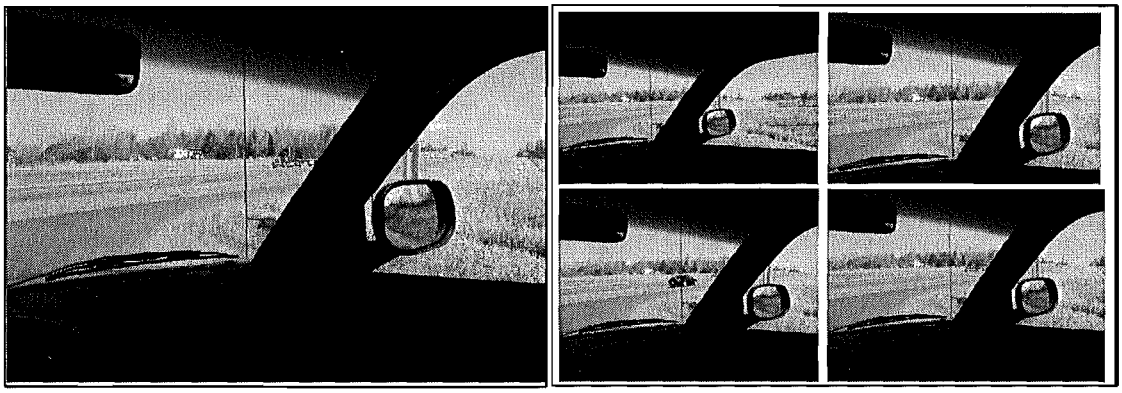


Figure 10. View of south bound US Hwy 53 while at the west bound stop sign on CT Hwy V. The semi truck showen on the left is hidden in the blind spot for 1.2 seconds in the sequence of pictures on the right.

The blind spot created to the north, by a 1999 Dodge Ram pickup, facing west while stopped in the median at the intersection of US HWY 53 and CT HWY V, is approximately 148 feet from an average of 335 feet to 187 feet. It takes a car traveling on US HWY 53 approximately 1.32 seconds to cross through the blind spot if the Dodge is at a complete stop.

Figure 11. View of south bound US Hwy 53 while at the west bound yeild sign on CT Hwy V, in the median. A semi truck is hidden in the left picture is emergining in the right picture. The subject vehicle is less than 24 feet from the potenatl impact area.

The blind spot created to the south, by a 1999 Dodge Ram pickup facing east while stopped at the stop sign at the intersection of US HWY 53 and CT HWY V, is approximately 152 feet from an average of 451 feet to 341 feet. It takes a car traveling on

US HWY 53 approximately 1.92 seconds to cross through the blind spot if the Dodge is at a complete stop.

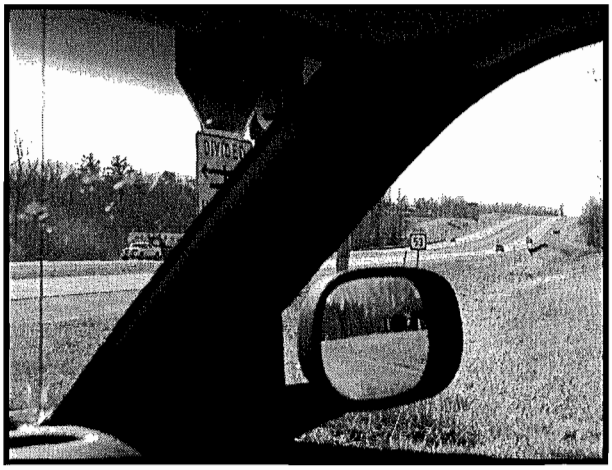


Figure 12. View of nouth bound US Hwy 53 while at the east bound stop sign on CT Hwy V, with SUV emerging from blind spot.

The blind spot created to the south, by a 1999 Dodge Ram pickup, facing east while stopped in the median at the intersection of US HWY 53 and CT HWY V, is approximately 127 feet from an average of 279 feet to 152 feet. It takes a car traveling on US HWY 53 approximately 1.60 seconds to cross through the blind spot if the Dodge is at a complete stop.

Discussion

On 26 March 2009 an interview was conducted with Marc Bowker, P. E. Regional Planning Engineer of the Northwest Region, Wisconsin Department of Transportation Spooner Office. The interview was conducted to discuss the continuing problems regarding the intersection of US Hwy 53 and CT Hwy V. He provided the following insight on the intersection:

1. He believed the majority of the accidents at the intersection involved complacency. This was due to the unusually high accident rates involving local residence being at fault in the majority of accidents

2. A three pronged approach of education, engineering, and enforcement was implemented in 2001 and 2002 after conducting a study of the intersection in 2000. The following actions were taken:

