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Final Report

Review of Michigan's Rural Intersection Crashes: Application of Methodology for Identifying Intersections for Intersection Decision Support (IDS)

Report #3 in the Series: Toward a Multi-State Consensus on Rural Intersection Decision Support

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Report #3 in the Series: Toward a Multi-State Consensus on Rural Intersection Decision Support

16. Abstract (Limit: 200 words)

The objective of the Intersection Decision Support (IDS) research project, sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA), is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes. Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating in intersection-crash research. This report documents the crash analysis phase of the pooled fund study for the State of Michigan, culminating in a recommendation of an intersection for instrumentation. The driver gap acceptance behavior data to be collected at the selected intersection will feed into the Cooperative Intersection Collision Avoidance System (CICAS) Stop Sign Assist Program.

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- California
- Georgia
- Iowa
- Michigan
- Minnesota
- Nevada
- New Hampshire
- North Carolina
- Wisconsin

We would also like to especially acknowledge several individuals at the Michigan Department of Transportation (MDOT) who played key roles in the analysis of Michigan intersections and development of this report. We would like to thank Dale Lighthizer, Supervising Engineer in the Safety Programs, Standards, and Technical Services in the Traffic and Safety section with MDOT, who provided the crash record information, supplied technical direction for the crash reviews, and participated in the intersection field reviews. The research team would also wish to acknowledge James Schultz, ITS Program Manager with MDOT, who participated in the field reviews. The authors also appreciate the traffic engineers from each region that met the field review team at the intersections. The additional information and background provided by the regions' traffic engineers on each of the intersections was crucial in the selection of the appropriate location for further study.

Finally, we wish to acknowledge the assistance provided by Ray Starr of the Minnesota Department of Transportation (Mn/DOT) who served as technical manager of the pooled fund project and Jim Klessig of Mn/DOT who served as administrative liaison of the pooled fund.

Table of Contents

List of Figures

List of Tables

Executive Summary

The Intersection Decision Support (IDS) research project is sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA) whose objective is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes. Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

Based on the Minnesota crash analysis, one intersection was identified for instrumentation (collection of driver behavior information) and deployment of the IDS technology is under development. Also underway, alternative Driver Infrastructure Interfaces (DII) designs are being tested in a driving simulator at the University of Minnesota.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating in intersection-crash research. The participating states are:

- California
- Georgia
- Iowa
- Michigan
- Minnesota
- Nevada
- New Hampshire
- North Carolina
- Wisconsin

The first facet of this pooled fund project is a review of intersection crash data from each participating state, applying methods developed in previous IDS research. The crash data will be used to understand rural intersection crashes on a national basis, and to identify candidate intersections for subsequent instrumentation and study. The second facet is a participatory design process to design and refine candidate intersection Driver Infrastructure Interfaces. The third facet is to instrument candidate intersections in participating states, as a means to acquire data regarding the behavior of drivers at rural intersections over a wide geographical base. States choosing to instrument intersections will be well positioned to reap the benefits of the new Cooperative Intersection Collision Avoidance System (CICAS) research funded by the United States Department of Transportation (USDOT). The CICAS Stop Sign Assist Program will investigate the human factors and technical considerations associated with the proposed IDS mechanisms used to communicate with the driver at the intersection. A planned Field Operational Test has been designed to evaluate the performance of these systems.

Review of Michigan's Intersections

This report documents the initial phase of the pooled fund study for the State of Michigan. The crash analysis focused on thru-STOP intersections of two rural two-lane highways in central Michigan. Initially, the Michigan Department of Transportation (MDOT) used crash data from

January 1, 2001 through December 31, 2003 to identify 15 potential intersections for further review. Several screens were then used to identify the best candidates for the final review, including a field review. The criteria used included critical crash rate and an evaluation of crash frequency, crash severity, and crash type distribution. The six intersections that best fit these criteria were:

1. M-50 & Vermontville Road
2. M-100 & Mount Hope Highway
3. M-37 & Peach Ridge Avenue
4. M-50 & 64th Street
5. M-44 & Ramsdell Drive
6. M-20 & Vance Road

A field visit revealed that the MDOT had deployed a wide variety of strategies at each intersection, including some or all of the following: STOP AHEAD sign, second STOP sign placed on left side of roadway, intersection lighting, overhead red-yellow flashers, and CROSS TRAFFIC DOES NOT STOP sign. However, all of these strategies are most effective at addressing crashes in which the driver fails to recognize he/she is approaching the intersection and runs the STOP sign and provide the driver with no assistance in gap recognition and selection.

Looking at the crash data, these strategies did prove effective at reducing run-the-STOP crashes since there were few of these crash types. Instead, the crossing path crashes at the six candidate intersections were predominately associated with a driver's poor gap identification and selection.

Using the crash factors of at-fault driver age, crash severity, driver's contributing factor along with several other factors, the intersection selected as the overall best candidate for test deployment of the IDS technology was M-44 and Ramsdell Drive. This intersection has one of the worst crash experiences, including the highest crash rate and tied for the highest percentage of crossing path crashes that were gap related. Furthermore, there was strong support from MDOT's area engineers for a technology based safety mitigation strategy.

1. Project Background

The Intersection Decision Support (IDS) research project is sponsored by a consortium of states (Minnesota, California, and Virginia) and the Federal Highway Administration (FHWA) and its objective is to improve intersection safety. The Minnesota team's focus is to develop a better understanding of the causes of crashes at rural unsignalized intersections and then develop a technology solution to address the cause(s).

In the original study, a review of Minnesota's rural crash records and of past research identified poor driver gap selection as a major contributing cause of rural intersection crashes (*1*,*2*,*3*). Consequently, the design of the rural IDS technology has focused on enhancing the driver's ability to successfully negotiate rural intersections by communicating information about the available gaps in the traffic stream to the driver.

Based on the Minnesota crash analysis, one intersection was identified for instrumentation (collection of driver behavior information) and deployment of the IDS technology under development. Also underway, alternative Driver Infrastructure Interface (DII) designs are being tested in a driving simulator at the University of Minnesota.

In order to develop an IDS technology that has the potential to be nationally deployed, the regional differences at rural intersections must first be understood. Only then can a universal solution be designed and evaluated. To achieve this goal of national consensus and deployment, the University of Minnesota and the Minnesota Department of Transportation initiated a State Pooled Fund study, in which nine states are cooperating on intersection-crash research. The participating states are:

- California
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The first facet of this pooled fund project is a review of intersection crash data from each participating state, applying methods developed in previous IDS research. The crash data will be used to understand rural intersection crashes on a national basis, and to identify candidate intersections for subsequent instrumentation and study. The second facet is a participatory design process to refine candidate intersection Driver Infrastructure Interfaces. The third facet is to instrument candidate intersections in participating states, as a means to acquire data regarding the behavior of drivers at rural intersections over a wide geographical base. States choosing to instrument intersections will be well positioned to participate in the second phase of the IDS program, a proposed Field Operational Test designed to evaluate the performance of these systems.

This technical memorandum documents the initial phase of the pool fund study for the State of Michigan. Following is a description of the crash analysis performed for Michigan and a recommendation of an intersection for design of an IDS system for possible deployment.

1.1. Typical Countermeasures for Rural Intersections

A typical right angle crash at a rural unsignalized intersection is most often caused by the driver's (on a minor street approach) inability to recognize the intersection (which consequently results in a run the STOP sign violation) or his/her inability to recognize and select a safe gap in the major street traffic stream.

Traditional safety countermeasures deployed at rural high crash intersections include:

- Upgrading traffic control devices
  - Larger STOP signs
  - Multiple STOP signs
  - Advance warning signs and pavement markings
- Minor geometric improvements
  - Free right turn islands
  - Center splitter islands
  - Off-set right turn lanes
- Installing supplementary devices
  - Flashing beacons mounted on the STOP signs
  - Overhead flashing beacons
  - Street lighting
  - Transverse rumble strips

All of these countermeasures are relatively low cost and easy to deploy, but are typically designed to assist drivers with intersection recognition and have not exhibited an ability to address gap recognition problems. Yet, up to 80% of crossing path crashes are related to selection of an insufficient gap (*1*). In addition, a Minnesota study of rural thru-STOP intersections for rural two-lane roadways found only one-quarter of right angle crashes were caused by the driver on the minor street failing to stop because they did not recognize they were approaching an intersection (*2*). At the same set of intersections, 56% of the right angle crashes were related to selecting an unsafe gap while 17% were classified as other or unknown.

The concept of gap recognition being a key factor contributing to rural intersection safety appears to be a recent idea. As a result, there are relatively few devices in the traffic engineer's safety toolbox to assist drivers with gap recognition and they mainly consist of a few high cost geometric improvements and a variety of lower cost strategies that are considered to be experimental because they have not been widely used in rural applications. **Figure 1-1** illustrates the range of strategies currently available to address safety deficiencies associated with gap recognition problems, organized in order of the estimated cost to deploy (based on Minnesota conditions and typical implementation costs). The strategies include:

- The use of supplemental devices such as street light poles to mark the threshold between safe and unsafe gaps
- Minor geometric improvements to reduce conflicts at intersection such as inside acceleration lanes, channelized median openings to eliminate certain maneuvers (sometimes referred to as a J-Turn), or revising a 4-legged intersection to create off-set T's
- Installing a traffic signal to assign right-of-way to the minor street
- Major geometric improvements such as roundabout or grade separated interchanges to eliminate to reduce crossing conflicts. (Refer to *Rural Expressway Intersection Synthesis of Practice and Crash Analysis* for a review of various alternatives [*4*].)

The use of these strategies may not be appropriate, warranted or effective in all situations. Also, the construction cost or right of way may prove to be prohibitive at some locations. All of this combined with a recommendation in AASHTO's Strategic Highway Safety Plan to investigate the use of technology to address rural intersection safety led to the on-going research to develop a cost-effective Intersection Decision Support (IDS) system, including a new driver interface. The IDS system is intended to be a relatively low cost strategy (similar to the cost of a traffic signal), but at the same time is technologically advanced, using roadside sensors and computers to track vehicles on the major road approaches, computers to process the tracking data and measure available gaps and then using the driver interface to provide minor road traffic with real-time information.

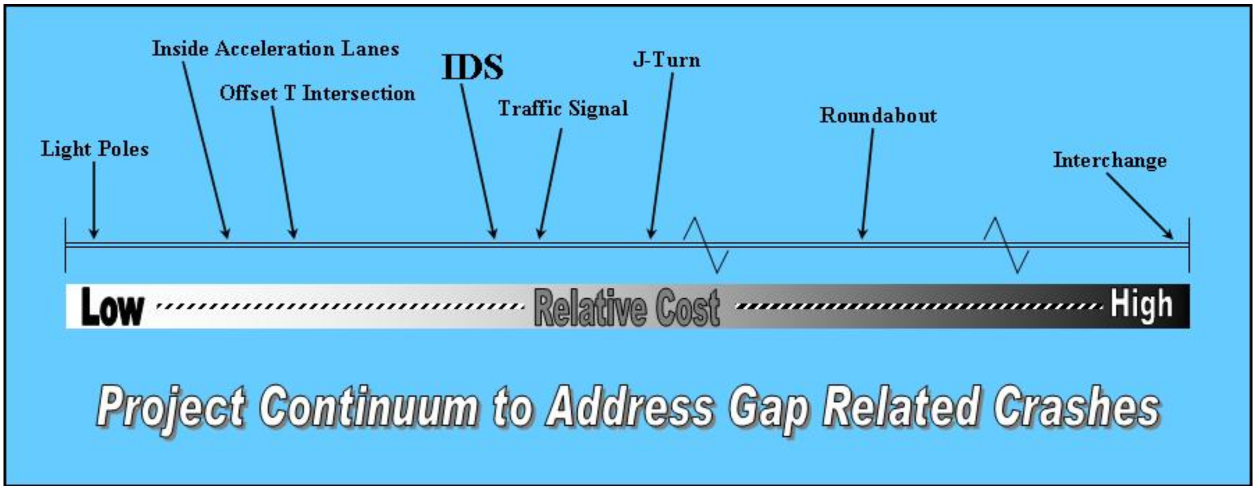


FIGURE 1-1
Gap Selection Related Safety Strategies

2. Crash Analysis Methods for Candidate Intersection Identification

A comprehensive method for intersection identification was developed using Minnesota's crash record system (see **Figure 2-1**). The method was applied to all rural, thru-STOP intersections in Minnesota, as this is the most frequent intersection situation in Minnesota. This intersection type is also the most likely where a driver will have to judge and select a gap at a rural intersection (i.e., stopped vehicle on the minor approach). The approach to identify the intersection selected for a potential field test of the technology used the three screens described in the following:

- **Critical Crash Rate –** The first screen was to identify the rural thru-STOP intersections that have a crash rate greater than the critical crash rate. The critical crash rate is a statistically significant rate higher than the statewide intersection crash rate. Therefore, any intersection with a crash rate equal to or above the critical crash rate can be identified as an intersection with a crash problem due to an existing safety deficiency.
- **Number and Severity of Correctable Crashes –** Once the intersections meeting the first criteria were identified, this second screen was performed to identify intersections where a relatively high number and percentage of crashes were potentially correctable by the IDS technologies being developed. In Minnesota's crash record system, "right angle" crashes were the crash type most often related to poor gap selection. Therefore the ideal candidate intersections had a high number & percentage of right angle collisions and tended to have more severe crashes. This screen was used to identify the top three candidate intersections for the final screen.
- **Crash Conditions and At-Fault Driver Characteristics –** The IDS technology is believed to have the greatest benefit for older drivers. Therefore, the at-fault driver age was reviewed to identify intersections where older drivers were over represented. Other aspects of the crashes that were reviewed include whether the crashes were typically a problem with intersection recognition or gap recognition and the crash location (near lanes or far lanes).

In Michigan, application of the preferred process was not feasible due to the State DOT's current crash record system. The State has no database of intersection characteristics (i.e., rural versus urban, traffic control device, roadway type, etc.) that is linked to the crash records. Essentially, Michigan is currently unable to automatically identify and query intersections (including crash records) based on physical characteristics and type of traffic control. Furthermore, daily traffic volumes for local streets (i.e., county roads or city streets) had to be acquired through the local agencies. Therefore, a modification of the approach was needed since it was impractical to manually search the State for all rural, thru-STOP intersections.

To address this problem, staff from the Michigan Department of Transportation (MDOT) had to search their crash database to identify potential intersections. However, rather than searching the entire State, the focus was on an area around Lansing, MI. Lansing was selected as the central location simply because staff was available in Lansing to work with and visit, if required, local agencies to collect minor street volumes. In addition to looking for rural, unsignalized intersections, MDOT staff also screened intersections using a minimum crash frequency (three or more angle crashes in a three year period) and a minimum posted speed limit of 55 mph for the major (thru) street. In previous IDS studies, States elected to focus on expressway intersections because the traditional solution of installing a traffic signal can have a significant impact on mobility. However, this was not a criteria MDOT chose in the search for potential locations because of the limited amount of expressway in the Lansing area, instead the search was expanded to include rural two-lane roads. Through this process, MDOT identified and provided crash information for 37 intersections.

The initial list was reduced to 15 intersections because four were found to be signalized, two had missing or incomplete crash data, and 16 had a combination of low crash frequency, low severity, and/or low percentage of the correctable crash types. For the remaining 15 intersections, the local agencies were contacted to collect minor street volumes. Using this information, a crash rate was calculated for each intersection.

Additional information needed was an average crash rate for rural, thru-STOP intersections in Michigan, which MDOT also could not easily provide without a statewide database. Therefore, the decision was made to use Minnesota's statewide rate (0.4 crashes per million entering vehicle [MEV]) to determine the critical crash rate. With this assumption, the process described previously was applied to the 15 intersections.

