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16. Abstract

Results of a direct observation of safety belt and motorcycle helmet use in Michigan for Fall of 1993 are reported. The current survey represents a complete departure from the procedures and sample design used in previous surveys. In the present survey, 17,719 front outboard occupants were observed in 13,669 passenger vehicles between September 2 and September 23, 1993. Statewide shoulder belt use for front outboard occupants in passenger vehicles was 64.4 percent. This shoulder belt use rate represents the highest use rate found in any previous University of Michigan Transportation Research Institute survey. It also shows an increase in belt use of around 13 percent since the most recent survey conducted 15 months earlier. In the current survey, 177 motorcycle riders were observed on 150 motorcycles. Of all motorcycle riders observed, all passengers and all but one driver were using helmets, a use rate of 99.4 percent. The safety belt and helmet use rates found in this study are a positive sign for the traffic safety efforts in Michigan.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

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INTRODUCTION

According to a report by the Centers for Disease Control (1992), motor vehicle injuries are the leading cause of death in the United States for people under 35 years of age. This statistic is even more illuminating when it is considered along side the fact that the number of motor vehicle fatalities has significantly *declined* over the last several decades (National Safety Council, 1993). This decline has resulted primarily from a nationwide effort to reduce the incidence of alcohol impaired driving, to reduce the speeds at which drivers travel, and to promote the use of helmets and restraint devices. As the National Safety Council statistics reveal, this effort has been effective. It is equally clear, however, that programs for reducing injuries and fatalities on the roadways still have much headway to make.

As a part of the national program to reduce motor vehicle injuries, in the late 1970s numerous states began writing legislation to mandate statewide safety belt use. Since the first safety belt law was passed in 1984 (New York), 44 states and the District of Columbia have passed similar laws. In general, these laws have produced a dramatic increase in belt use immediately following implementation, followed by a subsequent decline in belt use that is generally above pre-law levels. Such was the case in Michigan following implementation of a safety belt law in July 1985 (see Streff, Molnar, and Christoff, 1993).

To measure compliance with Michigan's mandatory safety belt law, The University of Michigan Transportation Research Institute (UMTRI) is conducting a series of direct-observation surveys of safety belt use among motor vehicle occupants statewide. Fourteen previous survey waves have been completed. The first two waves were conducted prior to implementation of the law to establish a baseline safety belt use rate (Wagenaar and Wiviott, 1984; Wagenaar, Wiviott, and Compton, 1985). The third wave was conducted during the first month of implementation (Wagenaar and Wiviott, 1985). The next eight survey waves were conducted roughly every five months between December 1985 and May 1988 (Wagenaar, Wiviott, and Businski, 1986; Wagenaar, Businski, and Molnar, 1986a, 1986b; Wagenaar, Molnar, and Businski, 1987a, 1987b, 1987c, 1988a, 1988b). The twelfth, thirteenth, and fourteenth survey waves were conducted in April 1989 (Wagenaar and Molnar, 1989), May 1990 (Streff and Molnar, 1990), and June 1992 (Streff, Molnar, and Christoff, 1993). The fifteenth survey wave, reported here, was conducted during September 1993, 98 months after the Michigan safety belt law first took effect.

Each of the previous surveys examined belt use by age, gender, seating position, time of day, day of week, type of road, weather conditions, vehicle type, and region of the state by direct observation of vehicles stopped at traffic lights or stop signs. In the present survey wave, only the front outboard occupants of passenger cars were observed and safety belt use was examined only as a function of time of day, day of week, and weather conditions. In addition, the direct observation of motor vehicles was conducted on *moving* vehicles. This change increased the number of potential sites for observation and enabled us to survey more vehicles at each site than with the stopped vehicle method. Because of these changes (and other changes discussed in the methods and results sections), meaningful comparison between the results of this survey and any of the previous surveys is tenuous; that is, we would expect to see some differences between belt use rates simply because of changes in the methods and sample. All comparisons in this report between the present survey and previous survey waves should be interpreted with this in mind.

METHODS

Sample Design

The goal of the sample design was to select observation sites that represent accurately all passenger vehicle motorists in Michigan, while following federal guidelines for safety belt survey design (National Highway Traffic Safety Administration, 1992). An ideal sample minimizes total survey error while providing sites that can be surveyed efficiently and economically. To achieve this goal, the following sampling procedure was used.

To reduce the costs associated with direct observation of remote sites, the National Highway Traffic Safety Administration (NHTSA) guidelines allow states to omit from their sample space the lowest population counties, provided these counties account for 15 percent or less of the state's total population. Therefore, all 83 Michigan counties were rank ordered by population (U.S. Bureau of the Census, 1992) and the low population counties were eliminated from the sample space. This step reduced the sample space to 28 counties.