- *Education.* Dining placemats were designed and distributed at restaurants in the Highway 53 corridor to inform the public of the hazards at the intersection. The placemats provided instructions on how to properly negotiate the expressway intersections on US Hwy 53. (Appendix C)
- *Engineering.* On US HWY 53, as a motorist approaches the intersection there is a intersection warning sign with a flashing yellow light. On CT HWY V the DOT cut "rumble strips" into the pavement and placed two sets of warning red lights on the stop signs. The DOT alternates between the large blinking light on top of the stop sign and the blinking perimeter light around the stop sign. It is thought that the change keeps the drivers' interest and they pay more attention to the intersection as they approach. In addition, the county highway department installed "dangerous intersection" warning signs on the approach to the intersection. This was discouraged by the Wisconsin DOT because it may amount to an admission of knowing the intersection posed a hazard and not taking corrective action.
- *Enforcement.* The County Sheriffs Department and State Patrol stepped up enforcement efforts at this intersection. Both the Wisconsin DOT and law enforcement agencies noticed a decline in accidents rates and inappropriate drivers' behavior when enforcement was in place. However,

shortly after law enforcement personnel would leave, drivers in the area would resume risky driving behavior. Keeping law enforcement personnel on this particular intersection continuously was viewed as cost prohibitive. In addition, it was taking them away from other duties and responsibilities that needed to be performed in their jurisdiction. Routine enforcement is maintained in the area of the intersection; however, it cannot be maintained on a preeminent basis.

3. Mr. Bowker shared data regarding a study he completed on the intersection (Appendix D). The most notable points in his study from 1994 to 2003 are as follows:

- Most all of the accidents occur in daylight condition on dry pavement.
- 28 out of 36 accidents were right angle crashes and 26 of the accidents occurred in the far lanes after negotiating the median.
- 8 of the 32 at fault drivers were between the ages of 41 to 50 years old, which is not consistent with state and national averages.
- A request to put stop signs in the median was made; however, the median at the intersection of US HWY 53 and CT Hwy V is only 55 feet wide and a semi truck tractor trailer is approximately 70 feet long and needs additional space to safely stop and start.

4. Additionally, Mr. Bowker shared some timing data that he collected while studying the intersection. He did the timing test due to one theory, which was that West bound vehicles do not have the ability to negotiate the intersection in one step from the stop sign while south bound cars are approaching on US HWY 53. He concluded that from the time a vehicle is visible in the southbound lane it takes a minimum of 13

seconds at 65 miles per hour to 70 miles per hour to reach the intersection. A driver heading in a westerly direction from the stop sign clears the intersection in 10 seconds or less in a one part move while crossing the intersection (speed distance charts provided in Appendix E).

5. The interview concluded with a conversation about blind spots which are created by the post between a vehicle windshield and door, particularly on the passenger side of the vehicles. Over the last 15 to 20 years it appears these posts are engineered and constructed larger in automobiles than they use to be.

Vehicle timing. After the interview with Mr. Bowker additional research and data was gathered on the intersection consisting of rudimentary vehicle timing. The timing data was measured using a Casio wrist watch with a stop watch function. Data was collected on four aspects of vehicle traveling thru the intersection of US Hwy 53 and CT Hwy V. First, vehicles traveling south bound over the hill on US HWY 53 were timed to determine how long it took them to reach the apex of the intersection. Second, vehicles were timed on how long it took them to fully cross over the intersection on CT Hwy V if they did it in one event without stopping or yielding in the median. Third, vehicles were timed on CT Hwy V while crossing US Hwy 53 to the point where the entered or were in the far traffic stream of US Hwy 53. Fourth, vehicles were timed from the time the disappeared in the blind spot (created by the roof support post on vehicle between the windshield and passenger door) until they reached the intersection of CT Hwy V. Timing results are as follows:

- From the time it is identified, it takes a car or truck approximately 12.33 seconds coming from the north to south on US HWY 53 to reach the intersection based on the average time of three vehicles.
- If there are no automobiles on US HWY 53 a 1999 Dodge Ram with a 5.2 L, V8 engine can safely cross the intersection in approximately 7.24 seconds based on a average of three crossings.
- When timing the 1999 Dodge Ram it takes approximately 4.71 seconds to reach the far lanes of the intersection without yielding or stopping in the median based on the average of three tests.
- It take approximately 4.79 seconds for a car traveling south bound on US HWY 53 to travel from the blind spot created by the post between the windshield and door on the passenger side of a 1999 Dodge Ram to the intersection of US HWY 53 and CT HWY V.

It is critical to note in this instance; that the time it takes a vehicle traveling on US Hwy 53 from the blind spot to the intersection is 4.79 seconds. The time it takes a 1999 Dodge Ram to cross from the stop sign on CT Hwy V to the far lanes (impact area) of US Hwy 53 is 4.71 seconds. This is only $8/100^{th}$ of a second difference. If the car on CT Hwy V performs a rolling stop and crosses the median; then the vehicle on US Hwy 53 may not appear out of the blind spot which is created by the ceiling post on the passenger side until it is 63 feet from the intersection. This is less than $6/10^{th}$ of a second from a potential impact.

Distance measurements. On 7 April 2008 Mr. Bowker assisted in the research by using a DOT vehicle with a built in Nu-Metrics measuring device to determine perceived

visual distances from the stop signs. From the east and west bound stop sign on CT Hwy V, looking north and south on US HWY 53, physical measurements were taken of the perceived blind spots.