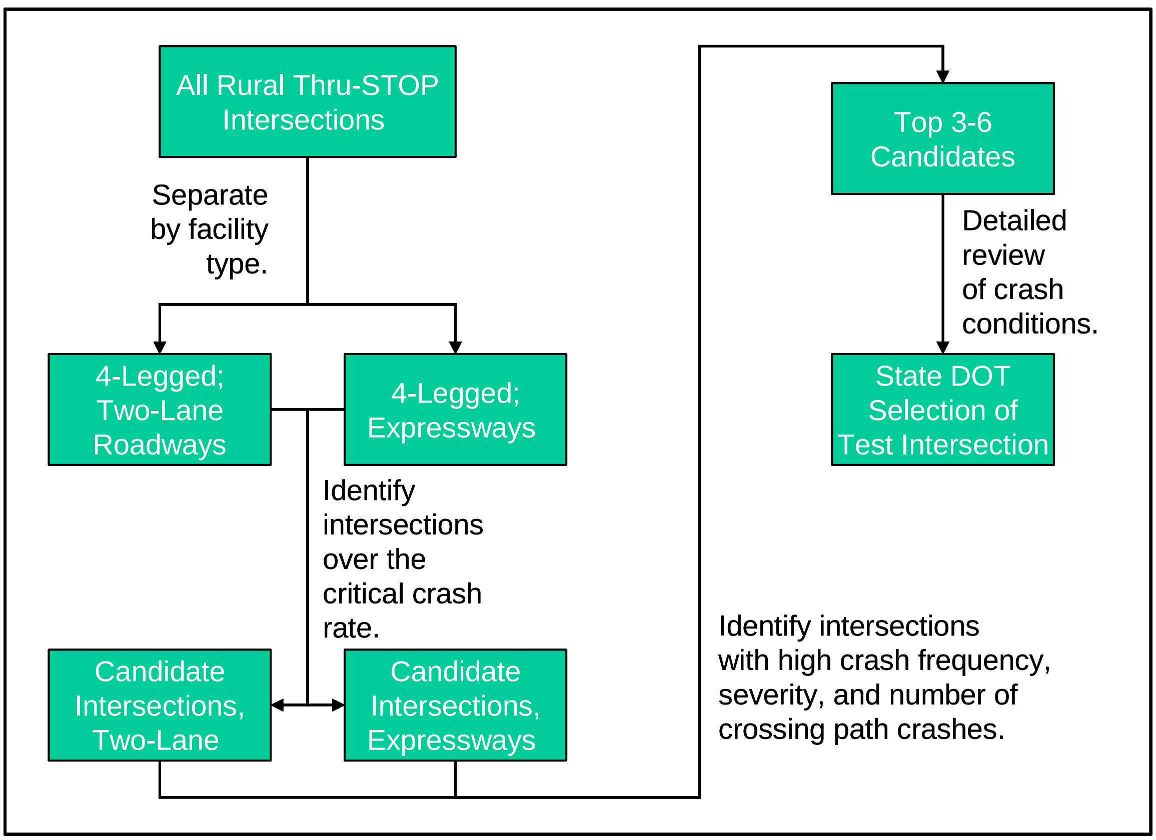


FIGURE 2-1
Preferred Crash Analysis Process

3. Identification of Top 6 Candidate Intersections

Review of the 15 intersections began with crash records from January 1, 2001 through December 31, 2003 (3 years), which were provided by MDOT (see **Table 3-1**). To identify the top candidate intersections, the first screen was to identify those intersections where the crash rate exceeded the critical crash rate. Of the 15 intersections, only State Highway 37 (M-37) & 12 Mile Road had a crash rate below the critical crash rate. The 14 intersections where the crash rate was above the critical crash rate are shown highlighted in **Table 3-1**.

These 14 intersections were then reviewed to determine if they had experienced a relatively high crash frequency, high crash severity, and a high proportion of angle crashes (the crash type believed to be most often caused by poor gap selection). The six intersections that best fit these criteria were:

1. M-50 & Vermontville Road
2. M-100 & Mount Hope Highway
3. M-37 & Peach Ridge Avenue
4. M-50 & 64th Street
5. M-44 & Ramsdell Drive
6. M-20 & Vance Road

The locations of these six intersections are shown in **Figure 3-1** and also noted in **Table 3-1**. Unlike Minnesota, North Carolina, and Wisconsin, none of the candidate intersections are located on expressways. Instead, all six intersections are located on two-lane highways, except for M-20 & Vance Road, where M-20 is a five-lane, undivided highway.

TABLE 3-1
Michigan Intersection Summary Table

Intersection of	County	Total Crashes	Crashes by Year			Entering ADT
			2001	2002	2003	
M-37 and Heath Rd.	Barry	16	8	3	5	13,142
M-50 & Perkey Rd.	Eaton	9	4	1	4	7,115
M-50 & Vermontville Rd.	Eaton	12	6	2	4	6,925
M-100 & Mount Hope Hwy.	Eaton	12	2	5	5	7,115
M-100 & St. Joe Hwy	Eaton	26	8	4	14	7,905
M-37 & 12 Mile Rd.	Kent	9	1	2	6	24,051
M-37 & 10 Mile Rd.	Kent	22	10	6	6	25,490
M-37 & Peach Ridge Ave.	Kent	17	3	4	10	26,875
M-50 & 64th St.	Kent	12	4	3	5	8,090
M-50 & 84th St.	Kent	10	5	4	1	3,005
M-50 & Freeport Ave.	Kent	6	2	3	1	4,640
M-44 & Ramsdell Dr.	Kent	21	7	9	5	8,730
M-44 & Lincoln Lake Ave.	Kent	27	14	6	7	12,155
M-57 & White Creek Ave.	Kent	14	6	4	4	13,665
M-20 & Vance Rd.	Midland	26	11	11	4	18,700

Source: Michigan Crash Records; January 1, 2001 to December 31, 2003.

The Statewide Distributions is for all crashes in the State of Michigan that were reported in the *2003 Michigan Traffic Crash Facts*. The percentages listed for each intersection are the actual severity and crash type distributions at the individual intersections.

Highlighted rows are intersections where the crash rate was greater than the critical crash rate.

TABLE 3-1 (continued)
Michigan Intersection Summary Table

Intersection of	Rate			Severity		
	Crash Rate	Expected Crash Rate	Critical Crash Rate	Fatal	Injury	PDO
		Statewide Distribution		0.3%	20.0%	79.7%
M-37 and Heath Rd.	1.1	0.4	0.7	1 6%	7 44%	8 50%
M-50 & Perkey Rd.	1.2	0.4	0.8	0 0%	2 22%	7 78%
M-50 & Vermontville Rd.	1.6	0.4	0.8	1 8%	6 50%	5 42%
M-100 & Mount Hope Hwy.	1.5	0.4	0.8	1 8%	6 50%	5 42%
M-100 & St. Joe Hwy	3.0	0.4	0.8	0 0%	9 35%	17 65%
M-37 & 12 Mile Rd.	0.3	0.4	0.6	1 11%	3 33%	5 56%
M-37 & 10 Mile Rd.	0.8	0.4	0.6	0 0%	7 32%	15 68%
M-37 & Peach Ridge Ave.	0.6	0.4	0.6	1 6%	5 29%	11 65%
M-50 & 64th St.	1.4	0.4	0.8	0 0%	8 67%	4 33%
M-50 & 84th St.	3.0	0.4	1.1	0 0%	5 50%	5 50%
M-50 & Freeport Ave.	1.2	0.4	1.0	1 17%	2 33%	3 50%
M-44 & Ramsdell Dr.	2.2	0.4	0.8	0 0%	5 24%	16 76%
M-44 & Lincoln Lake Ave.	2.0	0.4	0.7	0 0%	8 30%	19 70%
M-57 & White Creek Ave.	0.9	0.4	0.7	0 0%	4 29%	10 71%
M-20 & Vance Rd.	1.3	0.4	0.7	0 0%	6 23%	20 77%

TABLE 3-1 (continued)
Michigan Intersection Summary Table

Intersection of	Crash Type: Left Turn	Right Turn	Rear End	Run-Off Road / Overturn / Other Object	Angle	Sideswipe / Head-On	Other
	2.7%	----	25.6%	34.7%	18.7%	12.5%	5.8%
M-37 and Heath Rd.	0	0	8	1	4	0	3
	0%	0%	50%	6%	25%	0%	19%
M-50 & Perkey Rd.	0	0	0	0	6	0	3
	0%	0%	0%	0%	67%	0%	33%
M-50 & Vermontville Rd.	1	0	3	3	5	0	0
	8%	0%	25%	25%	42%	0%	0%
M-100 & Mount Hope Hwy.	0	0	1	1	10	0	0
	0%	0%	8%	8%	83%	0%	0%
M-100 & St. Joe Hwy	0	0	8	2	8	3	5
	0%	0%	31%	8%	31%	12%	19%
M-37 & 12 Mile Rd.	0	0	2	1	4	0	2
	0%	0%	22%	11%	44%	0%	22%
M-37 & 10 Mile Rd.	0	1	8	3	8	1	1
	0%	5%	36%	14%	36%	5%	5%
M-37 & Peach Ridge Ave.	0	1	0	0	14	1	1
	0%	6%	0%	0%	82%	6%	6%
M-50 & 64th St.	2	0	2	0	7	0	1
	17%	0%	17%	0%	58%	0%	8%
M-50 & 84th St.	0	0	0	1	6	2	1
	0%	0%	0%	10%	60%	20%	10%
M-50 & Freeport Ave.	0	0	0	1	4	0	1
	0%	0%	0%	17%	67%	0%	17%
M-44 & Ramsdell Dr.	0	0	2	3	10	3	3
	0%	0%	10%	14%	48%	14%	14%
M-44 & Lincoln Lake Ave.	0	0	4	3	8	2	10
	0%	0%	15%	11%	30%	7%	37%
M-57 & White Creek Ave.	0	0%	3	0	6	4	1
	0%	0%	21%	0%	43%	29%	7%
M-20 & Vance Rd.	2	0	2	8	8	1	5
	8%	0%	8%	31%	31%	4%	19%

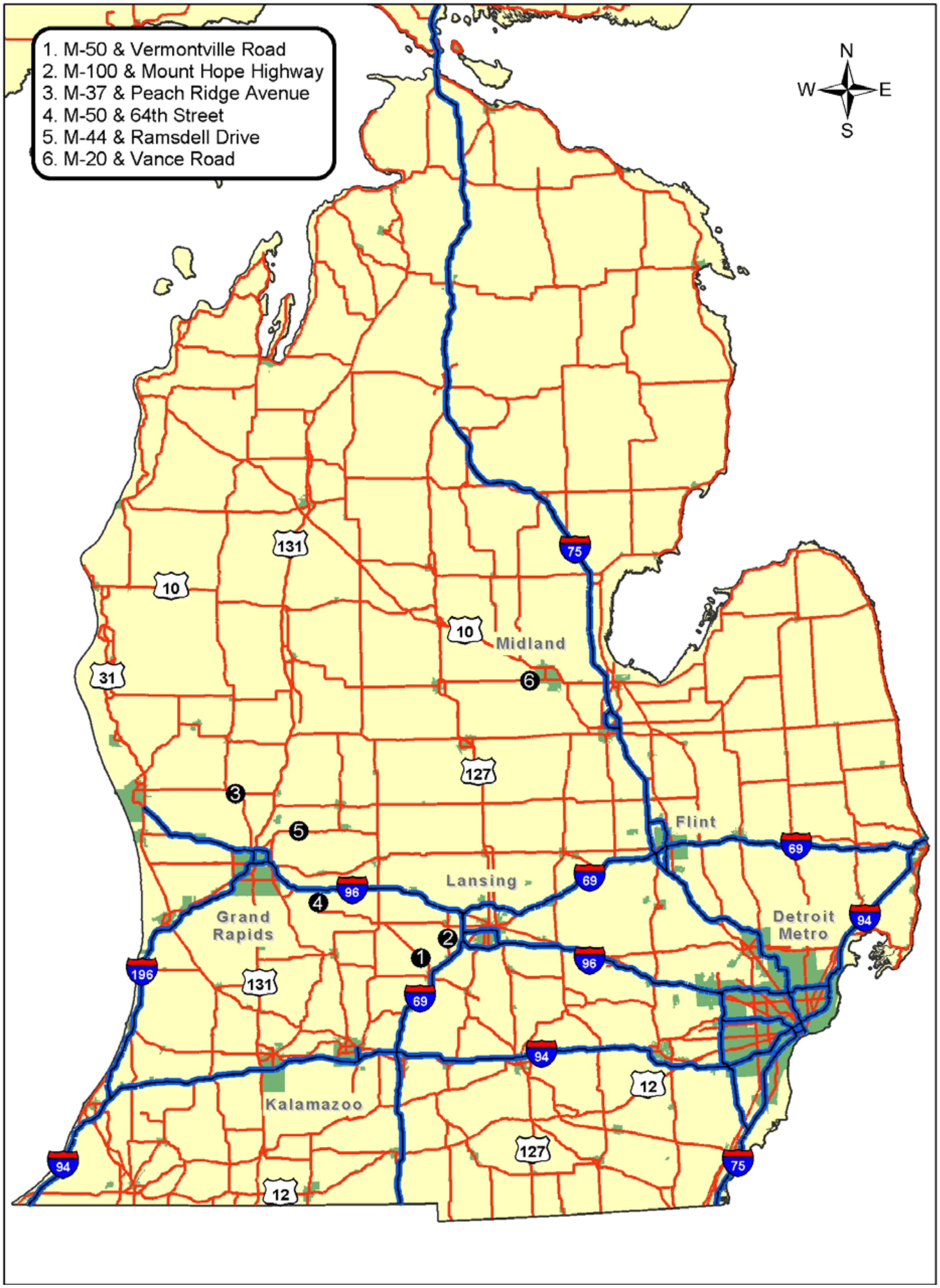


FIGURE 3-1
Candidate Intersection Locations

4. Crash Record Review of Candidate Intersections

It was already known that the candidate intersections had high crash rates, high crash frequencies, and a high number of angle crashes, but the decision was made to investigate each intersection further for specific information pertinent to the IDS technology and also to learn of any unusual circumstances at the intersections. At the candidate intersections, the factors reviewed included at-fault driver age, crash severity, crash location, contributing factors, and the effects of weather. For all of these summaries, the focus is on correctable crossing path crashes only (see following section for definition), which are the crash types that have the greatest potential to be corrected by the IDS device.

4.1. Correctable Crash Types

The General Estimates System (GES) crash database is a national sample of police-reported crashes used in many safety studies. In the GES, five crossing path crash types have been identified (see **Figure 4-1**), they are:

- Left Turn Across Path – Opposite Direction (LTAP/OD),
- Left Turn Across Path – Lateral Direction (LTAP/LD),
- Left Turn Into Path – Merge (LTIP),
- Right Turn Into Path – Merge (RTIP), and
- Straight Crossing Path (SCP).

At this time, the IDS system under development is intended to address the crash types involving at least one vehicle from the major and minor street, which includes all five GES crash types except for LTAP/OD. This research has not focused on the LTAP/OD crash type at unsignalized rural intersections because they are expected to be a relatively small problem. However, it is believed the system could be adapted to address LTAP/OD crashes if an intersection had a significant number of these crashes. For example, LTAP/OD crashes involving two vehicles from the minor street may be reduced if the device is designed to detect potential conflicts with vehicles from the opposing approach.

At the candidate intersections, the number and percent of correctable crashes is summarized in **Table 4-1**. As listed in **Table 4-1**, approximately 50% or more of the crashes at the six identified intersections are potentially correctable. The intersection of M-37 & Peach Ridge Avenue (#3) had the most correctable crashes during the study period with 15 crashes.

4.2. At-Fault Drivers

For each candidate intersection, all crash reports from January 1, 2001 to December 31, 2003 were reviewed to identify the driver whose action caused the accident, also known as the at-fault driver. The age of the at-fault driver is important since the IDS technology may have its greatest benefit in assisting older drivers in particular (see **Figure 4-2**). From the 2003 Michigan Traffic Crash Facts, 16.6% of involved drivers were under the age of 20, 75.9% between the age of 20 and 64, and 7.5% over the age of 64. Michigan Traffic Crash Facts lists involved drivers and not specifically at-fault drivers. Because of the differences between involved drivers and at-fault drivers, comparisons between statewide involvement rates and the at-fault age distributions at the six candidate intersections must be carefully considered.