These 28 counties then were separated into four strata. The strata were constructed by obtaining historical belt use rates and vehicle miles of travel (VMT) for each county. Historical belt use rates were determined by averaging results from three previous UMTRI surveys (Wagenaar et al., 1987b, 1988b; Wagenaar and Molnar, 1989). Since no historical data were available for six of the counties, belt use rates for these counties were estimated using multiple regression based on per capita income and education for the other 22 counties (r^2 = .56; U.S. Bureau of the Census, 1992).[1] These factors previously have been shown to correlate positively with belt use (e.g., Wagenaar, et al., 1987). Because of the disproportionately high VMT for Wayne County, and because we wanted to ensure that observation sites were selected within this county, Wayne County was chosen as a separate stratum. Three other strata were constructed by rank ordering each county by historical belt use rates and then adjusting the stratum boundaries until there was roughly equal total VMT within each stratum. The stratum boundaries were: high belt use (54.0 percent or greater), medium belt use (45.0 percent to 53.9 percent), low belt use (44.9 percent or lower), and Wayne County (41.9 percent belt use). The historical belt use rates and VMT by county and strata are shown in Table 1.

[1] Education was defined as the proportion of population in the county over 25 years of age with a professional or graduate degree.

Table 1. Descriptive Characteristics of the Four Strata[2]					
Strata	County	Belt Use, Percentage	Belt Use Average, %	VMT, billions of miles	Total VMT, billions of miles
1			56.3		17.48
	Ingham	54.3		1.98	
	Kalamazoo	54.3		1.98	
	Oakland	54.5		10.66	
	Washtenaw	62.0		2.86	
2			48.8		17.42
	Allegan	***45.2***		0.86	
	Bay	53.7		1.13	
	Eaton	52.5		0.9	
	Gr. Traverse	47.2		0.63	
	Jackson	46.2		1.41	
	Kent	48.9		4.07	
	Livingston	***48.7***		1.44	
	Macomb	48.0		4.83	
	Midland	***50.7***		0.68	
	Ottawa	47.4		1.45	
3			40.9		17.15
	Berrien	41.6		1.68	
	Calhoun	***43.2***		1.4	
	Genesee	42.8		4.12	
	Lapeer	39.6		0.71	
	Lenawee	44.4		0.82	
	Marquette	39.6		0.56	
	Monroe	44.2		1.53	
	Muskegon	41.8		1.11	
	Saginaw	40.7		1.86	
	Shiawassee	***41.6***		0.64	
	St. Clair	34.1		1.38	
	St. Joseph	***41.6***		0.51	
	Van Buren	36.7		0.83	
4					
	Wayne	41.9	41.9	15.29	15.29

To achieve the NHTSA required precision of less than 5 percent relative error, the minimum number of observation sites for the survey (N = 56) was determined based on within- and between-county variances from previous belt use surveys and an estimated 50 vehicles per

[2]Note: Boldface italics type indicates values estimated from multiple regression. The belt use percentages were used only for statistical purposes in this design. Caution should be taken in interpreting these values.

observation period in the current survey. This minimum number was then increased (N = 168) to get an adequate representation of belt use for each day of the week and all daylight hours.

Because total VMT within each stratum was roughly equal, observation sites were evenly divided among the strata (42 each). In addition, since an estimated 23 percent of all traffic in Michigan occurs on limited-access roadways (Federal Highway Administration, 1982), ten (24 percent) of the sites within each stratum were freeway exit ramps, while the remaining 32 were roadway intersections.

Within each stratum, observation sites were randomly assigned to a location using different methods for intersections and freeway exit ramps. The intersection sites were chosen using a method that ensured each intersection within a stratum had an equal probability of selection. Detailed, equal-scale road maps for each county were obtained and a grid pattern was overlaid on each county map. The grid dimensions were 62 lines horizontally and 42 lines vertically. The lines of the grid were separated by 1/4 inch. With the *3/8 inch:mile* scale of the maps, this created grid squares that were .67 miles per side. (Because Marquette County is so large, it was divided into four maps and each part was treated as a separate county.) Each grid square was uniquely identified by two numbers, a horizontal (or *x*) coordinate and a vertical (or *y*) coordinate.

The 42 sites for each stratum were sampled sequentially. The 32 local intersection sites were chosen by first randomly selecting a grid number containing a county within a stratum.[3] This was achieved by generating a random number between 1 and the number of grids within the stratum. So, for example, since the high belt use stratum had four grid patterns overlaying four counties, a random number between 1 and 4 was generated to determine which grid would be selected. Thus, each grid had an equal probability of selection at this step. Once the grid was selected, a random *x* and a random *y* coordinate was chosen and the corresponding grid square identified. Thus, each intersection had an equal probability of selection. If a single intersection was contained within the square, that intersection was chosen as an observation site. If the square did not fall within the county, there was no intersection within the square, or there was an intersection but it was located one road link from an already selected intersection, then a new grid number and x, *y* coordinate was randomly selected. If there was more than one intersection within the grid square, the grid square was subdivided into four equal sections and a random number between 1 and 4 was selected until one of the intersections was randomly chosen. This happened for only two of the sites.

[3] It is important to note that grids were selected during this step rather than counties. This was necessary only because it was impractical to construct a single grid that was large enough to cover all of the counties in the largest stratum when they were laid side by side.