While sitting in the control vehicle (a 1999 Dodge Ram 1500), at the east bound stop signs at the intersection of US Hwy 53, and CT Hwy V, physical measurements of blind spots were determined. This procedure was completed while observing the north bound lanes of US HWY 53 looking toward the south. The subject in a DOT approved safety vehicle drove the far eastern lane of the north bound US Hwy 53 until he was no longer visible to the driver at the stop sign. This was due to the blind spot created by the ceiling post on the passenger side of the vehicle. This location was set on the Nu-Metrics measuring device as the starting measurement point for the blind spot. The driver on US Hwy 53 continued north until he was again visible to the driver at the stop sign. This location was set as the end point of the blind spot. A measurement determined between the two points was the blind spot distance. As the driver on US Hwy 53 continued north, the distance from the end of the blind spot to the leading edge of the intersection was determined. This procedure was followed for three measurements. The three measurements were averaged to determine the average distance of the blind spot created by this particular vehicle. Using this same technique, the average distance from the end of blind spot to the intersection was also determined. This procedure was then used three more times. The results are as follows:

1. The blind spot created to the north by a 1999 Dodge Ram pickup, facing west while stopped at the stop sign at the intersection of US HWY 53 and CT HWY V, is approximately 251 feet from an average of 560 feet to 308 feet.

2. The blind spot created to the north by a 1999 Dodge Ram pickup, facing west while stopped in the median at the intersection of US HWY 53 and CT HWY V, is approximately 63 feet from an average of 119 feet to 63 feet.
3. The blind spot created to the south by a 1999 Dodge Ram pickup, facing east while stopped at the stop sign at the intersection of US HWY 53 and CT HWY V, is approximately 191 feet from an average of 475 feet to 285 feet.
4. The blind spot created to the south, by a 1999 Dodge Ram pickup, facing east while stopped in the median at the intersection of US HWY 53 and CT HWY V, is approximately 66 feet from an average of 131 feet to 66 feet.

Summary

When comparing the average distances of the blind spot as determined by the laser range finder and the Nu-Metrics measuring device, there are a number of factors that need to be considered. One type of measurement is taken while a vehicle is rolling on US Hwy 53 and the other is measuring to a stationary point. Likewise every vehicle and driver of a vehicle will have different blind spot areas depending on:

- The drivers height
- How far back they sit in the seat
- How far they are from ceiling post
- The width of the post in a particular vehicle

However, every person and vehicle creates a blind spot that has the ability to significantly interfere with the driver's vision to the right side of a vehicle.

Chapter V: Conclusions and Recommendations

The expressway intersection at US Hwy 53 and CT Hwy V in Barron County has continually been a hazard to those who use this traffic route. Due to the nature of the severity of the accidents that have occurred since the construction, it is imperative safety professionals and traffic engineers continually conduct analyses to reduce the occurrences and severity of accident at this location. Data in this study was obtained and analyzed comparing the crash data collected on accidents at this intersection to the State of Wisconsin averages for 2006. The intersection was observed for 12 hours during prime commuting hours to gain knowledge and collect data on drivers' behaviors as they travel through the intersection. An interview was conducted with the lead traffic engineer for the State of Wisconsin who has this intersection in his area of responsibility. Following the interview, additional blind spot measurements and timing data were collected.

Conclusions

72% of the accidents that occur at the intersection of US Hwy 53 and CT Hwy V occur when vehicles are crossing over or accessing the far lanes of US Hwy 53. Either the accident-causing vehicle on CT Hwy V is struck in the passenger side or it strikes a vehicle on US Hwy 53 on the drivers side. This may be due to a number of factors:

1. The propensity of the drivers on CT Hwy V to perform rolling stops during times of perceived inactivity on US Hwy 53.
2. The blind spot created at this intersection is large enough, and positioned in such a way to make cross-traffic hard to see. This can make it difficult for drivers to identify the hazard of the cross traffic.

3. Brown, blue, and green vehicles appear to have a higher percentage of accidents at this intersection which is consistent with the United States averages. At this intersection it maybe due to foliage in the area creating a masking effect.

While interviewing DOT officials during this study, it was discovered that this particular expressway intersection is proposed to have an interstate construction standard exit and entrance ramp potentially constructed in 2011. This was due to the severity of the accidents that occur. However, this study contains relevant information that may be applied to any expressway intersection of similar construction.

Recommendations

The evidence presented indicates that the intersection presents undue hazards for motorists. Based on the number of drivers exhibiting risky driving behavior and the timing measurements determined to the potential impact area, it is apparent that the current situation is unacceptable and must be changed. It is therefore recommended that the following courses of action be taken on the part of the Wisconsin Department of Transportation.

- Education of new drivers and continued education of current drivers on:

  - The hazards of rolling stops

  -.The blind spot that is created on the passenger side of vehicles by the ceiling support post

  - The advantage of an additional look to the right before proceeding thru expressway intersections, or any intersection

- A standard interstate entrance/exit ramp should be constructed to reduce the number of accidents, thus reducing the number of severe accidents.
- Traffic stop signals with advance flashing warning lights should be considered for these types of intersections if the accident crash rate or severity rate exceeds acceptable DOT standards.