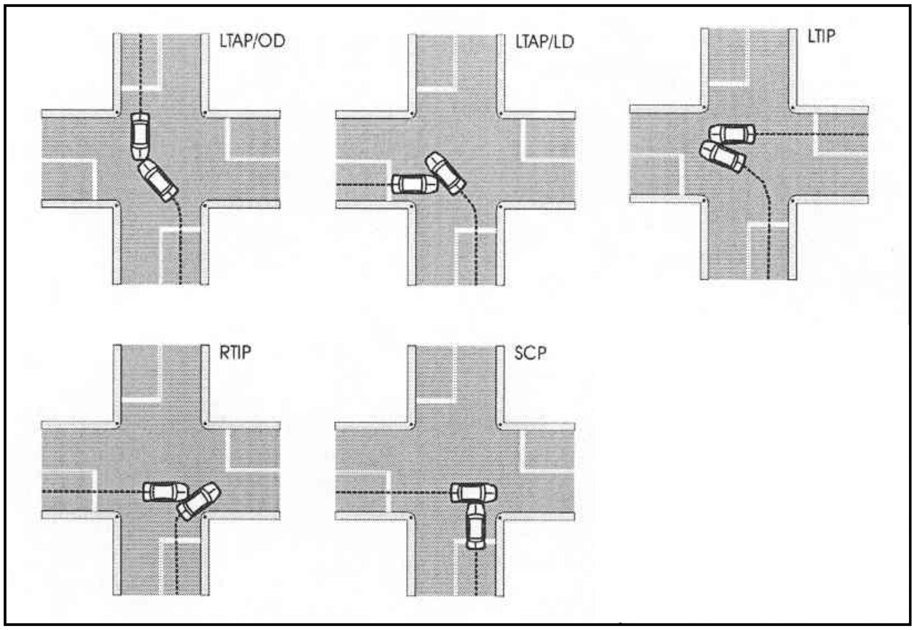


FIGURE 4-1
GES Crossing Path Crash Types

TABLE 4-1
Potential Correctable Crashes for IDS Technology at Candidate Intersections

	M-50 & Vermontville Road (#1)	M-100 & Mount Hope Highway (#2)	M-37 & Peach Ridge Avenue (#3)	M-50 & 64th Street (#4)	M-44 & Ramsdell Drive (#5)	M-20 & Vance Road (#6)
Number of Crashes	12	12	17	12	21	26
Number of Correctable Crashes	6	10	15	7	12	10
Percent of Crashes that are Correctable	50%	83%	88%	58%	57%	38%

NOTE: Correctable crashes have been defined as SCP, LTAP/LD, LTIP, and RTIP.

Based on the statewide age distributions, the intersections of M-100 & Mount Hope Highway (#2) and M-20 & Vance Road (#6) have an older driver involvement rate considerably above the expected value. For the young drivers, the only intersection where they are noticeably over represented is M-50 & Vermontville Road (#1) (approximately 16 percentage points above the expected value). Of the three remaining intersections, the driver age distribution is relatively close to expected distributions.

To assess whether the at-fault drivers are likely to be familiar with the intersection and enter it routinely, the distance from the crash location to their residence was examined (see **Table 4-2**). This can be an important factor if simulation testing reveals that drivers have a difficult time understanding the DII their first time through the intersection. If at-fault drivers are generally local residents, an educational program might be necessary and could be focused on the local population. However, if many of the at-fault drivers were not from the area and also did not have a high understanding of the DII, it is likely the IDS device would not have helped the driver avoid the crash.

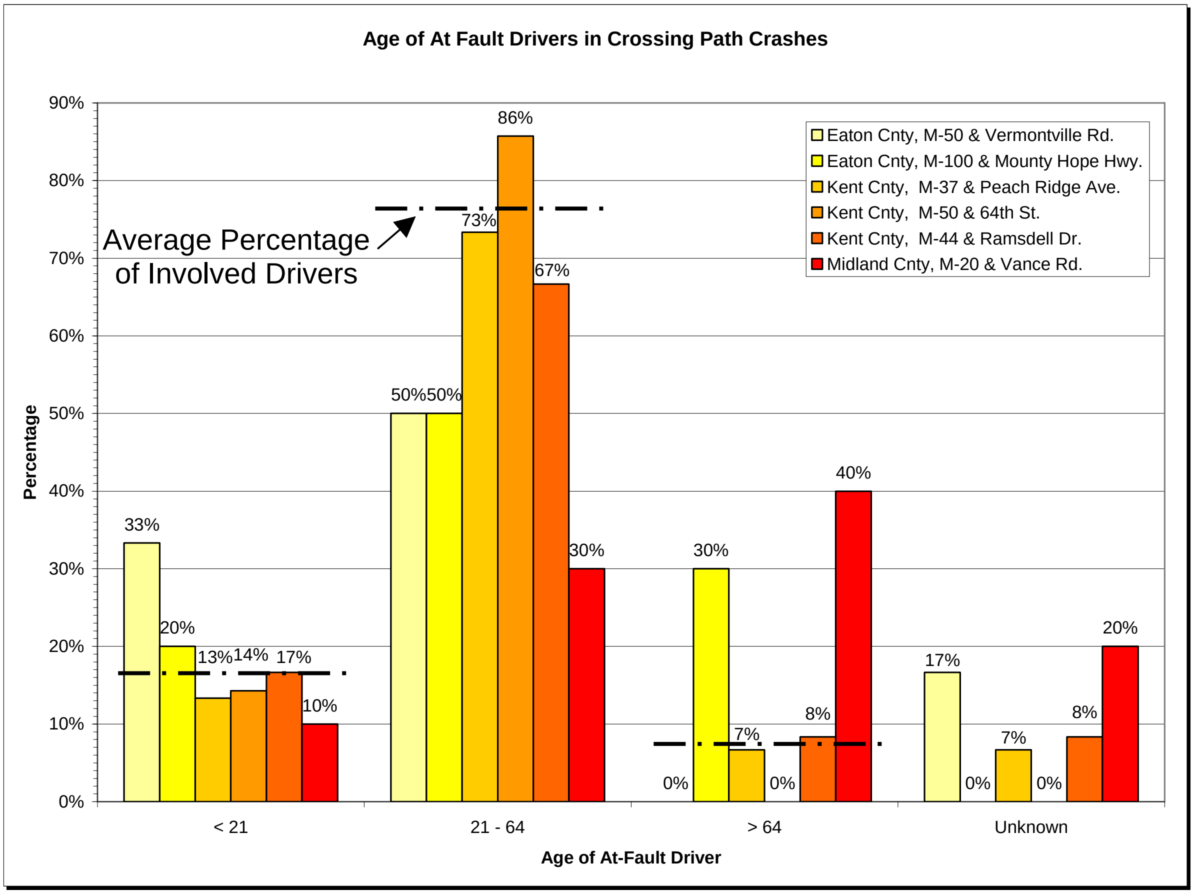


FIGURE 4-2

At-Fault Driver Age of Correctable Crash Types at Candidate Intersections

NOTE: Expected values based on involved driver age of all crashes reported in 2003 Michigan Traffic Crash Facts

A general trend among the at-fault drivers is that they were local to the area (i.e., 90% or more lived within 30 miles of the crash location). At four of the intersections, at least half of the at-fault drivers lived within 10 miles of the crash location. At the intersection of M-50 & Vermontville Road (#1), only 40% lived within 10 miles of the intersection, which was the lowest of all intersections. Furthermore, a total of two at-fault drivers (one at M-100 & Mount Hope Highway (#2) and one at M-44 & Ramsdell Drive (#5)) clearly do not live in the local area (i.e., live more than 30 miles from the crash location).

4.3. Crash Severity

Another goal of the IDS technology is to address the most serious intersections crashes, especially fatal crashes. Therefore, the best candidate intersection would have a high distribution of fatal and injury crashes. Of Michigan's 2003 crashes, fatal crashes represented approximately 0.3% of all of crashes, with injury crashes at 19.6% and property damage (PD) crashes representing 80.1% of all crashes (Source: 2003 Michigan Traffic Crash Facts). **Figure 4-3** shows that five of the intersections have a much higher percentage of injury crashes than expected, where only M-20 & Vance Road (#6) is below the expected rate. The intersection of M-50 & Vermontville Road (#1) had the highest percentage of fatal crashes, but the intersections of M-100 & Mount Hope Highway (#2) and M-37 & Peach Ridge Avenue (#3) were also above the expected percentage. The remaining three intersections had no fatal crashes.

TABLE 4-2
Distance from Crash Location to At-Fault Driver's Residence

	M-50 & Vermontville Road (#1)	M-100 & Mount Hope Highway (#2)	M-37 & Peach Ridge Avenue (#3)	M-50 & 64th Street (#4)	M-44 & Ramsdell Drive (#5)	M-20 & Vance Road (#6)
Median Distance	15 miles	8 miles	11 miles	11 miles	5 miles	6 miles
Average Distance	13 miles	16 miles	11 miles	12 miles	14 miles	5 miles
Minimum Distance	4 miles	4 miles	<1 mile	<1 mile	<1 mile	<1 mile
Maximum Distance	21 miles	78 miles	25 miles	27 miles	69 miles	11 miles
Percent of Distances ≤ 10 miles	40%	70%	50%	43%	55%	88%
Percent of Distances ≤ 30 miles	100%	90%	100%	100%	91%	100%
Unknown Drivers (i.e., hit and run)	1	0	1	0	1	2

4.4. Crash Location and Contributing Factors

From the initial review of Minnesota's crash records (*3*), it was observed that crossing path crashes at the candidate intersections were predominately on the far side of the intersection. [NOTE: For the divided expressway in Minnesota, a far-side crash occurs when the stopped vehicle safely negotiates the first two lanes it crosses, but is involved in a crash when leaving the median to either cross or merge into traffic in the second set of lanes.] The primary cause of the high number of far-side crashes was not evident from review of the crash records. However, it was speculated that drivers used a one-step process for crossing rather than a two-step process. When a driver enters the median, rather than stopping to reevaluate whether the gap is still safe (a two-step process), it is believed that drivers simply proceed into the far lanes without stopping (a one-step process). At the selected intersection in Minnesota (U.S. 52 and Goodhue County 9), vehicle detection equipment has already been installed along with video cameras. The information recorded at the intersection will be used to quantify how drivers typically cross this and similar intersections. Even though it is still unknown how this may affect the device's final design, the decision was made to still document this crash characteristic.

For the pooled fund study to date, rural expressway intersections in North Carolina and Wisconsin have been reviewed. At the candidate intersections in these states, the pattern was similar to what was observed in Minnesota with a majority of crossing path crashes occurring in the far lanes. This analysis differs from the states previously studied since Michigan is the first state to focus on two-lane highways. In this situation, it is necessary for the driver to complete a crossing maneuver (i.e., straight across or left turn) in one step since there is no median refuge. However, documenting this crash characteristic is the first step to understanding the contributing circumstances.

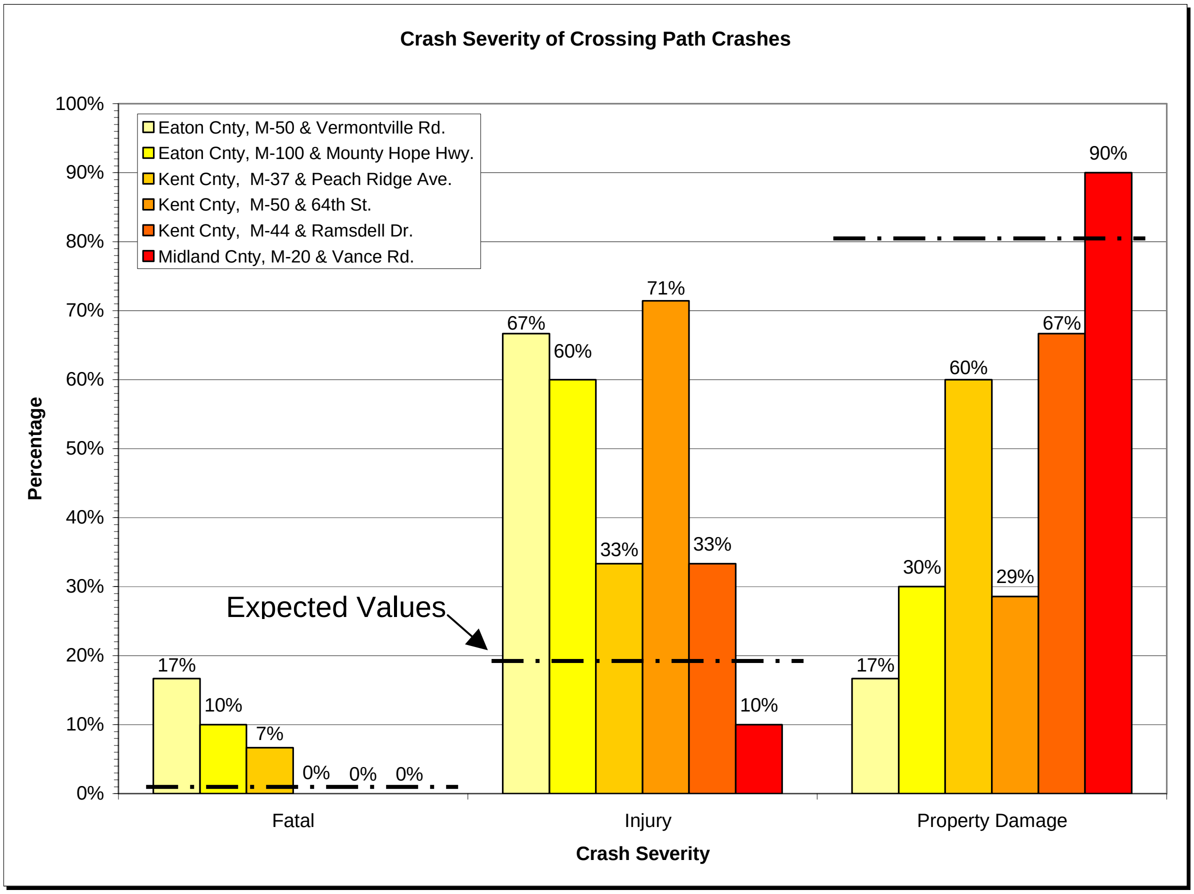


FIGURE 4-3

Crash Severity of Correctable Crash Types at Candidate Intersections

NOTE: Expected values based on crash severity of all crashes reported in 2003 Michigan Traffic Crash Facts

At the Michigan candidate intersections (see **Figure 4-4**), two sites had a majority of the crossing path crashes on the farside (M-50 & Vermontville Road (#1) with 67% and M-44 & Ramsdell Drive (#5) with 83%). At the intersection of M-50 & 64th Street (#4), all of the crossing path crashes were nearside and the remaining three intersections experienced a near equal split between farside and nearside crashes. At this time, it is unknown if this change in the crash pattern is due to regional differences in driving behavior or is a characteristic consistent with the type of roadway (i.e., two-lane highway versus expressway). In addition to Michigan; Nevada, Georgia and New Hampshire crash reviews will focus on two-lane highways instead of expressways. Information learned from these states will help in understanding if the road type plays a factor in the crash location.

Another important crash characteristic is whether the at-fault driver failed to recognize the intersection (i.e., ran-the-STOP) or failed to select a safe gap (i.e., stopped, pulled out). Since the IDS device is intended to help drivers with selecting safe gaps, crashes where the driver ran-the-STOP may not be correctable. To classify the crashes as either intersection recognition or gap recognition, the narratives on the officer reports were reviewed. However, some officer reports did not include a narrative. For these crashes, the contributing factor was classified as "unknown." Also, some narratives did not specifically state whether the driver stopped at the STOP sign, in which case they may have also considered been classified as "unknown." However, for many of these situations, the officer's narrative provided enough information to make a determination as to whether or not the driver recognized the intersection. For example, the officer may have reported that the driver was turning onto the highway. Even though the officer did not comment if the driver stopped, their decision to turn at the intersection is a strong indication that they were aware of the intersection but was unable to select a safe gap. This scenario would have been classified as a gap recognition crash.