Once a site was chosen, the following procedure was used to determine the particular street and direction of traffic flow that would be observed. For each intersection, all possible combinations of street and traffic flow were determined. From this set of observer locations, one location was randomly selected with a probability equal to 1/number of locations. For example, if the intersection, was a "+" intersection, as shown in Figure 1, then there would be four possible combinations of street and direction of traffic flow to be observed (observers watched traffic on only the side of the street on which they were standing). In Figure 1, observer location #1 indicates that the observer would watch westbound traffic and stand next to Main Street. For observer location #2, the observer would watch southbound traffic and stand next to Second St., and so on. In this example, a random number between 1 and 4 would be selected to determine the observer location for this specific site. The probability of selecting an intersection approach is dependent on the type of intersection. Four-legged intersections like that shown in Figure 1 have four possible observer locations, while three-legged intersections like "T" and "Y" intersections have only three possible observer locations. The effect of this slight difference in probability accounts for .01 percent or less of the standard error in the belt use estimate.

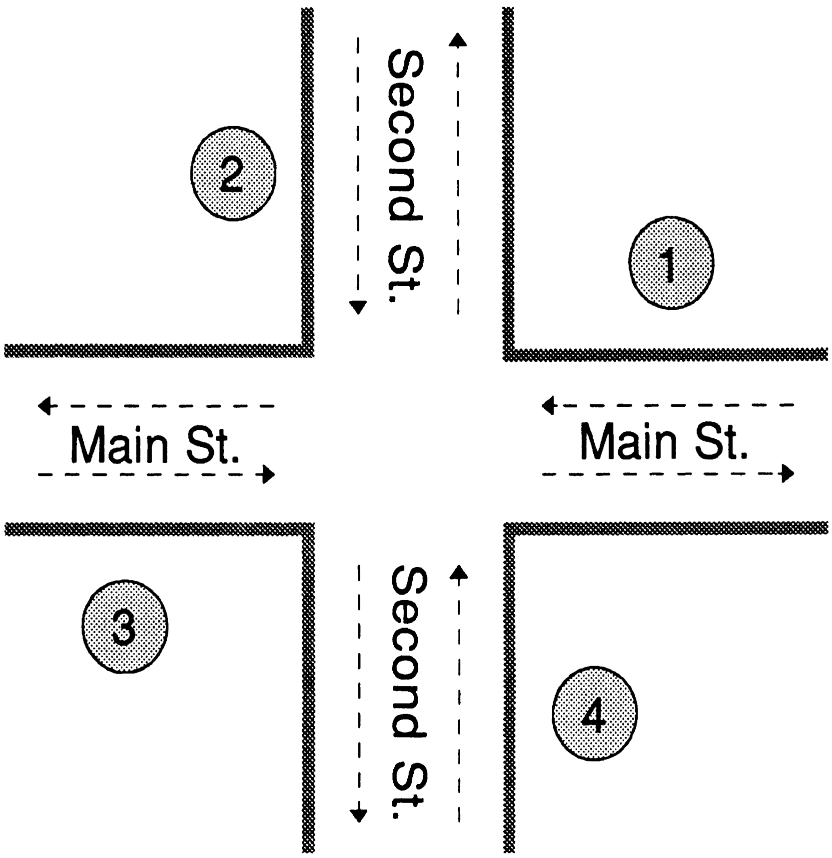

Figure 1
An example "+" intersection showing four possible observer locations

For each chosen intersection site, an alternate site was also selected. The alternate sites were chosen within a 20 x 20 square unit area around the grid square containing the original intersection, corresponding to a 13.4 square mile area around the site. This was achieved by randomly picking an *x, y* grid coordinate within the alternate site area. Grid coordinates were selected until a grid square containing an intersection was found. No grid squares were found that contained more than one intersection. The observer location at the alternate intersection was determined in the same way as at the primary site.

The ten freeway exit ramps sites within each stratum also were selected so that each exit ramp had an equal probability of selection.[4] This was done by enumerating all of the exit ramps within a stratum and randomly selecting without replacement ten numbers between 1 and the number of exit ramps in the stratum. For example, in the high belt use stratum there was a total of 109 exit ramps. To select an exit ramp, a random number between 1 and 109 was generated. This number corresponded to a specific exit ramp. To select the next exit ramp, another random number between 1 and 109 was selected with the restriction that no previously selected numbers could be chosen. Once the exit ramps were determined, the observer location for the actual observation was determined by enumerating all possible combinations of direction of traffic flow and side of ramp on which to stand. As in the determination of the observer locations at the roadway intersections, the possibilities were then randomly sampled with equal probability. The alternate exit ramp sites were selected by taking the first interchange encountered after randomly selecting a direction of travel along the freeway from the primary site. If this alternate site was outside of the county or it was already selected as a primary site, then the other direction of travel along the freeway was used.

Because the observation sites were randomly chosen from all possible intersections within a stratum, it was conceivable that some counties would not have observation sites within them. In the present sample, this happened for both Marquette and Midland Counties. These counties were part of the sample space, but none of their intersections or exit ramps were chosen during the random selection process.