Areas of Further Research

Additional research should be explored in the area of the blind spot created by the post on the passenger side of vehicle, including:

- The measurements of the blind spot created by different production vehicles.
- The relationship of blind spots to the time necessary to merge or cross intersections at various speeds.

References

American Automobile Association (AAA). (2008). U.S. car accident cost: $164.2 billion. *Cable News Network.* Retrieved April 27, 2009, from http://money.cnn.com/2008/03/05/news/economy/AAA_study/

DuPont Automotives. (2003). 2003 *DuPont Automotive Color Popularity Report Shows Gray Gaining as New Color Options Emerge.* Retrieved December 12, 2008, from http://www2.dupont.com/Automotive/en_US/assets/downloads/ColorpopRelease%2003.pdf

Furness, S., Connor, J., Robinson, E., Norton, R., Ameratunga, S., & Jackson, R. (2003). Car colour and risk of car crash injury; population based case control study [Electronic version]. *BMJ, 327,* 1455-1456.

Jose, G. I., Tye, W. B., & Winston C. (1999). Interstate Highway System, *United States History Encyclopedia.* Retrieved December 15, 2008, from http://www.answers.com/topic/intersatte-highway-system

Mayhew D. R., Simpson H. M., & Ferguson S. A. (2006). Collisions involving senior drivers: high-risk conditions and locations. *Traffic Injury Prevention 7*(2),117-24. *Insurance Institute for Highway Safety Status Report, 42*(3), 1-6. Retrieved December 10, 2008, from http://www.iihs.org/sr/pdfs/sr4203.pdf

National Safety Council. (2005). *Report on Injuries in America.* Retrieved April 8, 2009, from http://www.nsc.org/resources/library/report_table_1.aspx

Noyce D. A. (2004). *Reducing Median Crossover Crashes in Wisconsin.* Retrieved November 2, 2008, from http:www.topslab.wisc.edu/publications/noyce_2006_AB06H283.pdf

Preston, H., Storm, R., Donath, M., Shankwitz, C., & Crowson, G. (2008). *Overview of rural intersection crashes at candidate intersections for the intersection decision support (IDS) system.* Unpublished Study, University of Minnesota, St, Paul.

Retting, R. A., Weinstein, H. B., & Solomon, M. G. (2002). Analysis of motor-vehicle crashes at stop signs in four U.S. cities. *Insurance Institute for Highway Safety Status Report,* 37(9), 6-7. Retrieved December 10, 2008, from http://www.iihs.org/sr/pdfs/sr3709.pdf

US Department of Transportation Federal Highway Administration. (n.d.). *Celebrating 50 years: The Eisenhower Interstate Highway System.* Retrieved December 3, 2008, from http://www.fhwa.dot.gov/interstate/faq.htm

Wisconsin Department of Transportation. (2000). *US Highway 53 Safety Team.* Retrieved, April 8, 2009, from http://www.superiordays.com/PDFs/SD%20Issues%202007/Transportation.pdf