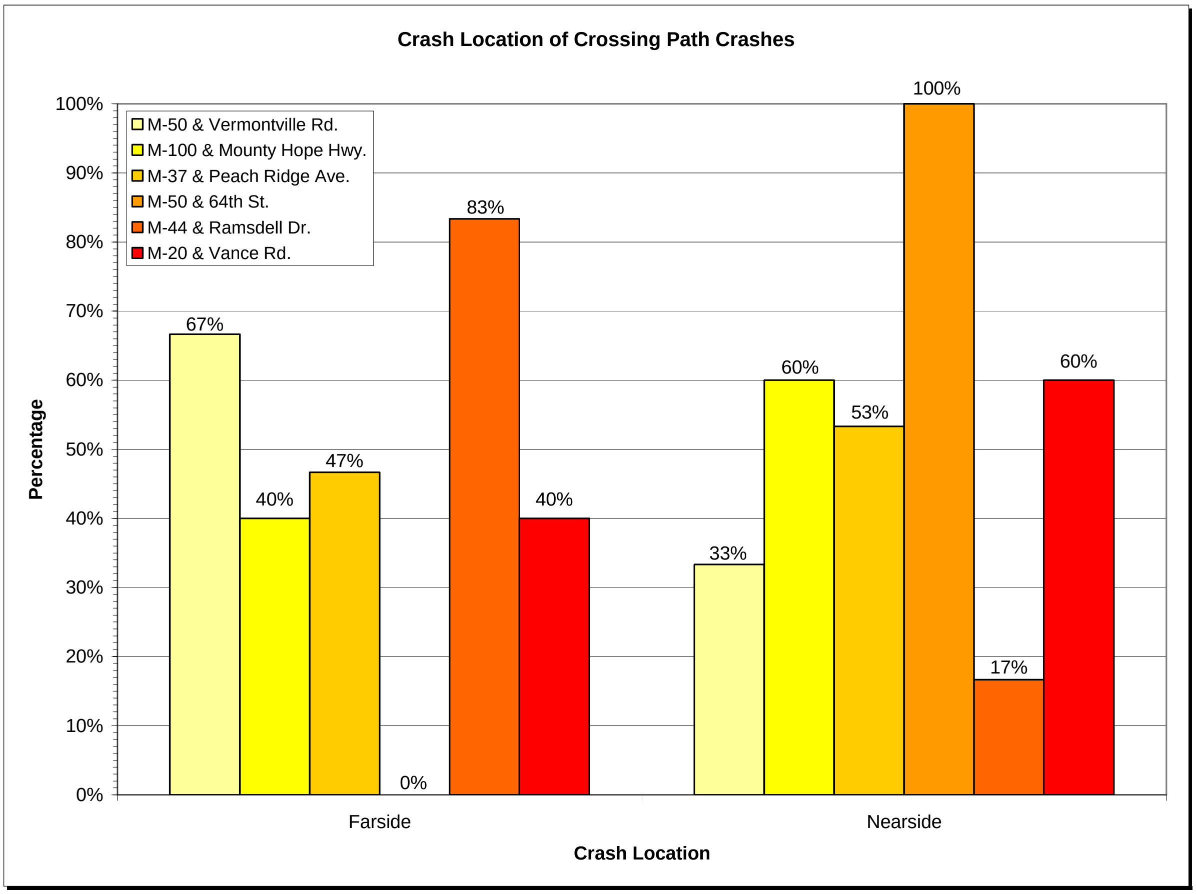


FIGURE 4-4
Crash Location of Correctable Crash Types at Candidate Intersections

At the intersections of M-37 & Peach Ridge Avenue (#3), M-44 & Ramsdell Drive (#5), and M-20 & Vance Road (#6), at least 87% of the crossing path crashes were gap recognition crashes (see **Figure 4-5**). At M-50 & Vermontville Road (#1), a majority of the crashes (57%) were intersection recognition. At the remaining three intersections, there was a mixture of gap recognition crashes, intersection recognition crashes, and crashes where the contributing factor was unknown.

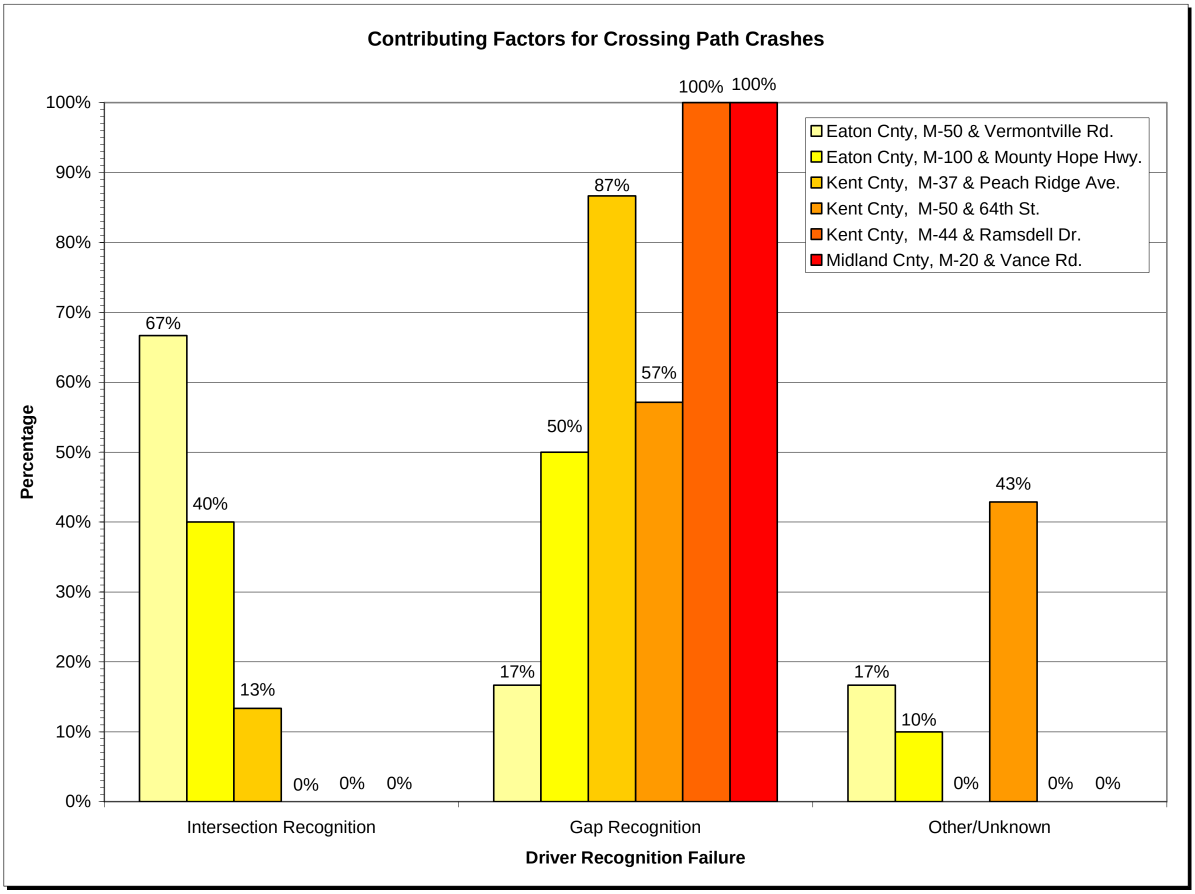


FIGURE 4-5
Contributing Factors of Correctable Crash Types at Candidate Intersections

4.5. Effect of Weather, Road Condition, and Light Condition

The final factors reviewed for the crossing path crashes at each candidate intersection were the weather, road, and light conditions. If the crashes tended to occur during adverse weather conditions (i.e., snow, rain, dark), then deployment of a new technology may have a limited benefit unless it can be coordinated with a local RWIS station.

For the weather condition (see **Table 4-3**) at the intersections of M-37 & Peach Ridge Avenue (#3), M-44 & Ramsdell Drive (#5), and M-20 & Vance Road (#6), the percentage of crashes that occurred during good weather (i.e., clear or cloudy skies) was at or above the expected distribution. At M-50 & Vermontville Road (#1) (33%), M-100 & Mount Hope Highway (#2) (20%), and M-50 & 64th Street (#4) (43%), each had a relatively high percentage of crashes that occurred during a snow/sleet storm (expected = 9%).

Regarding the road surface conditions (see **Table 4-4**), there was an increase in the percentage of crashes that occurred on snowy or icy pavements (expected = 14%) at M-50 & Vermontville Road (#1) (33%) and M-50 & 64th Street (#4) (43%), which corresponds to the crashes that occurred during a snow/sleet storm. There was an increase in the number of crashes that occurred on wet pavements at M-44 & Ramsdell Drive (#5) (33% compared to 17% expected).

The percentage of crashes reported during daylight conditions at all six intersections was at or above the expected distribution (see **Table 4-5**). Further, none of the intersections had a higher than expected number of crashes that occurred during dark conditions. The only noticeable discrepancy was that 17% of the crossing path crashes at M-50 & Vermontville Road (#1) occurred either at dawn or at dusk, compared to 7% expected.

TABLE 4-3
Weather Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	M-50 & Vermontville Road (#1)	M-100 & Mount Hope Highway (#2)	M-37 & Peach Ridge Avenue (#3)	M-50 & 64th Street (#4)	M-44 & Ramsdell Drive (#5)	M-20 & Vance Road (#6)
Clear or Cloudy	78%	67%	60%	93%	43%	83%	80%
Rain	9%	0%	0%	7%	14%	8%	10%
Snow or Sleet	9%	33%	20%	0%	43%	8%	10%
Other/ Unknown	3%	0%	20%	0%	0%	0%	0%

NOTE: Expected values based on all crashes reported in 2003 Michigan Traffic Crash Facts

TABLE 4-4
Roadway Surface Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	M-50 & Vermontville Road (#1)	M-100 & Mount Hope Highway (#2)	M-37 & Peach Ridge Avenue (#3)	M-50 & 64th Street (#4)	M-44 & Ramsdell Drive (#5)	M-20 & Vance Road (#6)
Dry	66%	67%	70%	80%	29%	58%	80%
Wet	17%	0%	20%	20%	14%	33%	20%
Snow or Ice	14%	33%	0%	0%	43%	8%	0%
Other/ Unknown	3%	0%	10%	0%	14%	0%	0%

NOTE: Expected values based on all crashes reported in 2003 Michigan Traffic Crash Facts

TABLE 4-5
Light Condition Distribution for Crossing Path Crashes at Candidate Intersections

	Expected	M-50 & Vermontville Road (#1)	M-100 & Mount Hope Highway (#2)	M-37 & Peach Ridge Avenue (#3)	M-50 & 64th Street (#4)	M-44 & Ramsdell Drive (#5)	M-20 & Vance Road (#6)
Daylight	60%	83%	80%	60%	71%	83%	90%
Dawn or Dusk	7%	17%	10%	7%	0%	8%	0%
Dark	32%	0%	0%	33%	29%	8%	10%
Other/ Unknown	2%	0%	10%	0%	0%	0%	0%

NOTE: Expected values based on all crashes reported in 2003 Michigan Traffic Crash Facts

5. Field Review

On June 22, 2005, a field review of the six candidate intersections was performed. Some of the general observations made during the field review include:

- The typical minor street approach (stopped approach) was unimproved; typically a single approach lane with an overhead flasher to supplement the STOP sign. Occasionally STOP AHEAD signs or a second STOP sign (posted on the left side of the road) were used at an intersection.
- Power is readily available at all intersections to operate an IDS system.
- The intersection sight distance was typically at or above the recommended values. However, at many of the stopped approaches, a vehicle would have to creep past the STOP sign in order to have a clear view of the through roadway/traffic.

Following is a brief description of each of the intersections. For each intersection, crash diagrams are included in **Appendix A** and aerial photos are in **Appendix B**.

5.1. M-50 & Vermontville Road (#1)

The intersection is located in a rural area of Eaton County, but there were several single-family residences located on the east approach (residences are visible in the right photo of **Figure 5-1**). The intersection's most notable characteristic is that the intersection has a skew angle of approximately 45° (see **Figure B-1**), which creates complications for drivers stopped on the minor street (Vermontville Road) looking for vehicles approaching from their left.

Both roadways are a typical two-lane two-way rural highway with no turn lanes at the intersection (see **Figure 5-1**). In addition to the STOP signs, two red/yellow flashers were installed following a fatal crash in 2001 (see **Figure 5-2**). The terrain in the area is slightly rolling, but neither M-50 approach has a vertical curve that is large enough to hide a vehicle (see **Figure 5-3** and **5-4**). Also, M-50 has no horizontal curves near the intersection that may make it difficult for a stopped vehicle to see an approaching vehicle.

FIGURE 5-1
Typical Approach for M-50 and Vermontville Road

The final observation was that for a vehicle stopped on the east approach looking at SE M-50, several mailboxes will hide a large portion of M-50. The difficulty of seeing a vehicle from this approach is highlighted in **Figure 5-4**, where a close inspection reveals that a vehicle is partially hidden by the mailbox in the foreground (a portion of the car including one headlight is visible between the poles for the mailbox and the newspaper).

FIGURE 5-2
Red/Yellow Warning Flashers Located at Intersection

FIGURE 5-3
Looking at NW M-50 from the West Approach (Vermontville Road)

FIGURE 5-4
Looking at SE M-50 from the East Approach (Vermontville Road)

5.2. M-100 & Mount Hope Highway (#2)

The area around the intersection is currently rural with only a few houses nearby. Yet, during discussions with MDOT's area engineer it was learned that the general area had experienced significant growth in housing developments and new developments are anticipated to continue to be built quickly, resulting in increases to traffic volumes.

Both roadways are two-lane highway with narrow shoulders and there are currently no turn lanes at the intersection (see **Figure 5-5** and **5-6**). The only visible improvement to the intersection was the installation of street lighting, which can be seen in **Figure 5-5**. The MDOT area engineer made it known that turn lanes will be constructed for all approaches as part of a safety improvement project in 2006. If the improvements are completed, the change to the intersection would make it an unattractive location for a before/after study.

In the vicinity of the intersections, the alignments are level and straight; therefore, there are no vertical or horizontal curves that easily hide a vehicle from a driver looking from the stopped approaches. However, for a driver stopped on the west approach looking to the south, there are four signs (STOP sign, route marker, Adopt-A-Highway, and PASS WITH CARE sign), a mailbox and a utility pole which created a cluttered line of sight, preventing an unobstructed view without having to creep partially into the intersection (see **Figure 5-7**).

5.3. M-37 & Peach Ridge Avenue (#3)

This intersection was not visited after the review team learned from the MDOT area engineers that the intersection had been reconstructed in 2003/2004 (i.e., primarily added left and right turn lanes to the M-37 approaches). Even though it is unknown exactly how the reconstruction would impact the safety performance of the intersection, the changes to the intersection make it no longer a quality candidate since these changes make it difficult to evaluate whether any future changes in crash statistics are due to the construction or the introduction of IDS technologies.

FIGURE 5-5
West Approach of
Mount Hope Highway
(Looking East)

FIGURE 5-6
M-100 Looking Away from Intersection
(Left Photo = Looking North; Right Photo = Looking South)

5.4. M-50 & 64th Street (#4)

This intersection was also improved in 2003/2004 with the addition of right turn lanes to the M-50 approaches as well as removing trees and shrubs that restricted intersection sight distance for a vehicle stopped on the 64th Street approaches. Because of the changes to the intersection, this location is also not a preferred candidate for a before/after study.

Despite this change, the intersection was still visited because it was located on the route to another intersection. A general observation for the intersection was that the sight distance was within acceptable ranges if a driver moved up past the STOP sign for a better viewpoint. If stopped at the STOP sign, slight vertical curves combined with trees, back slopes, utility poles or signs restricted the sight distance (see **Figures 5-8** and **5-9**).