The day of week and time of day for site observation were pseudo-randomly assigned to sites in such a way that all days of the week and all daylight hours (7 am - 7 pm) had essentially equal probability of selection. The sites were observed using a clustering procedure. That is, sites that were located spatially adjacent to each other were considered to be a cluster. Within each

[4] An exit ramp is defined here as a point of access to a limited-access freeway, irrespective of the direction of travel. Thus, on a north-south freeway corridor, the north and south bound exit ramps at a particular cross street are considered a single exit ramp location.

cluster, a shortest route between all of the sites was decided (essentially a loop) and each site was numbered. An observer watched traffic at all sites in the cluster during a single day. The day in which the cluster was to be observed was randomly determined. After taking into consideration the time required to finish all sites before darkness, a random starting time for the day was selected. In addition, a random number between 1 and the number of sites in the cluster was selected. This number determined the site within the cluster where the first observation would take place. The observer then visited sites following the loop in either a clockwise or counter-clockwise direction (whichever direction left them closest to home at the end of the day). This direction was determined by the project manager prior to sending the observer into the field. Because of various scheduling limitations (e.g., observer availability, number of hours worked per week, etc.) certain days and/or times were selected that could not be observed. When this occurred, a new day and/or time was randomly selected until a usable one was found. The important issue about the randomization is that the day and time assignments to the sites were not correlated with belt use at a site. This pseudo-random method is random with respect to this issue.

The sample design was constructed so that each observation site was self-weighted by VMT within each stratum. This was accomplished by selecting sites with equal probability and by setting the observation interval to a constant duration (50 minutes) for each site.[5] Thus the number of cars observed at an observation site reflected safety belt use by VMT; that is, the higher the VMT at a site, the greater the number of vehicles that would pass during the 50-minute observation period. However, at the very high traffic volume sites (> 200 passenger cars/50 minutes) and at sites in which there were multiple lanes in the traffic leg under observation, the observer could not have accurately recorded belt use for all passing vehicles. Therefore, a vehicle count of all passenger cars on the traffic leg under observation was conducted for a set duration (five minutes) immediately prior to and immediately following the observation period (ten minutes total).

Table 2 shows descriptive statistics for the 168 observation sites. As shown in this table, the sites were fairly well distributed over day of week and time of day. Note that an observation session was included in the time slot that represented the majority of the observation period. If the observation period was evenly distributed between two time slots, then it was included in the later time slot. This table also shows that nearly every site observed was the primary site and most observations occurred on sunny or cloudy days.

[5] Because of safety considerations, sites in the city of Detroit were observed for a different duration. See data collection section for more information.

Table 2. Descriptive Statistics for the 168 Observation Sites							
Day of Week		Start Time		Site Choice		Weather	
Monday	13.1%	7-9 AM	13.7%	Primary	96.4%	Sunny	42.3%
Tuesday	13.7%	9-11 AM	17.3%	Alternate	3.6%	Cloudy	36.3%
Wednesday	8.3%	11-1 PM	16.7%			Rain	21.4%
Thursday	18.5%	1-3 PM	20.2%			Snow	0.0%
Friday	16.7%	3-5 PM	20.8%				
Saturday	16.7%	5-7 PM	11.3%				
Sunday	13.1%						
TOTALS	100%		100%		100%		100%

Data Collection

Data collection for the study involved direct observation of safety belt and motorcycle helmet use. Trained field staff observed shoulder belt use of drivers and front-right passengers traveling in passenger cars during daylight hours between September 2-23, 1993. Vehicles other than passenger cars (e.g., vans, utility vehicles, pickup trucks, medium and large trucks) and commercial vehicles were excluded from safety belt observations. Because observations were limited to shoulder belt use of front outboard occupants, moving vehicles could be observed. Concurrent with the safety belt observations, helmet use by motorcycle riders also was observed.

Data Collection Forms

Two forms were used for data collection: a site description form and an observation form. The site description form (see Appendix A) provided descriptive information about the site including the site number, location, site type (freeway exit ramp or local intersection), site choice (primary or alternate), observer number, date, day of week, time of day, weather, and information about the traffic leg being observed (e.g., number of lanes, whether there was a median, and a count of passenger cars traveling on the leg). A diagram was also furnished for observers to sketch the intersection and to identify observation locations and traffic flow patterns. Finally, a comments section was available for observers to identify landmarks that might be helpful in characterizing the site (e.g., school, shopping mall) and to discuss problems or issues relevant to the site or study.

The second form, the observation form, was used to record both safety belt and motorcycle helmet use (see Appendix A). Safety belt use was recorded on the upper portion of the form and helmet use on the lower portion of the form. Each form contained space to record data for 30 passenger cars and ten motorcycles. For each car observed, observers recorded shoulder belt use for drivers and front-right passengers by checking appropriate boxes on the form (belted or not belted). A separate box was checked if there was no front-right passenger in the car. Children riding in child safety seats were recorded as belted. Occupants observed with their shoulder belt worn under the arm or behind the back were recorded as belted and information about the type of misuse was also recorded. At each site the observer carried several data collection forms and completed as many as were necessary during the observation period.