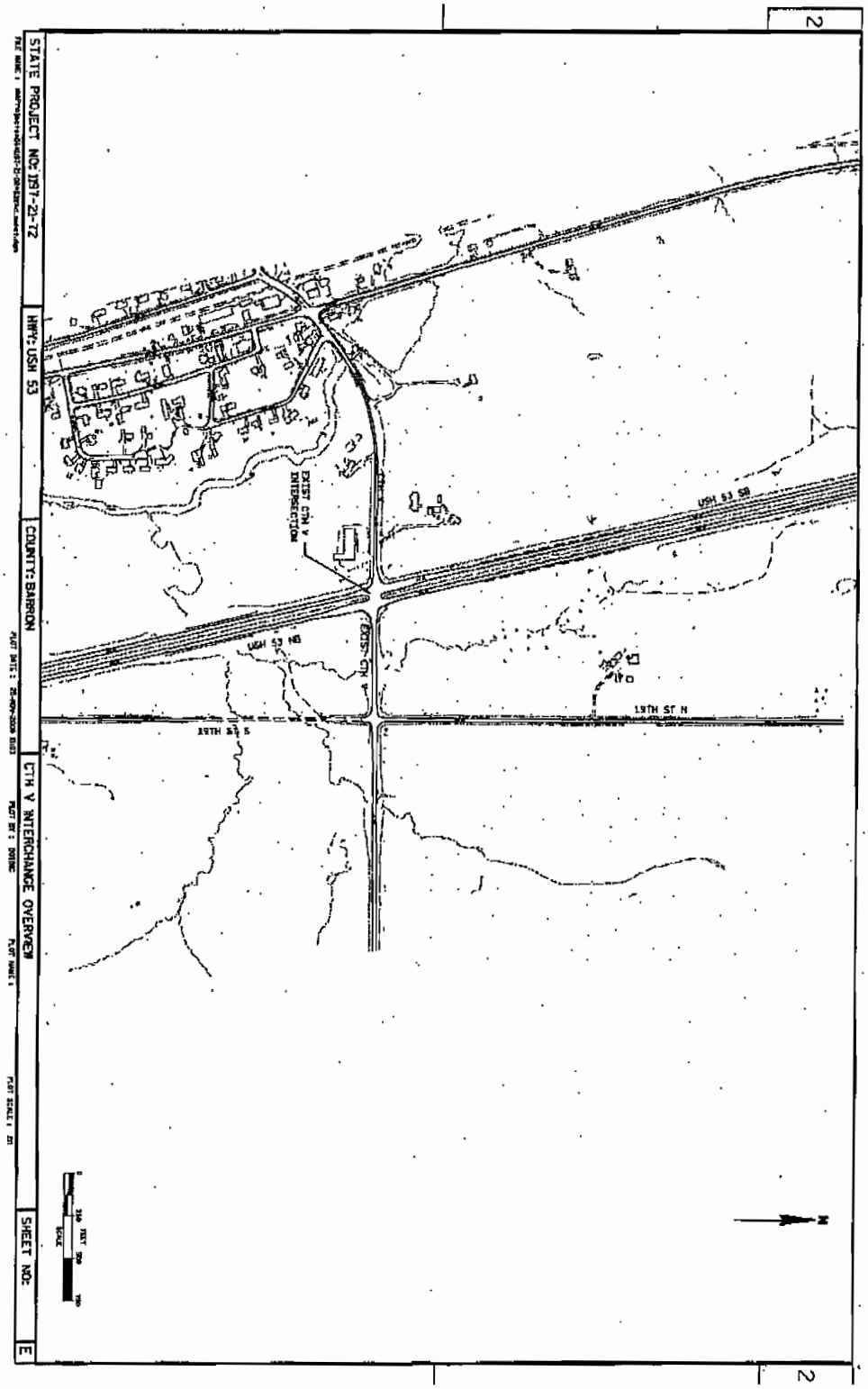
Wisconsin Department of Transportation. (2008). *2006 Wisconsin Traffic Crash Facts.* Retrieved November 2, 2008, from http://www.dot.wisconsin.gov/safety/motorist/crashfacts/index.htm

Wisconsin Highways Organization. (2008). *Wisconsin Highways*: *Highways 50 through 59.* Retrieved September 29, 2008 from http://www.wisconsinhighways.org/listings/WiscHwys50-59.html

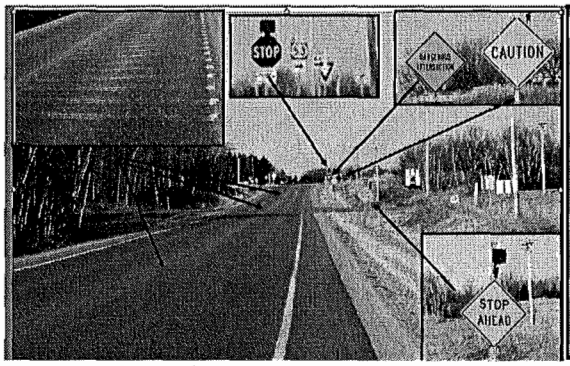
Wisconsin Statues Data base, Updated 07–08 Wis. Stats. Database. (2009). *Wisconsin Statues*, Retrieved April 25, 2009, from http://www.legis.state.wi.us/statutes/Stat0346.pdf

Wisconsin Department of Transportation. (2008).*Wisconsin Traffic Crash Facts 2006,* Retrieved November 2, 2008, from http://www.dot.wisconsin.gov/safety/motorist/crashfacts/index.htm

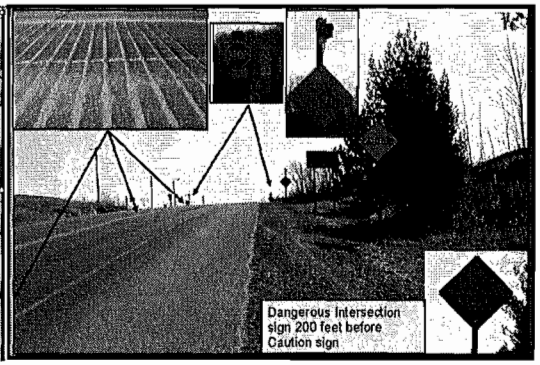
Appendix A 1: Current Layout of Intersection
Located at US Hwy 53 and CT Hwy V



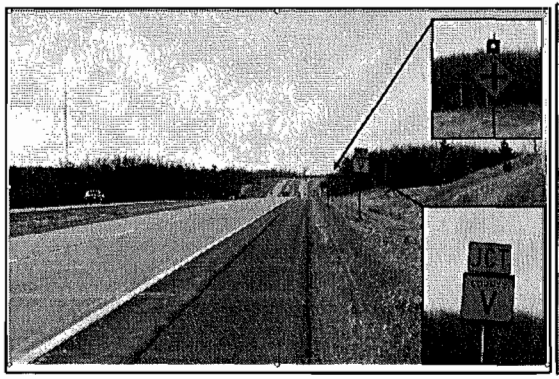
Appendix A 2: Approaches to the Intersection
of US Hwy 53 and CT Hwy V