FIGURE 5-7
Cluttered Line of Sight While Stopped on the West Approach

FIGURE 5-8
Restricted Sight Distance When Stopped at STOP Sign (Looking South from East Approach)

5.5. M-44 & Ramsdell Drive (#5)

The intersection is located approximately 20 miles from the outer limits of Grand Rapids in an area with several lakes where the surrounding area is primarily developed with single-family residences, which can be described as a bedroom community for Grand Rapids. The land use near the intersection included a gas station, a small strip mall, two repair shops and a small restaurant. The intersection had several improvements, including the installation of a red/yellow overhead flasher, intersection lighting, and CROSS TRAFFIC DOES NOT STOP signs mounted on the STOP signs (see **Figure 5-10**).

FIGURE 5-9
Improved Sight Distance if Driver Pulls Past STOP Sign (Looking South from East Approach)

Two CROSS TRAFFIC DOES NOT STOP signs were mounted under each STOP sign; one facing drivers waiting at the STOP sign and the second facing drivers stopped on the opposing intersection leg.

FIGURE 5-10
Intersection Improvements

Both roadways are two-lane highways with unmarked right turn lanes on the M-44 approaches (see **Figure 5-11**). All approaches have a straight alignment (i.e., no horizontal curves), but a crest vertical curve is located just several hundred feet to the west of the intersection, which limits the sight distance for vehicles stopped on the minor street approaches (see **Figure 5-12**). From the MDOT area engineers, it was learned the area had been previously considered for safety improvements. However, the preferred strategy of lowering the crest curve to the west was not determined to be a cost effective safety mitigation strategy for this location.

FIGURE 5-11
Intersection Approaches for M-44 and Ramsdell Drive

FIGURE 5-12
Restricted Sight Distance Due to Crest Vertical Curve Located West of Intersection

5.6. M-20 & Vance Road (#6)

This intersection is located on the outer edge of the City of Midland. The land use in the area can be best described as developed suburban, with a gas station, restaurant, bank, repair shop, and strip mall near the intersection. During the field visit, it was noticed that the grocery store in the strip mall (southeast quadrant) was closed for business, which the MDOT area engineer reported as happening recently. Also, intersection lighting has been installed at the intersection.

M-20 is a five-lane roadway (two lanes in each direction plus a continuous center left turn lane) with right turn lanes added at the intersection (see **Figure 5-13**). Vance Road is a two-lane local street that was widened at the intersection to add a left turn lane (see **Figure 5-14**).

FIGURE 5-13
M-20 West Approach

FIGURE 5-14
Vance Road North Approach

At the time of the field visit, even though most of the stores in the area had not yet opened for the day, the minor street approaches did not appear to carry significant traffic volumes. This was confirmed by the MDOT area engineer, who informed the review team that a traffic signal study had been previously completed and found that the intersection volumes did not justify the installation of a traffic signal.

When stopped on the south approach of Vance Road, the sight distance is partially blocked by vehicles parked at a repair shop to the west (see **Figure 5-15**) and trees to the east (see **Figure 5-16)**. In order to have clear line of sight, a driver has to move up past the STOP sign.

FIGURE 5-15
Intersection Sight
Distance Restricted by
Vehicles at Repair Shop

FIGURE 5-16
Intersection Sight
Distance Restricted by
Low Hanging Branches

6. Summary and Intersection Recommendation

A summary of the pertinent crash statistics has been summarized in **Table 6-1** for the six candidate intersections. Following is a set of general observations from the analysis and review of the Michigan candidate intersections.

- MDOT has applied many strategies in the traffic safety toolbox at each of these intersections. Generally, these strategies (minor street improvements such as STOP AHEAD sign, second STOP sign placed on left side of road, overhead red/yellow flasher, CROSS TRAFFIC DOES NOT STOP sign, and street lights) have been very effective at reducing intersection recognition crashes at many of these locations, but have not been effective at addressing gap related crashes – a crash type which is over represented at the highest crash frequency intersections in the State.
- The crash characteristics for the subset of high crash frequency intersections examined are very similar to the data for comparable intersections in Minnesota. The intersections have a crash rate greater than the critical crash rate (statistically significantly different than the expected value), the distribution of crash types skewed to angle crashes, gap related, more severe than expected, and typically not caused by weather and/or light conditions.
- There is a complicating geometric or traffic pattern at each of the intersections – vertical curve, intersection skew, restricted sight distance, etc. However, the actual intersection sight distance at each intersection appears to be consistent with AASHTO guidelines.
- Overall, many of the at-fault drivers are local to the area (live within 30 miles of crash location).

6.1. Recommended Intersection for Deployment

For the six candidate intersections, the pros and cons of each is summarized in **Table 6-2**. Because of the close proximity to existing small urban areas or quickly growing areas, the candidate locations are not isolated rural intersections. Yet, deploying at one of these intersections will allow for data collection at a site that is different than the intersection instrumented in Minnesota. Furthermore, none of the intersections are located on high speed divided expressways (like the selected intersections in Minnesota, Wisconsin, and North Carolina), which again will provide diversity in the collected data.

Dismissed Sites: At two locations, M-37 & Peach Ridge Avenue (#3) and M-50 and 64th Street (#4), physical intersection improvements were recently implemented and improvements are planned for 2006 at third location, M-100 & Mount Hope Highway (#2). Testing IDS technology at these locations is undesirable because it would be impossible to determine the effectiveness of the IDS technology separate from the physical improvements. At M-20 and Vance Road (#6), the minor streets were observed to have very low volumes during the field reviews, which may be related to several store closings adjacent to the intersection. Without sufficient exposure, it will be difficult to collect an adequate amount of data.

TABLE 6-1
Candidate Intersection Summary

Performance Measure	M-50 & Vermontville Road (#1)	M-100 & Mount Hope Highway (#2)	M-37 & Peach Ridge Avenue (#3)	M-50 & 64th Street (#4)	M-44 & Ramsdell Drive (#5)	M-20 & Vance Road (#6)
Crash Frequency	12	12	17	12	21	26
Crash Severity Fat	1 (8%)	1 (8%)	1 (6%)	0 (0%)	0 (0%)	0 (0%)
"A" Inj	0 (0%)	2 (17%)	2 (12%)	3 (25%)	3 (14%)	1 (4%)
"B" Inj	3 (25%)	2 (17%)	0 (0%)	3 (25%)	1 (5%)	1 (4%)
"C" Inj	3 (25%)	2 (17%)	3 (18%)	2 (18%)	1 (5%)	4 (15%)
PD	5 (42%)	5 (42%)	11 (65%)	4 (33%)	16 (76%)	20 (77%)
Daily Entering ADT	6,925	7,115	26,875	8,090	8,730	18,700
Crash Rate	1.6	1.5	0.6	1.4	2.2	1.3
Expected Rate	0.4 (MN)	0.4 (MN)	0.4 (MN)	0.4 (MN)	0.4 (MN)	0.4 (MN)
Critical Crash Rate	0.8	0.8	0.6	0.8	0.8	0.7
Correctable Crash Type (See Sec. 5.1)	6 (50%)	10 (83%)	15 (88%)	7 (58%)	12 (57%)	10 (38%)
Crash Severity Fat	1 (17%)	1 (10%)	1 (7%)	0 (0%)	0 (0%)	0 (0%)
"A" Inj	0 (0%)	2 (20%)	2 (13%)	3 (43%)	2 (17%)	0 (0%)
"B" Inj	2 (33%)	2 (20%)	0 (0%)	1 (14%)	1 (8%)	0 (0%)
"C" Inj	2 (33%)	2 (20%)	3 (20%)	1 (14%)	1 (8%)	1 (10%)
PD	1 (17%)	3 (30%)	9 (60%)	2 (29%)	8 (67%)	9 (90%)
At-Fault Driver						
< 21	2 (33%)	2 (20%)	2 (13%)	1 (14%)	2 (17%)	1 (10%)
21 – 64	3 (50%)	5 (50%)	11 (73%)	6 (86%)	8 (67%)	3 (30%)
> 64	0 (0%)	3 (30%)	1 (7%)	0 (0%)	1 (8%)	4 (40%)
Unknown	1 (17%)	0 (0%)	1 (7%)	0 (0%)	1 (8%)	2 (20%)
Crash Location						
Farside	4 (67%)	4 (40%)	7 (47%)	0 (0%)	10 (83%)	4 (40%)
Nearside	2 (33%)	6 (60%)	8 (53%)	7 (100%)	2 (17%)	6 (60%)
Contributing Factors						
Int Recg	4 (67%)	4 (40%)	2 (13%)	0 (0%)	0 (0%)	0 (0%)
Gap Recg	1 (17%)	5 (50%)	13 (87%)	4 (57%)	12 (100%)	10 (100%)
Other	1 (17%)	1 (10%)	0 (0%)	3 (43%)	0 (0%)	0 (0%)

Recommended Site: Of the remaining two intersections, M-44 & Ramsdell Drive (#5) had twice as many crashes that were considered correctable. Also, all of these crashes were classified as a problem with gap recognition instead of intersection recognition. Furthermore, there appears to be strong initial support from MDOT's area engineers to a technology based safety mitigation strategy, especially since MDOT's review of geometric safety mitigation strategies (i.e., redesign of vertical curvature) was found to be cost inefficient. Therefore, the intersection recommended for data collection and potential deployment of the IDS technology is M-44 & Ramsdell Drive (#5). At this time, it is expected that the next phase of the study (deployment of the temporary vehicle surveillance system at this intersection) will occur in the summer of 2006.

6.2. Other Recommendations

The University of Minnesota could design an IDS system for any of the remaining candidate intersections if MDOT wished to implement additional intersections. If so, the second recommended intersection is M-50 & Vermontville Road (#1). Even though this intersection had a low percentage of crashes related to gap selection, this intersection has had no recent improvements. Also, the intersection skew and the roadside features that can make it difficult to see oncoming vehicles would allow researchers to observe how drivers select gaps in a difficult situation.

If the IDS system is only deployed at M-44 & Ramsdell Drive (#5), the two candidate intersections that have had no recent improvements may benefit from traditional mitigation strategies to address the high number of crossing path crashes (especially those related to gap recognition). The following recommendations are presented for MDOT's consideration. However, further investigation is required to determine if these recommendations are feasible solutions or if another strategy may be optimal.

- M-50 & Vermontville Road (#1) – A long-term, high cost strategy would include realignment of the roadways to remove or reduce the intersection skew. In the short term, potential strategies include providing clear intersection sight triangles. With the relative high number of intersection recognition crashes, the effectiveness of the overhead flashers (which were intended to improve intersection conspicuity) should be monitored. Strategies to increase intersection conspicuity may also include making sure advanced warning signs and pavement markings are in place, adding a left posted STOP sign, and adding intersection lighting.
- M-20 & Vance Road (#6) – Since the intersection is in a suburban area, it should be periodically evaluated to see if traffic signal warrants are met. In the short term, keeping intersection sight triangles clear could help address the crossing path crashes. For the remaining crashes, predominately run-off road, head-on and left turn, controlling vehicle speeds may yield positive results if speeding is found to be a problem in the area.
- At the three intersections that had improvements recently implemented or will be improved in 2006, the crash experience should continue to be monitored to ensure that safety has improved.

The final recommendation is that MDOT consider an electronic database that has key intersection attributes (i.e., entering ADT volumes, roadway design, posted speed limit, area type, traffic control device, etc.) which can be queried and is also linked to the crash record database. Development of a tool would allow the State to quickly and reliably screen through many intersections in order to determine expected rates and identify high crash locations.

TABLE 6-2
Pros and Cons of Candidate Intersections

Candidate Intersection	Pros	Cons
M-50 & Vermontville Road (#1)	High percentage of fatal and injury crashes. High percentage of farside crashes.	Relatively low number of correctable crash types. No older at-fault drivers (target group). Of the 6 crashes that were of a correctable crash type, only 1 was gap related.
M-100 & Mount Hope Highway (#2)	High percentage of fatal and injury crashes. Has a high involvement of older drivers	Of the 10 crashes that were of a correctable crash type, only 5 were gap related. Improvements planned at the intersection (2006).
M-37 & Peach Ridge Avenue (#3)	Highest number and percentage of correctable crash types. Has the highest number of gap related crashes.	Low percentage of fatal and injury crashes. Recent improvements performed at the intersection.
M-50 & 64th Street (#4)	High percentage of fatal and injury crashes.	Relatively low number of correctable crash types. No older at-fault drivers. Of the 7 crashes that were of a correctable crash type, only 4 were gap related. Recent improvements performed at the intersection.
M-44 & Ramsdell Drive (#5)	Highest percentage of farside crashes. Tied with M-20 & Vance Road for the highest percentage of gap related crashes. Vertical curve east of intersection limits sight distance. Highest crash rate.	Low percentage of fatal and injury crashes.
M-20 & Vance Road (#6)	Has the highest involvement of older drivers. Tied with M-44 & Ramsdell Drive for the highest percentage of gap related crashes.	Low percentage of fatal and injury crashes. Low volume on stopped approaches.

Note: “Correctable crash type” implies that the crash was potentially correctable by the IDS technology.

References

1. W.J Najm, J.A. Koopmann and D.L. Smith. “Analysis of Crossing Path Crash Countermeasure Systems.” Proceedings of the 17th International Technical Conference on the Enhanced Safety of Vehicles, Amsterdam, The Netherlands. June 2001.
2. K.A. Harder, J. Bloomfield, B.J. Chihak. *Crashes at Controlled Rural Intersection*. Report MN/RC-2003-15. Local Road Research Board, Minnesota Department of Transportation. July 2003.
3. H. Preston, R. Storm, M. Donath, C. Shankwitz. *Review of Minnesota’s Rural Intersection Crashes: Methodology for Identifying Intersections for Intersection Decision Support*. Report MN/RC-2004-31. Minnesota Department of Transportation. May 2004.
4. T. Maze, N. Hawkins, G. Burchett. *Rural Expressway Synthesis of Practice and Crash Analysis*. CTRE Project 03-157. Iowa Department of Transportation. October 2004.