For each motorcycle observed, observers recorded helmet use for drivers and passengers by checking appropriate boxes on the form (helmet or no helmet). Similar to observation of passenger cars, a separate box was checked if there was no passenger on the motorcycle. The helmet use portion of the observation form contained boxes to record data for one passenger for each motorcycle. If more than one passenger was observed on a motorcycle (e.g., one riding on the seat and one in a sidecar), observers were instructed to write in helmet use for all additional passengers.

Procedures at Each Site

All sites in the sample were visited by single observers for a period of one hour, with the exception of sites in the city of Detroit. To address potential security concerns, Detroit sites were visited by two-person teams of observers for a period of 30 minutes. Because each team member at Detroit sites recorded data for different lanes of traffic, the total amount of time of data collection at Detroit sites was equivalent to that at other sites.

Upon arriving at a site, observers determined whether observations were possible at the site. If observations were not possible (e.g., due to construction), observers proceeded to the alternate site. Otherwise, observers completed the site description form and then moved to their observation position. Although traffic legs for observation were determined during sample selection, specific observation positions were determined at each site based on the configuration of the intersection, the number of lanes in the designated traffic leg, whether there was a median and/or designated turn lanes in the designated traffic leg, and the number of observers at the site.

Observers were instructed to observe no more than two lanes out from the curb for safety belt use, recording data for one lane at a time and dividing their time evenly between lanes. At sites with more than two lanes and a median, observations were made from the median for lanes beyond the first and second lanes out from the curb. If there was a designated turn lane in the traffic leg being observed, observers moved back to a point before the turn lane began so that they could observe cars before they moved into the turn lane. This procedure helped to maximize the number of cars observed in the designated traffic leg. At sites visited by two-person teams that had designated traffic legs with multiple lanes, team members observed different lanes of the same traffic leg (either standing side by side if there were no more than two lanes, or with one observer on the curb and one observer on the median if there were more than two lanes and a median). Observation time was split evenly between lanes.

At some sites visited by two-person teams, the designated traffic leg contained only one lane of traffic. When this occurred at a local intersection, the first team member observed the designated traffic leg and the second team member moved across the intersection to observe traffic traveling on the same road but in the opposite direction. Similarly, at a freeway exit ramp with only one lane, the second team member moved to the opposite ramp at the exit to observe traffic exiting the same freeway but from the opposite direction.

At each site, observers conducted a five-minute count of all passenger cars on the designated traffic leg before beginning safety belt and helmet use observations. Observations began immediately after completion of the count and continued for 50 minutes at sites with one observer and 25 minutes at sites with two observers. During the observation period, observers recorded data for as many cars as they could observe. If traffic flow was heavy, observers were instructed to record data for the first car they saw and then look up and record data for the next car they saw, continuing this process for the remainder of the observation period. At the end of the observation period, a second five-minute passenger car count was conducted at single-observer sites (so that time spent at single-observer sites totaled one hour compared to one half hour at two-observer sites).

Because of the relatively low volume of motorcycle traffic, motorcycle helmet observations were not limited to the lanes designated for safety belt observations except at Detroit sites where the presence of two observers might have resulted in recording the same motorcycle more than once. At sites with a single observer, motorcycles on all traffic legs in the intersection were observed. Observers at all sites were instructed to record data only for motorcycles. Mopeds and motorscooters were excluded from observations because they do not qualify as motorcycles under the Michigan helmet law.

Observer Training

Prior to data collection, field observers participated in three days of intensive training including both classroom review of data collection procedures and practice field observations. Each observer received a training manual containing detailed information on field procedures for observations, data collection forms, and administrative policies and procedures. Included in the manual was a listing of the sites for the study (see Appendix B) that identified the location of each site and the traffic leg to be observed, as well as a site schedule identifying the date and time each site was to be observed.

After intensive review of the manual, observers conducted practice observations at several sites chosen to represent the types of sites and situations that would actually be encountered in the field. None of these practice sites were the same as sites observed during the study. Training at each practice site focused on completing the site description form, determining where to stand and which lanes to observe, conducting the passenger car count, and recording safety belt and helmet use on the observation form. Observers worked in teams of two, observing the same passenger cars, but recording data independently on separate data collection forms. Teams were rotated throughout the training to ensure that each observer was paired with every other observer at least twice. Each observer pair practiced recording safety belt and helmet use until there was an inter-observer reliability of at least 85 percent for both observed drivers and front-right passengers for each pair of observers.

On the final day of training, each observer was provided with an atlas of Michigan county maps and all necessary field supplies. Observers were given time to mark their assigned sites on the appropriate maps and plan travel routes to the sites. After marking the sites on their maps, the marked locations were compared to a master map to ensure that the correct sites had been pinpointed. Field procedures were reviewed for the final time and observers were informed that unannounced site visits would be made by the field supervisor during data collection to ensure adherence to study protocols.

Observer Supervision and Monitoring

During data collection, each observer was spot checked in the field on at least two occasions by the field supervisor. Contact between the field supervisor and field staff was also maintained on a regular basis through staff visits to the UMTRI office to drop off completed forms and through telephone calls from staff to report progress and discuss problems encountered in the field. Field staff were instructed to call the field supervisor at home if problems arose during evening hours or on weekends.