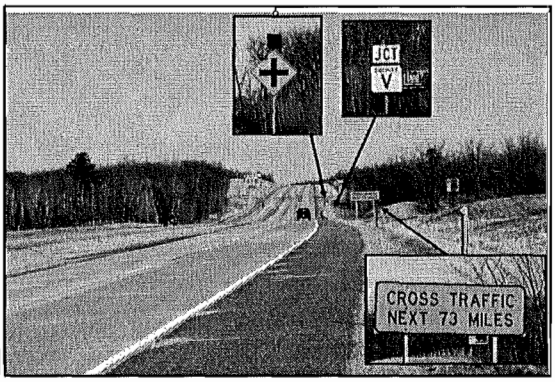
West bound approach on CT Hwy V



East bound approach on CT Hwy V



South bound approach on US Hwy 53



North bound approach on US Hwy 53

Appendix B: Wisconsin DOT Traffic Forecast

TRAFFIC FORECAST REPORT

PROJECT ID(S): 1197-21-72
ROUTE(S): USH 53

DISTRICT/COUNTY(IES): NW / Barron
LOCATION: CTH V Intersection
COMPLETED: November 25, 2008

Traffic Forecasting Section; Bureau of State Highway Programs; Division of Transportation Investment Management

Developed by: Lang Spicer
E-Mail ID: lang.spicer@dot.state.wi.us
Phone: (608) 266-7401
FAX #: (608) 267-0294

Design Values (%'s)

	USH 53	CTH V	
Design Volume(s):			--
K250	9.3	11.4	--
K100	10.3	12.8	--
K30	11.3	14.4	--
P(PHV)	14.5	21.4	--
T(DHV)	14.0	2.9	--
T(PHV)	7.9	1.6	--
D (Dsgn hr)	62/38	62/38	--
K8(ADT)	--	--	--
T(ASHV)	--	--	--

Truck Class %'s

Truck Class	Seg. 1	Seg 2	Seg. 3
2D	1.8	0.8	--
3AX	0.9	1.3	--
2S1+2S2	3.6	1.1	--
3-S2	0.3	0.4	--
DBL-BTM	0.5	0.0	--
TOTAL	17.5%	3.6%	--

Specify Last Count & Forecast Year:
(000) 2003 AADT
(000) 2011 AADT
-000- 2021 AADT
000 2031 AADT

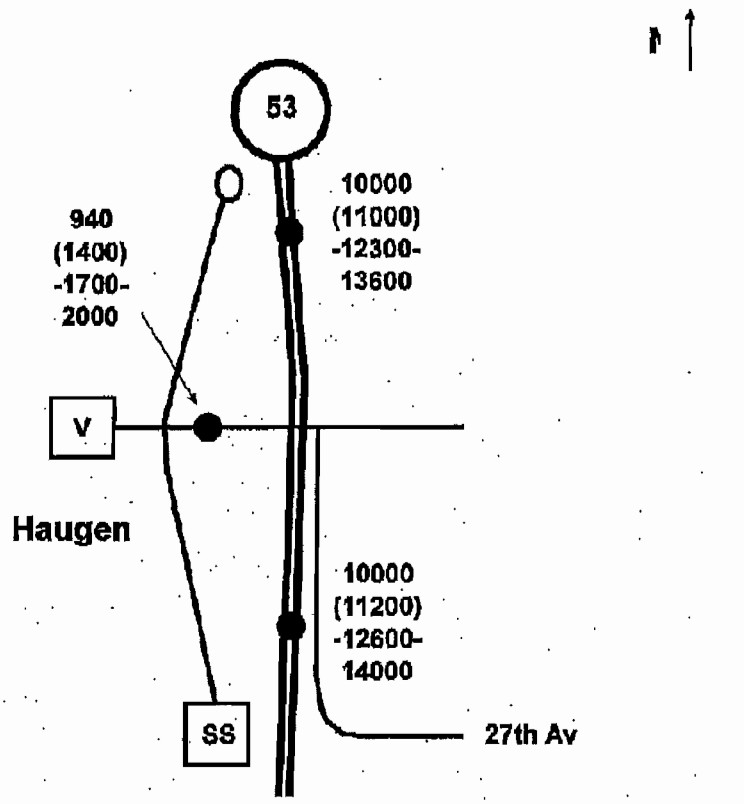
Notes on the Forecast:

1. The forecast assumes only one access point onto USH 53 at CTH V east of Haugen instead of CTH SS north of Haugen and 27th Av south of Haugen. Access will be eliminated at both of these locations north and south Haugen.

2. USH 53 is considered a factor group VI highway indicating high fluctuation in traffic from a seasonal perspective. It is considered a rural principal arterial highway for count purposes at this location.