Appendix A

Intersection Crash Diagrams

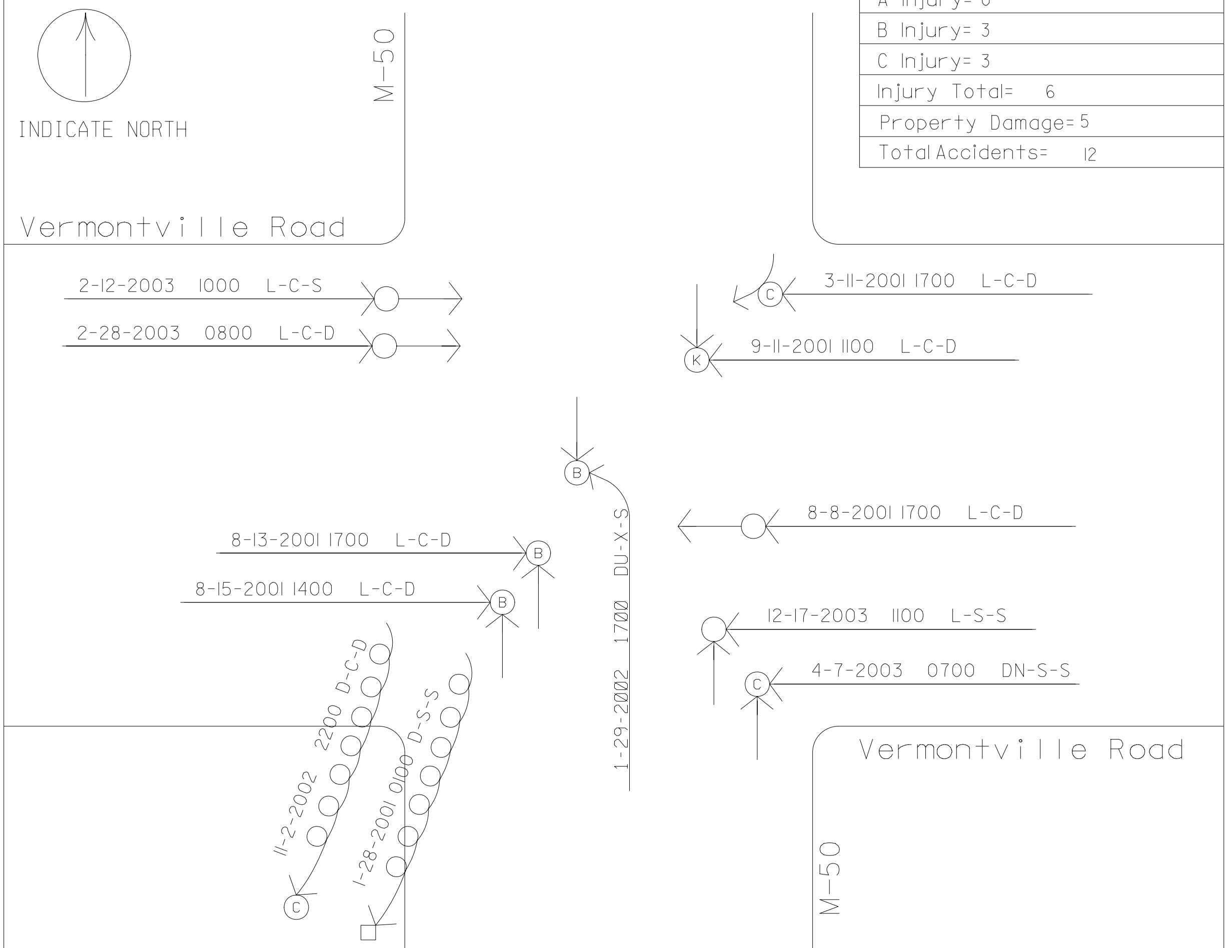
COLLISION DIAGRAM

LOCATION: M-50 & VERMONTVILLE ROAD (EATON COUNTY) 1 OF 1

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

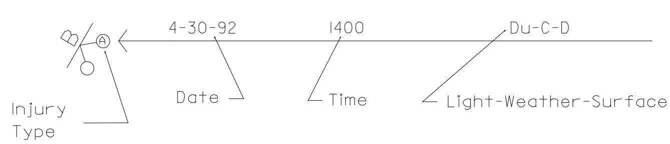
No. of Accidents
Fatal= 1
A Injury= 0
B Injury= 3
C Injury= 3
Injury Total= 6
Property Damage= 5
Total Accidents= 12



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



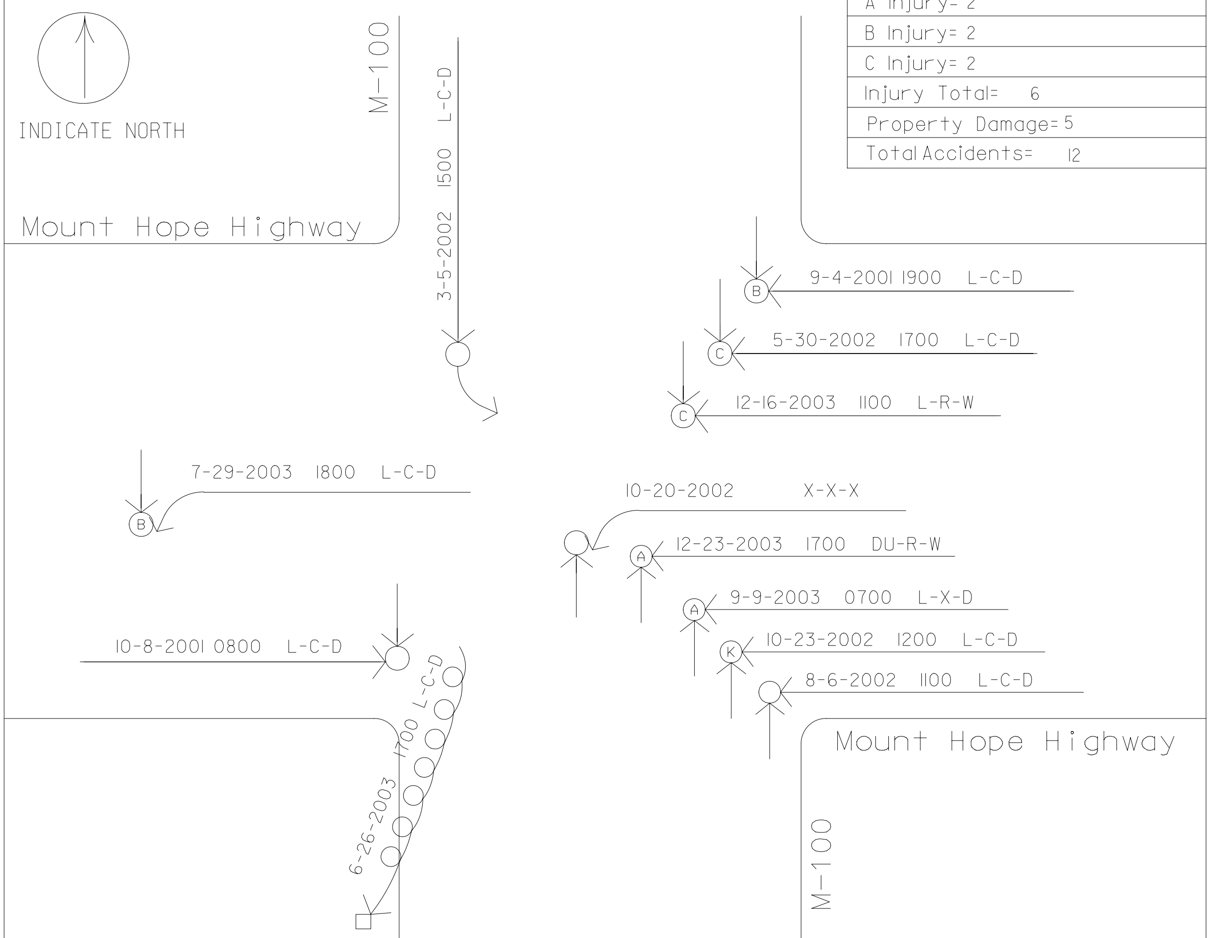
COLLISION DIAGRAM

LOCATION: M-100 & MOUNT HOPE HIGHWAY (EATON COUNTY) 1 OF 1

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

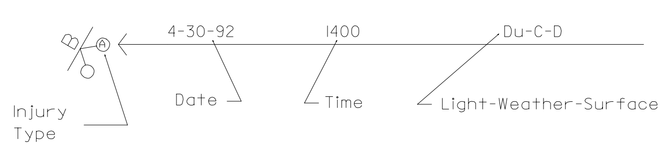
No. of Accidents
Fatal= 1
A Injury= 2
B Injury= 2
C Injury= 2
Injury Total= 6
Property Damage= 5
Total Accidents= 12



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

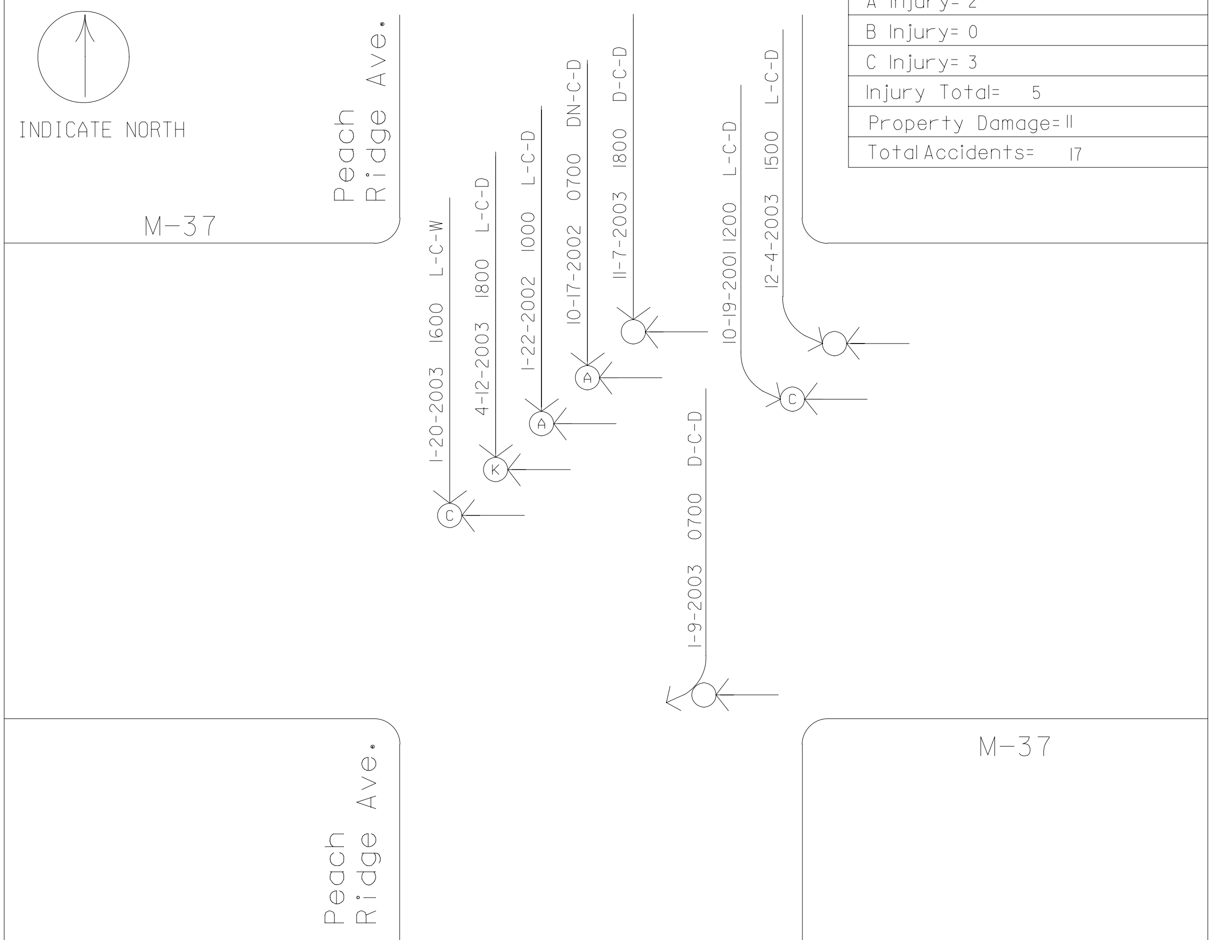
LOCATION: M-37 & PEACH RIDGE AVENUE (KENT COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

No. of Accidents

Fatal=	1
A Injury=	2
B Injury=	0
C Injury=	3
Injury Total=	5
Property Damage=	11
Total Accidents=	17



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.

* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

COLLISION DIAGRAM

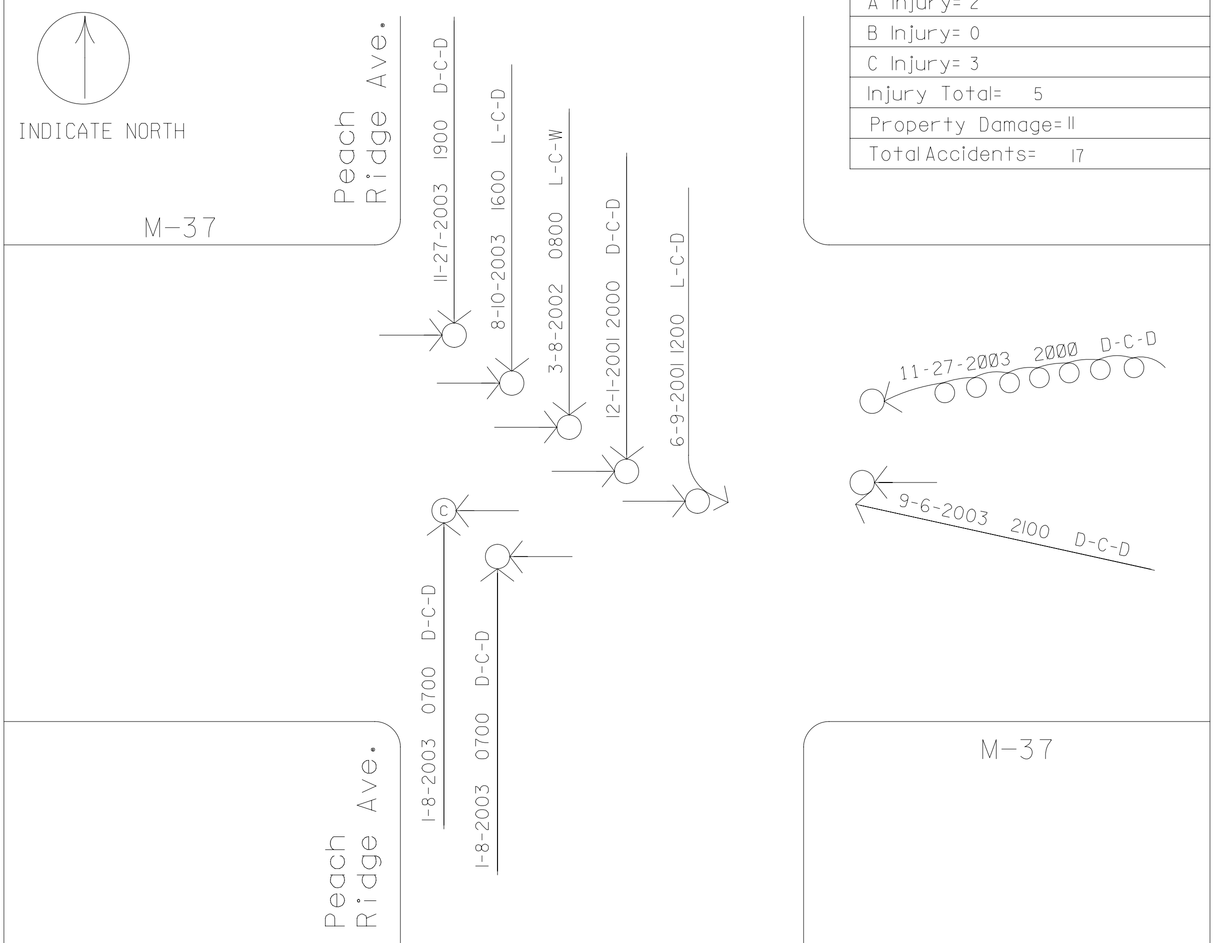
LOCATION: M-37 & PEACH RIDGE AVENUE (KENT COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

No. of Accidents

Fatal= 1
A Injury= 2
B Injury= 0
C Injury= 3
Injury Total= 5
Property Damage= 11
Total Accidents= 17



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.