Incoming data forms were examined by the field supervisor and problems (e.g., missing data, discrepancies between the site description form and site listing or schedule) were noted and discussed with field staff. Attention was also given to comments on the site description form about site-specific characteristics that might affect future surveys (e.g., traffic flow patterns, traffic control devices, site access).

Data Processing and Estimation Procedures

The site and data collection forms were keypunched into an electronic format. The accuracy of the data entry was verified in two ways. First, all data were keypunched twice and the data sets were compared for consistency. Second, the data from randomly selected sites were reviewed for accuracy by a second party and all site data were checked for inconsistent codes (e.g., the observation end time occurring before the start time). Errors were corrected after consultation with the original data forms.

Computer analysis programs tallied the number of cars, drivers, passengers, belted drivers, and belted passengers for each site. This information was combined with the site information to create a file used for generating study results. A similar procedure was followed for the motorcycle helmet data.

As mentioned earlier, our goal in this safety belt survey was to estimate belt use for the state of Michigan based on VMT. As also discussed, the self-weighting-by-VMT scheme employed is limited by the number of cars for which an observer can accurately record information. To correct for this limitation, the vehicle count information was used to weight the observed traffic volumes so they would more accurately reflect VMT at the high-volume and multiple-lane sites. This weighting was done by first adding each of the five-minute counts and then multiplying this number by five so that it would represent a 50-minute duration.[6] The resulting number was the estimated number of vehicles passing the site if all passenger cars had been included in the survey during the observation period at that site. The estimated count then was divided by the actual vehicle count to obtain a VMT weighting factor for that site. This weighting factor was multiplied by the actual counts at the site, yielding a weighted N for the number of total drivers and passengers and total number of belted drivers and belted passengers. Unless otherwise indicated, all analyses reported are based upon the weighted values.

The overall estimate of belt use per VMT in Michigan was determined by first calculating the belt use rate within each stratum using the following formula:

$$r_i = \frac{TotalNumberofBeltedOccupants, weighted}{TotalNumberofOccupants, weighted}$$

[6] As mentioned previously, the Detroit sites were visited by pairs of observers for half as long. For these sites, the single five-minute count was multiplied by five to represent the 25-minute observation period.

where r_i refers to the belt use rate for any of the four strata, the totals are the sums across all 42 sites within the stratum after weighting, and occupants refers to only front outboard occupants. The overall estimate of belt use was computed by averaging the belt use rates for each stratum. However, comparing total VMT among the strata one finds that the Wayne County stratum is only 88 percent as large as the total VMT for the other three strata (see Table 1). In order to accurately represent safety belt use for Michigan by VMT, the Wayne County stratum was multiplied by 0.88 during the averaging to correct for its lower total VMT. The overall belt use rate was determined by the following formula:

$$r_{all} = \frac{r_1 + r_2 + r_3 + (0.88 * r_4)}{3.88}$$

where r_i is the belt use rate within each stratum and r_4 is the Wayne County stratum.

The estimates of variance and the calculation of the confidence bands for the belt use estimates are complex. See Appendix C for a detailed description of the formulas and procedures.

RESULTS

The current direct observation survey of safety belt and helmet use in Michigan reflects a complete departure from the sample, methods, and weighting schemes used in all of the previous survey waves in this series. This departure occurred in order to reduce the cost of the sample design and to comply with new guidelines for measuring safety belt use issued by the United States Department of Transportation. The guidelines, authorized by Section 153 of Title 23, United States Code, are intended to ensure accurate and representative safety belt measurements by states (National Highway Traffic Safety Administration, 1992). States must comply with these guidelines to be eligible for grant funds authorized by Section 153 through a three-year grant program. To qualify for first-year funding, states must have in effect both a law requiring motorcycle riders to wear helmets and a law requiring front-seat occupants of passenger vehicles to use safety belts or be secured in child passenger safety systems. Funding criteria in the second and third years include compliance rate requirements, as well. As a result of the changes made in the present survey, care should be taken when comparing the results to previous reports in this series because changes in belt use rates could have resulted from changes in the survey.

Overall Safety Belt Use

A total of 64.4 ± 2.1 percent of all front outboard occupants traveling in passenger cars during September 1993 were restrained with shoulder belts (Figure 2). The "±" value following the use rate indicates a 95 percent confidence band around the percentage. This value should be interpreted to mean that we are 95 percent sure that the actual safety belt use rate falls somewhere between 62.3 percent and 66.5 percent.

Front Outboard Shoulder Belt Use
in Passenger Cars

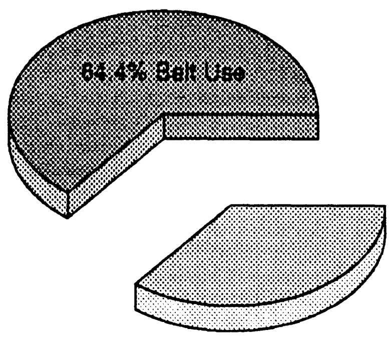

Figure 2

Estimated belt use rates and unweighted Ns for individual strata are shown in Table 3. The stratum estimates show that belt use patterns during September 1993 followed the historical trends; that is, the high belt use stratum had the highest belt use in the present survey, and so on. The Wayne County stratum (Number 4) had a low overall belt use rate compared to the other three strata. While the 55.4 percent belt use rate for Wayne County represents an impressive increase from previous years, this finding suggests that statewide efforts to increase safety belt use might be most effective if concentrated in the Wayne County area.