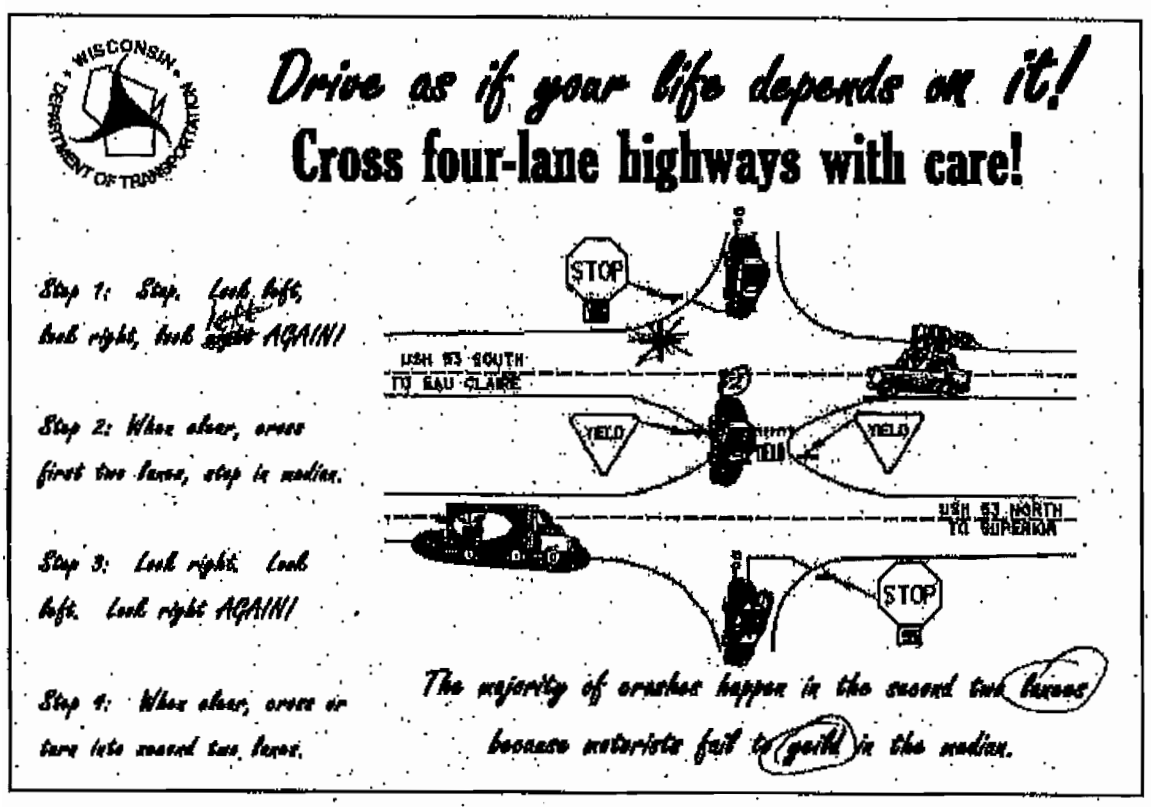
3. Truck type percentages were obtained from a vehicle class site on USH 53 near Cameron in Barron County. The CTH V site is based upon similar type highways as no data was available at this location.

4. 2003 was the most recent year mainline traffic count data was available.



Traffic forecast report on the intersection of US Hwy 53 and CT Hwy V

Appendix C: Copy of Draft Placemat



Placemat used to educate the public at restaurants along the US Highway 53 corridor from Superior to Rice Lake on the proper way to cross US High 53 at expressway intersections.

Appendix D 1: Wisconsin DOT Crash Data Analysis

CRASH SUMMARY

PERIOD: FROM 1/1/94, THRU 9/30/2000 INTERSECTION USH 53 & CTH "V"

Barron County

YEAR	NO. OF CRASHES
1994	5
1995	4
1996	6
1997	2
1998	4
1999	4
2000	2
2001	5
2002	2
2003	2
TOTAL	36

TIME OF DAY	NO. OF CRASHES
6 a.m. to 10 a.m.	2
10 a.m. to 4 p.m.	22
4 p.m. to 7 p.m.	10
7 p.m. to 12 MID	2
12 MID to 6 a.m.	0
TOTAL	36

WEATHER	NO. OF CRASHES
Clear	
Rain	
Snow/Sleet	
Fog	
TOTAL	

PAVEMENT	NO. OF CRASHES
Dry	26
Wet	3
Icy	5
Snow/Sleet	1
Blank	1
TOTAL	36

TIME OF YEAR	NO. OF CRASHES
Winter (Dec. to Feb.)	11
Spring (March to May	6
Summer (June to Aug.	13
Fall (Sept. to Nov.)	6
TOTAL	36

CRASH TYPE	NO. OF CRASHES
Right Angle	28
Left Turn	0
Rear End	2
Side Swipe	2
Pedestrian	0
Single Car	4
TOTAL	36

CRASH SEVERITY	NO. OF CRASHES
Fatal	3
Personal Injury	25
Property Damage	8
TOTAL	36