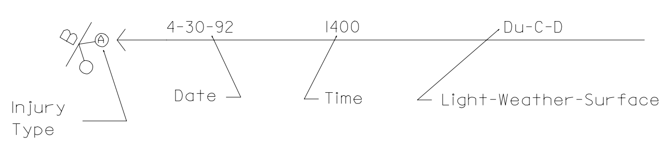
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

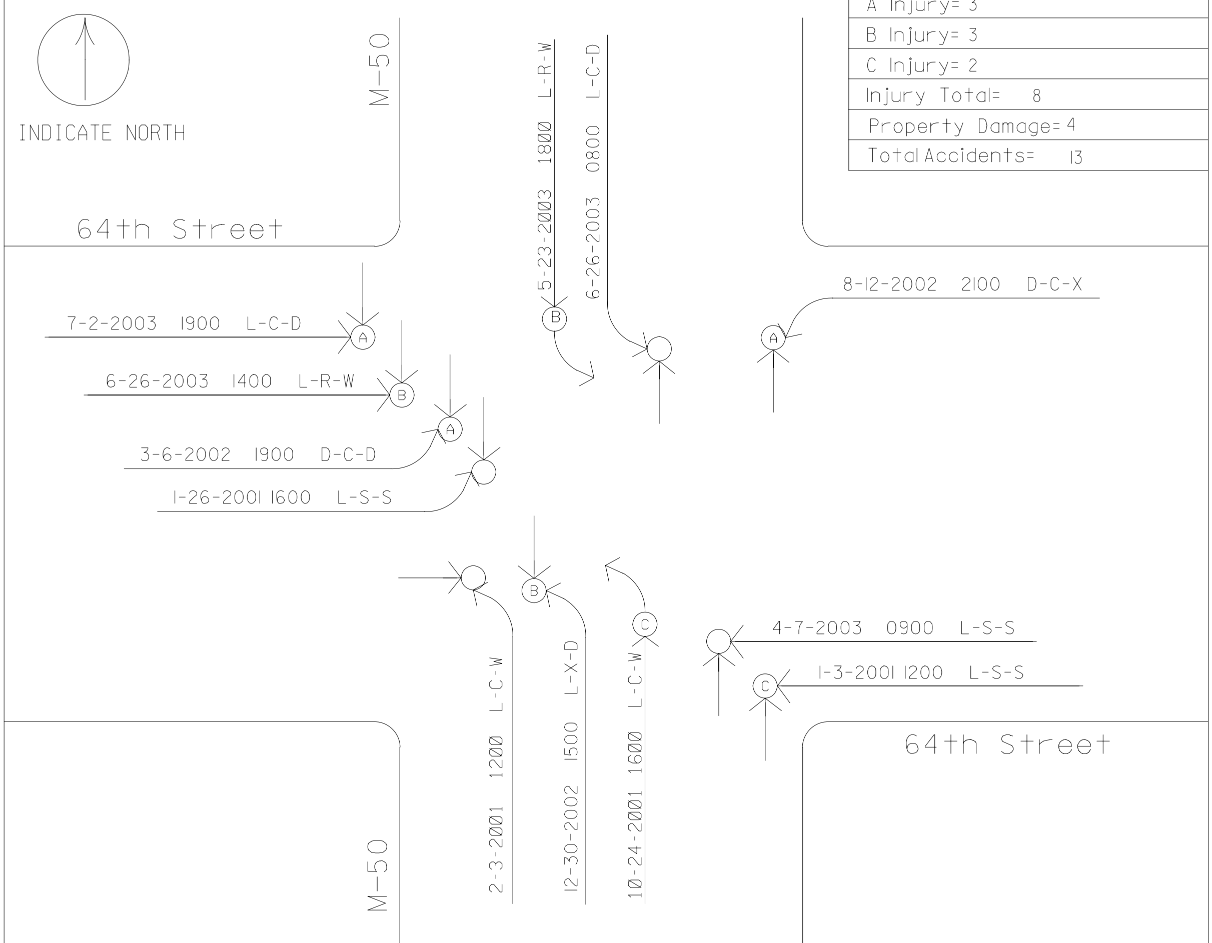
LOCATION: M-50 & 64TH STREET (KENT COUNTY) 1 OF 1

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

No. of Accidents

Fatal= 0
A Injury= 3
B Injury= 3
C Injury= 2
Injury Total= 8
Property Damage= 4
Total Accidents= 13

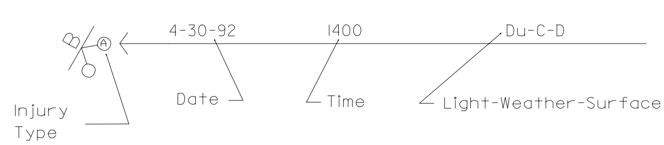


Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.

* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



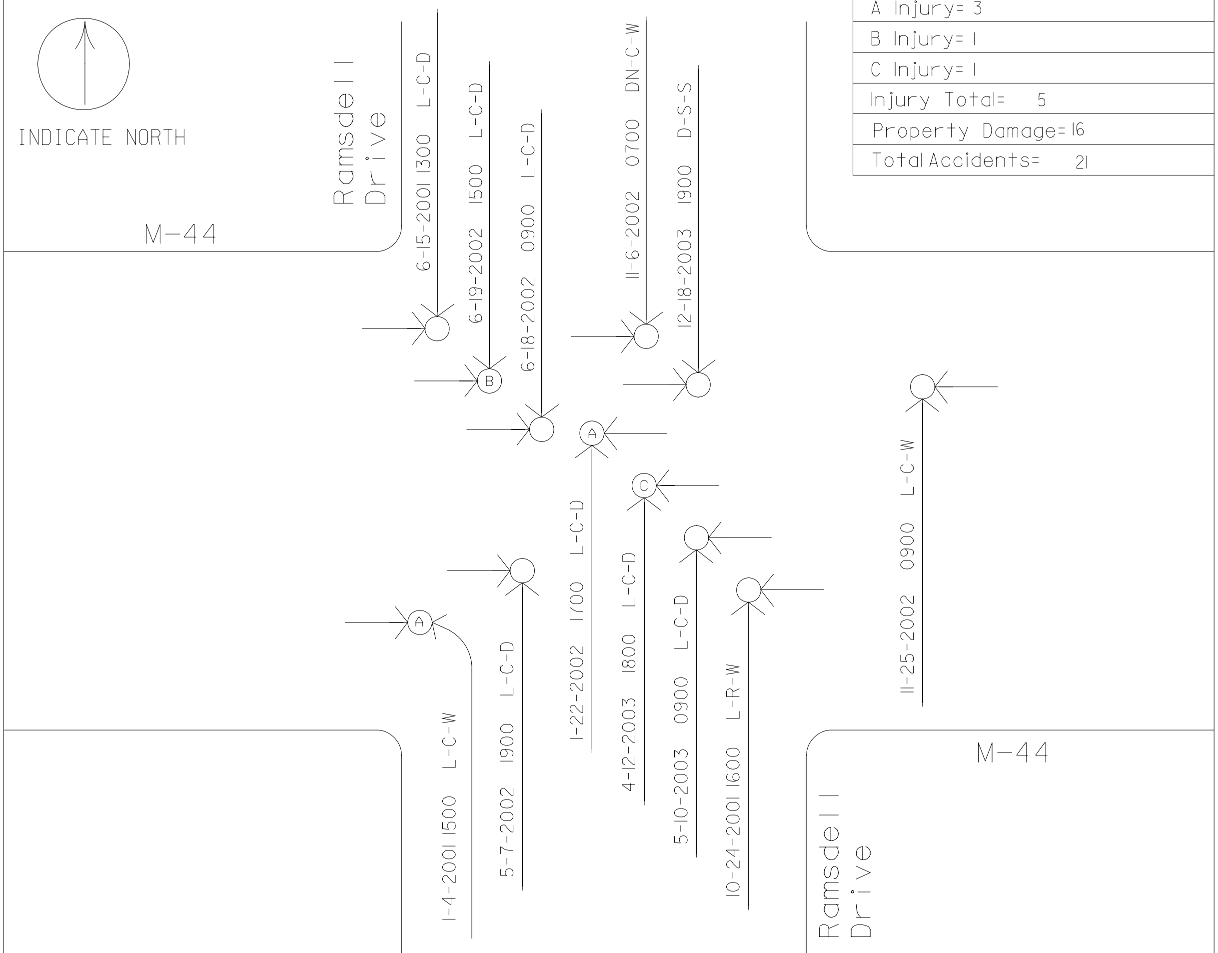
COLLISION DIAGRAM

LOCATION: M-44 & RAMSDELL DRIVE (KENT COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

No. of Accidents
Fatal= 0
A Injury= 3
B Injury= 1
C Injury= 1
Injury Total= 5
Property Damage= 16
Total Accidents= 21



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.

* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:
L= Daylight
DN= Dawn
Du= Dusk
D= Dark
X= Unknown

Weather:
C= Clear or Cloudy
R= Rain
S= Snow or Sleet
X= Other or Unknown

Surface:
D= Dry
W= Wet
S= Snow or Ice
X= Other or Unknown

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

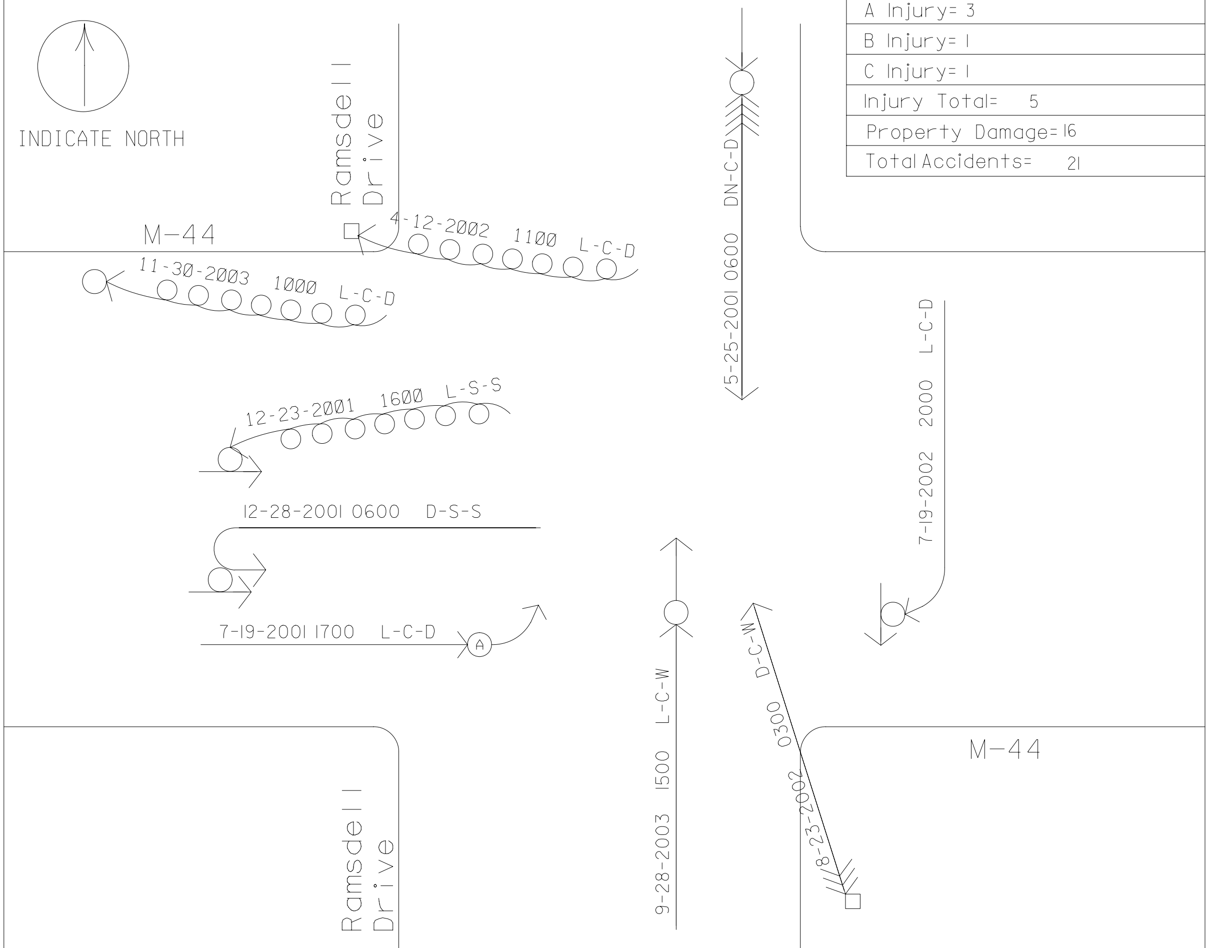
COLLISION DIAGRAM

LOCATION: M-44 & RAMSDELL DRIVE (KENT COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

No. of Accidents
Fatal= 0
A Injury= 3
B Injury= 1
C Injury= 1
Injury Total= 5
Property Damage= 16
Total Accidents= 21



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

COLLISION DIAGRAM

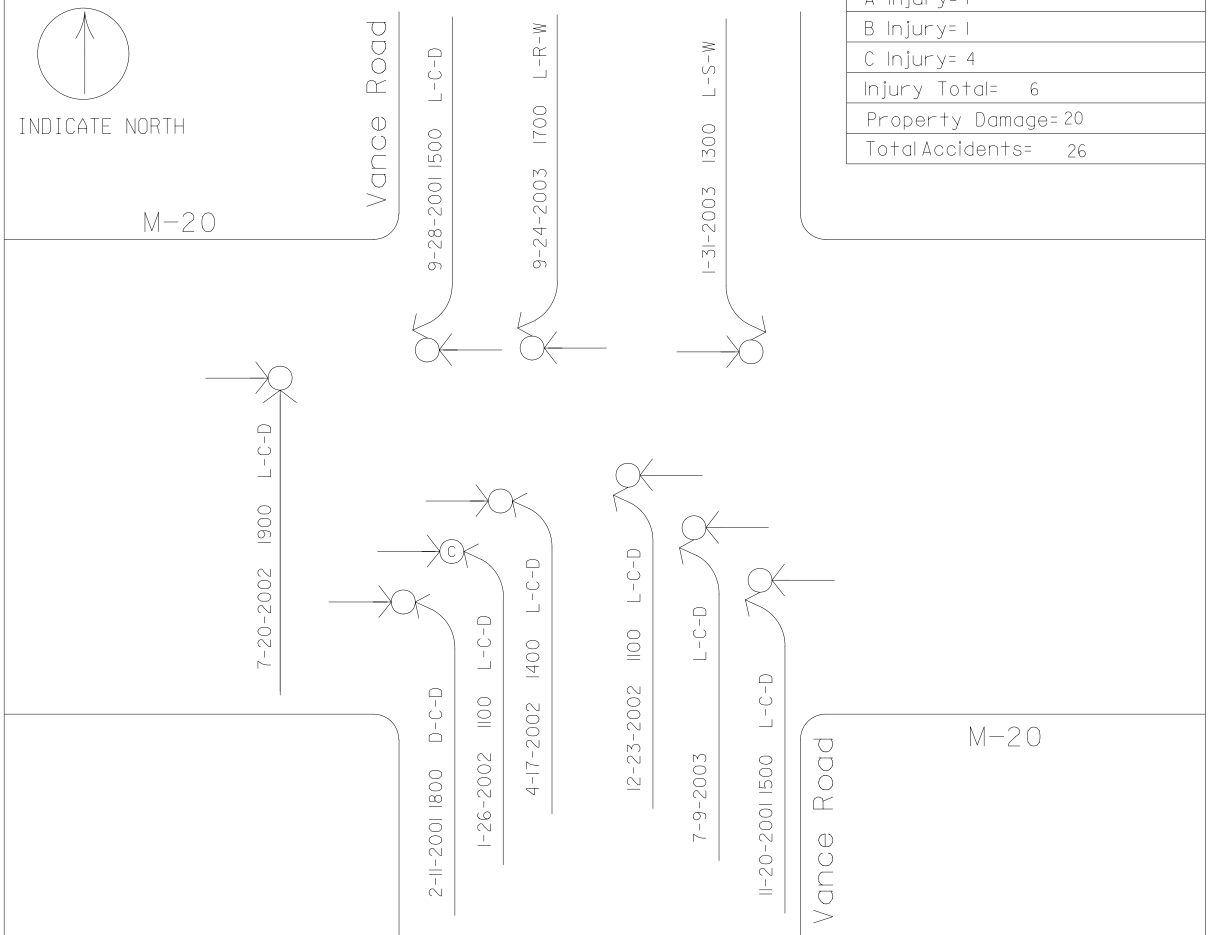
LOCATION: M-20 & VANCE ROAD (MIDLAND COUNTY) 1 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

No. of Accidents	
Fatal=	0
A Injury=	1
B Injury=	1
C Injury=	4
Injury Total=	6
Property Damage=	20
Total Accidents=	26

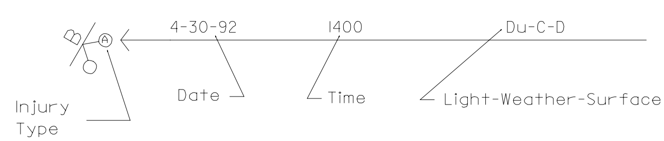
INDICATE NORTH



Motor Vehicle Ahead
Motor Vehicle Backing Up
Motor Vehicle Out of Control
Pedestrian
Bicycle/Moped
Motorcycle
Fixed Object
Fatal Acc.
A Injury Acc.
B Injury Acc.
C Injury Acc.
* Location/Details Unclear
Property Damage Acc.
Rear End Property Damage
Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:



COLLISION DIAGRAM

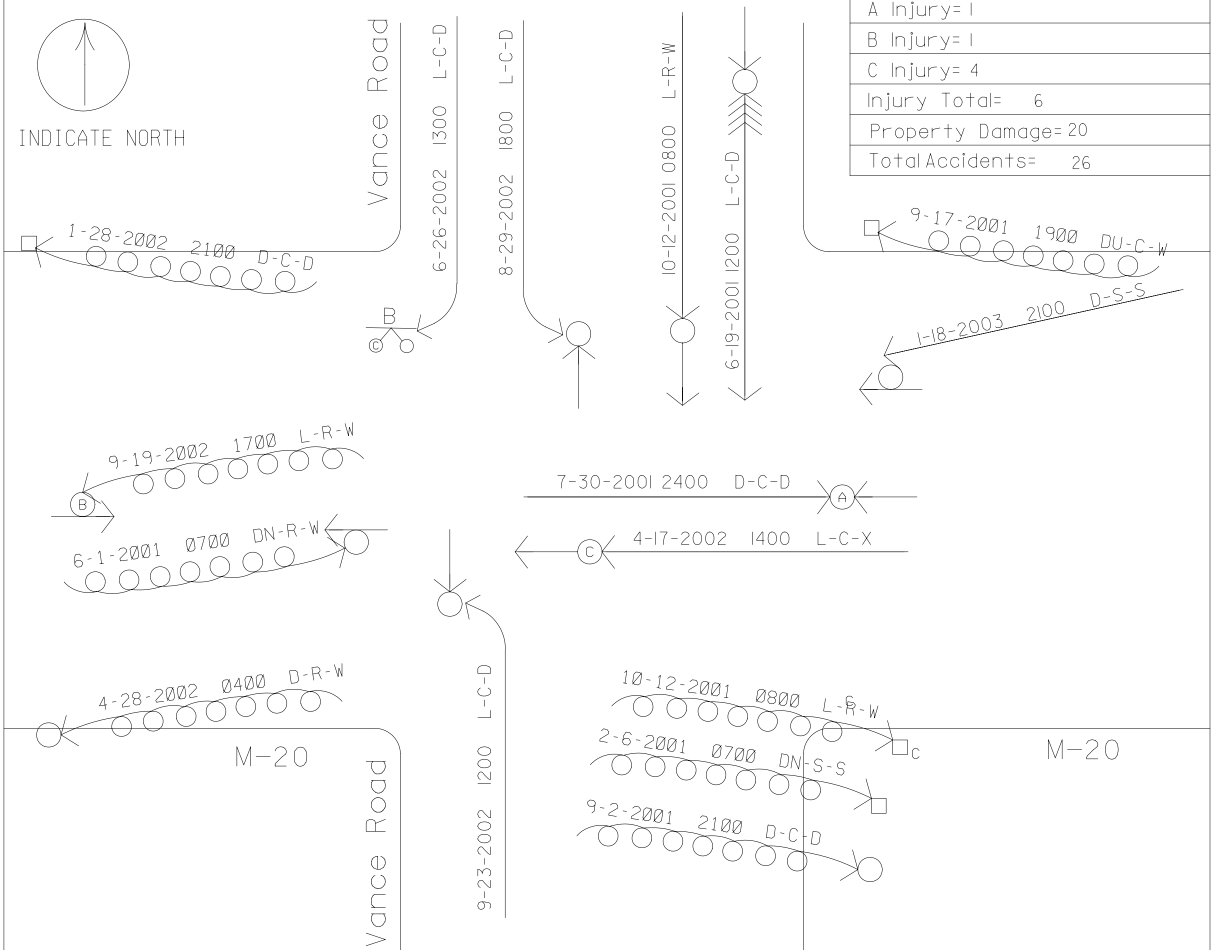
LOCATION: M-20 & VANCE ROAD (MIDLAND COUNTY) 2 OF 2

TIME PERIOD: 01/01/2001 - 12/31/2003

PREPARED BY: RJS DATE: 05-16-2005

No. of Accidents

Fatal=	0
A Injury=	1
B Injury=	1
C Injury=	4
Injury Total=	6
Property Damage=	20
Total Accidents=	26



Motor Vehicle Ahead

Motor Vehicle Backing Up

Motor Vehicle Out of Control

Pedestrian

Bicycle/Moped

Motorcycle

Fixed Object

Fatal Acc.

A Injury Acc.

B Injury Acc.

C Injury Acc.

* Location/Details Unclear

Property Damage Acc.

Rear End Property Damage

Right Angle A Injury

Light:	Weather:	Surface:
L= Daylight	C= Clear or Cloudy	D= Dry
DN= Dawn	R= Rain	W= Wet
Du= Dusk	S= Snow or Sleet	S= Snow or Ice
D= Dark	X= Other or Unknown	X= Other or Unknown
X= Unknown		

Example of Bicycle/Motor Vehicle Accident:

4-30-92 1400 Du-C-D

Injury Type — Date — Time — Light-Weather-Surface

Appendix B

Aerial Photographs

FIGURE B-1
Aerial Photo of M-50 & Vermontville Road (#1)
Source: Eaton County

FIGURE B-2
Aerial Photo of M-100 & Mount Hope Highway (#2)
Source: Eaton County

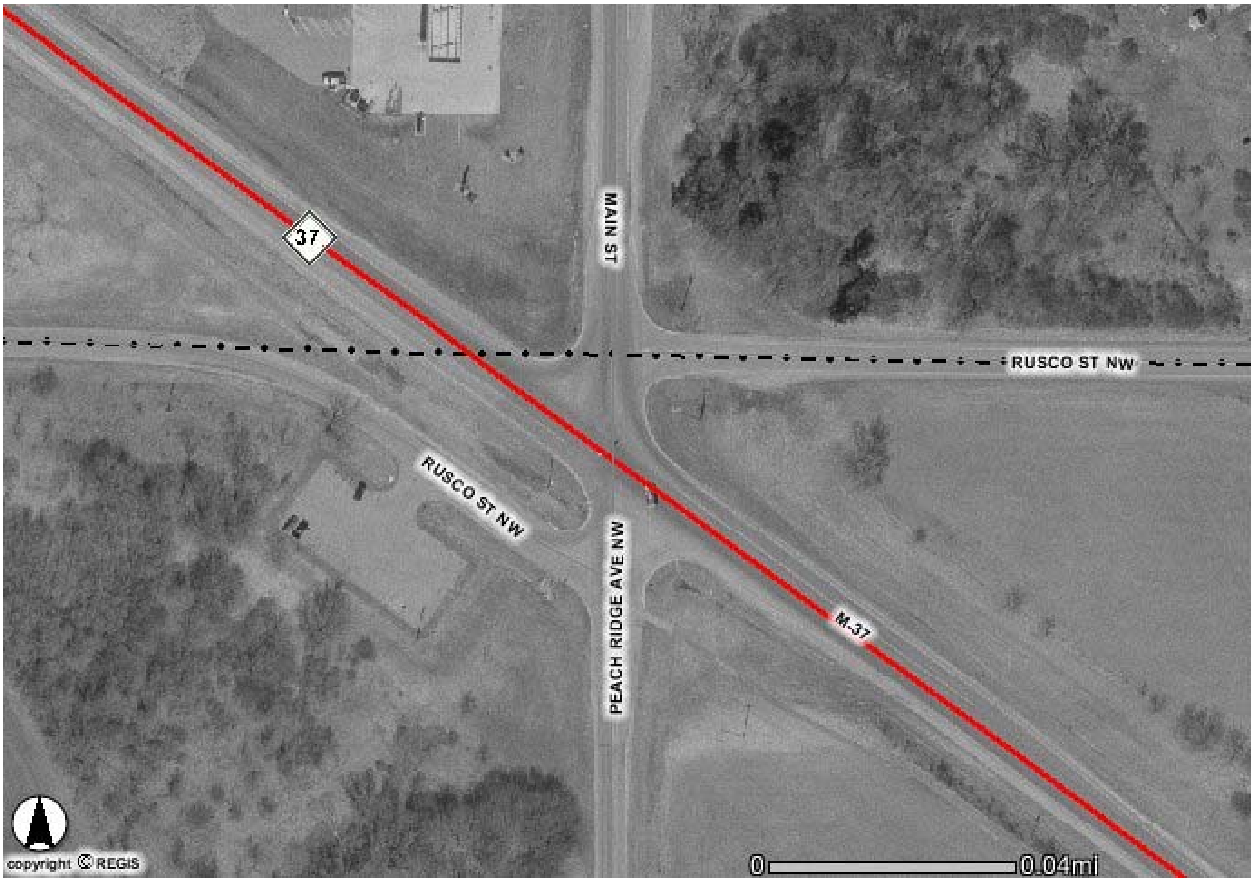


FIGURE B-3
Aerial Photo of M-37 & Peach Ridge Avenue (#3)
Source: Kent County

FIGURE B-4
Aerial Photo of M-50 & 64th Street (#4)
Source: Kent County

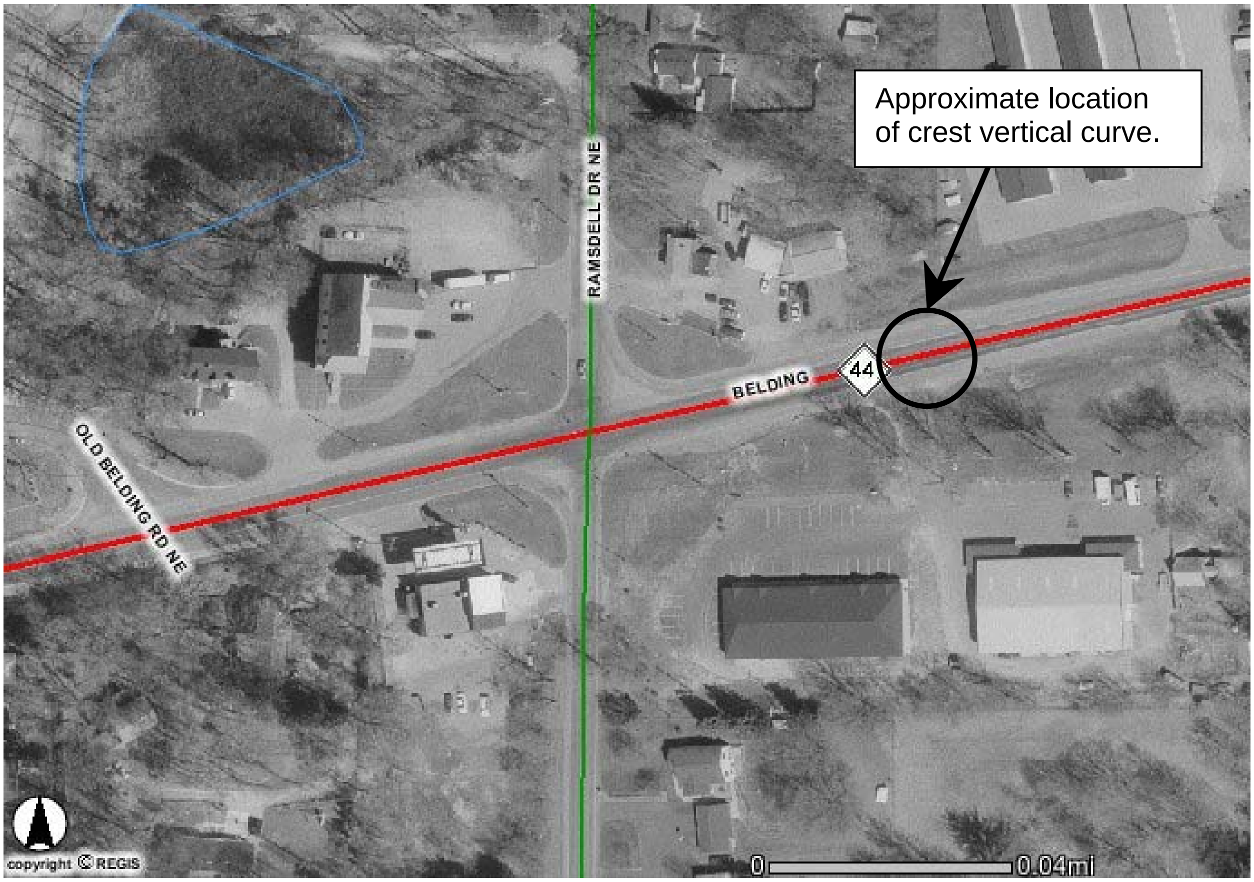


FIGURE B-5
Aerial Photo of M-44 & Ramsdell Drive (#5)
Source: Kent County

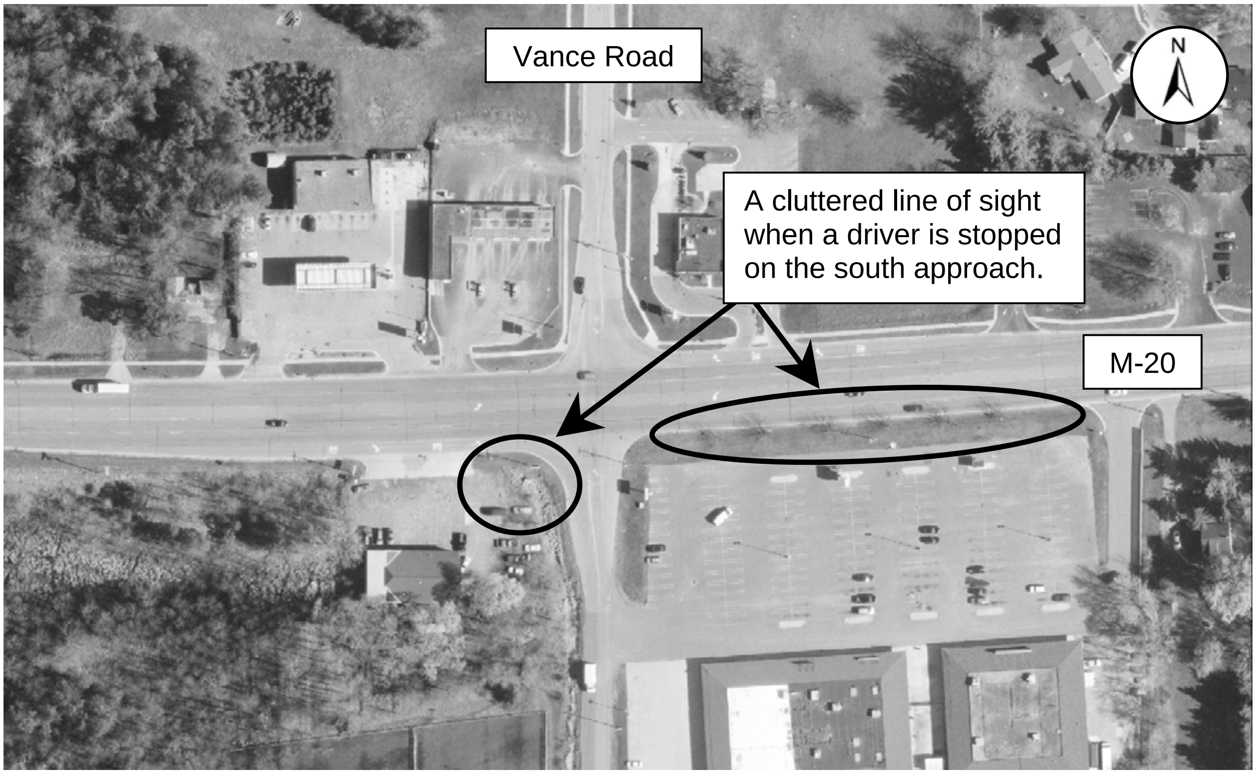


FIGURE B-6
Aerial Photo of M-20 & Vance Road (#6)
Source: City of Midland