Table 3. Percent Shoulder Belt Use by Stratum

	Percent Use	Unweighted N
Stratum 1	72.2	4,473
Stratum 2	67.9	2,054
Stratum 3	61.0	1,866
Stratum 4	55.4	9,326
STATE OF MICHIGAN	64.4	17,719

Safety Belt Use by Subgroup

Site Type. Estimated safety belt use by type of site is presented in Table 4. Occupants observed at freeway exit ramps showed slightly higher safety belt use rates than occupants observed at local intersections (66.3 percent and 63.5 percent). This is consistent with the findings of all previous survey waves and shows that occupants of passenger cars use restraint devices slightly more often when they are traveling on freeways.

Time of Day. Estimated safety belt use by time of day is shown in Table 4. Note that these data were collected only during daylight hours. While there were differences between time periods, no systematic trends were evident.

Day of Week. Estimated safety belt use by the day of week is shown in Table 4. Note that the survey was conducted over a three-week period that included Labor Day. Belt use clearly varied from day to day, but no systematic trends were evident.

Weather Conditions. Estimated safety belt use by weather condition is shown in Table 4. The results indicated little difference in belt use between the different weather conditions.

Table 4. Percent Shoulder Belt Use by Subgroup		
	Percent Use	Unweighted N
Site Type		
Intersection	63.5	12,963
Freeway exit	66.3	4,756
Time of Day		
7-9 AM	73.8	2,097
9-11 AM	66.0	1,918
11-1 AM	63.9	3,108
1-3 AM	61.4	3,892
3-5 PM	61.8	4,332
5-7 PM	63.6	2,372
Day of Week		
Monday	65.0	3,465
Tuesday	56.3	1,895
Wednesday	52.3	571
Thursday	63.2	3,288
Friday	59.3	4,896
Saturday	62.0	1,328
Sunday	53.5	2,276
Weather Condition		
Sunny	65.9	7,621
Cloudy	65.7	5,121
Rainy	59.4	4,977
Total		17,719

Overall Helmet Use

A secondary goal of this survey was to determine the frequency of helmet use for motorcycle riders in Michigan. Because the sampling design was not specifically intended for use in estimating helmet use, and because the density of motorcycles is so low, the estimates of helmet use do not include the weighting factors used in the safety belt estimate. Table 5 shows the number of observed drivers and passengers and the estimate of helmet use for these populations separately and combined. As can be seen in Table 5, of the 177 total motorcycle riders observed, only one driver was observed without a helmet. These impressive results show that Michigan's helmet law and the enforcement of this law are effective in promoting helmet use.

Table 5. Motorcycle Helmet Use			
Seating Position	Helmet Worn	Helmet Not Worn	Total
Driver	99.3% n=149	n=1	n=150
Passenger	100% n=27	n=0	n=27
Total	99.4% n=176	n=1	n=177

DISCUSSION

The estimated statewide belt use rate for front outboard occupants of passenger cars was 64.4 ± 2.1 percent. This overall belt use rate represents a higher use rate than in any of the previous 14 UMTRI surveys.[7] It also shows that about 13 percent more front outboard occupants of passenger cars were using shoulder restraints than fifteen months earlier.

Besides the unknown effect of the methodological and sample changes in the present survey, there are at least two possible reasons for this impressive increase in statewide shoulder belt use. One is the increasing presence of passenger cars with automatic restraint systems. Federal regulations stipulate that all 1990 model year and newer passenger vehicles must have automatic restraint systems installed (air bags or safety belts). There is consistent evidence that shows higher use rates for occupants in vehicles equipped with automatic shoulder restraint systems than those with manual systems (e.g., Streff, Molnar, and Christoff, 1993; Williams, Wells, Lund, and Teed, 1992). Another reason, and perhaps the most important reason, for the increased belt use discovered in the present study are the safety belt enforcement efforts and accompanying public information and education (PI&E) programs that have been conducted statewide by the Michigan State Police Office of Highway Safety Planning, as well as by various local programs promoting safety belt use. Several studies have shown that safety belt use can be increased by a strong enforcement program coupled with broad publicity of the program (e.g., Organization for Economic Cooperation and Development, 1986; Williams, Lund, Preusser, and Bloomberg, 1987; Jonah, Dawson, and Smith, 1982). These increases can occur quite rapidly. For example, in one study conducted in Ottawa, Ontario, the belt use rate increased from 58 percent to 80 percent during the one-month enforcement and PI&E program (Jonah, Dawson, and Smith, 1982). However, in this same study, the belt use rate gradually declined after the program ended, dropping to 77 percent after one month and 70 percent after six months. Findings of similar declines in belt use rates are common (e.g., Streff, Molnar, and Christoff, 1993; Williams et al., 1987). Taken together, these results suggest that Michigan's belt use rate is likely to decline unless the enforcement and accompanying PI&E programs are continued.