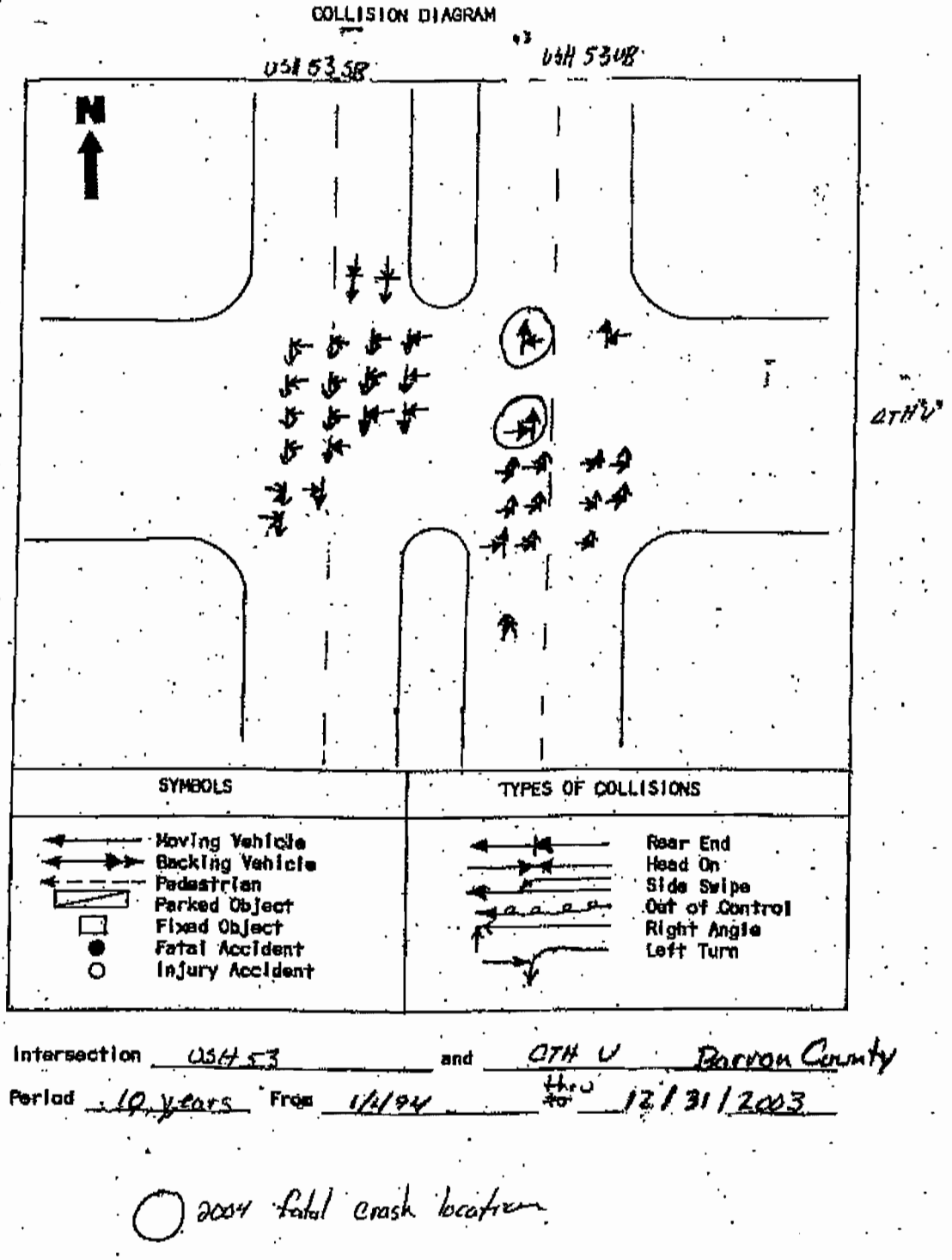
LIGHT CONDITION	NO. OF CRASHES
Daylight	28
Night	2
Dark/Lighted	4
Unknown	2
TOTAL	36

AGE OF DRIVER (fault)	NO. OF DRIVERS
16 to 20	0
21 to 30	5
31 to 40	5
41 to 50	8
51 to 60	1
61 to 75	4
76 +	9
TOTAL	32

DAY OF WEEK	NO. OF CRASHES
Monday	5
Tuesday	7
Wednesday	3
Thursday	3
Friday	5
Saturday	10
Sunday	3
TOTAL	36

Crash Data Analysis conducted by Mr. Bowker, P.E., Wisconsin DOT.

Appendix D 2: Crash Analysis Diagram



Crash Analysis Diagram completed by Mr. Bowker, P.E., Wisconsin DOT

Appendix E. Wisconsin DOT Speed Distance Charts

Speed		Distance traveled in			
MPH	Feet/ Second	5 Sec.	7 Sec.	9 Sec.	11 Sec.
45	66	330	462	594	726
50	73	367	513	660	807
55	81	403	565	726	887
60	88	440	616	792	968
65	95	477	667	858	1048
70	103	513	719	924	1129

6 seconds ⇒ first two lanes

10 seconds ⇒ all four lanes with no stop in the middle

Speed distance charts, with Mr. Bowkers' notes at the bottom regarding intersection crossing times for US Hwy 53 and CT Hwy V.