The 64.4 percent statewide belt use rate is a positive sign for the traffic safety efforts in Michigan. However, a national goal of 75 percent belt use has been set for 1997. In order to reach this goal, we must redouble our efforts to increase safety belt use. One activity that could

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[7] It is important to keep in mind that there were many methodological and sample changes between the present survey and all previous surveys. These changes should cause a change in the belt use rate; however, without further studies, the nature of these changes cannot be determined.

be effective in increasing safety belt use would be to change the specific provisions of Michigan's safety belt law. Specifically, compliance with Michigan's safety belt law would be facilitated if the law permitted primary enforcement. Findings from a study by Campbell (1987), as well as our own calculations, indicate that statewide belt use rates are higher in states with primary enforcement than in states with secondary enforcement. Further support for this claim comes from California, where primary enforcement recently has been implemented. Preliminary estimates show an increase in belt use as high as 20 percentage points in the first months of primary enforcement (Michaels, 1993).

Even without such new legislation, stricter enforcement of the current law, coupled with major publicity campaigns, can be effective in increasing belt use. Issuing safety belt citations regularly to motorists being cited for another violation can be particularly effective in increasing safety belt use, because traffic law offenders are less likely to use safety belts than nonoffenders (Evans, 1991). Thus, even with secondary enforcement, police have many opportunities to affect the segment of the population at greatest risk for nonuse. It is important to remember, however, that many police officers perceive significant disincentives for issuing secondary belt citations. Consideration should be given to including incentives for officers and their commanders in programs targeting increased belt law enforcement.

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APPENDIX A

Data Collection Forms

SITE DESCRIPTION

SITE # __ __ __ SITE LOCATION______________________________
1 2 3

SITE TYPE: 1☐ Intersection
2☐ Freeway
4

SITE CHOICE: 1☐ Primary
2☐ Alternate
5

TRAFFIC CONTROL:
1☐ Traffic Light
2☐ Stop sign
3☐ None
4☐ Other ______________
6

DATE (month/day): __ __/__ __/1993
7 8 9 10

OBSERVER
01☐ Bill
02☐ John
03☐ Stephan
04☐ Bob
10

DAY OF WEEK
1☐ Monday
2☐ Tuesday
3☐ Wednesday
4☐ Thursday
5☐ Friday
6☐ Saturday
7☐ Sunday
12

WEATHER
1☐ Mostly Sunny
2☐ Mostly Cloudy
3☐ Rain
4☐ Snow
13

START TIME: __ __:__ __ (24 hour clock)
14 15 16 17

END TIME: __ __:__ __ (24 hr clock)
18 19 20 21

BREAK TIME (total number of minutes during observation period): __ __
22 23

Number of Lanes:

In traffic leg ______

Observed ______
24

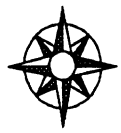
Median: 1☐ Yes
2☐ No
25

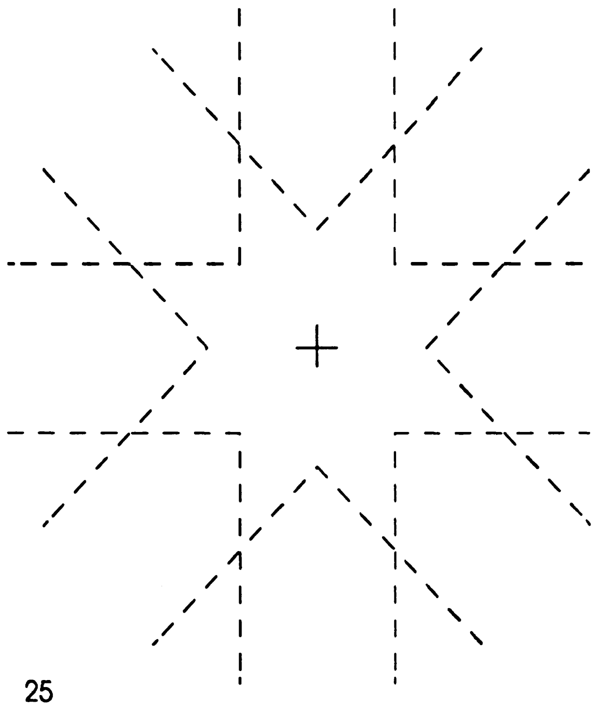
Traffic Count 1: ______

Traffic Count 2: ______

COMMENTS:

North





SITE #______________

Driver		Front-Right Passenger		
Belted	Not Belted	None	Belted	Not Belted

Driver		Front-Right Passenger		
Belted	Not Belted	None	Belted	Not Belted

Driver		Passenger		
Helmet	No Helmet	None	Helmet	No Helmet

Driver		Passenger		
Helmet	No Helmet	None	Helmet	No Helmet

APPENDIX B

Site Listing

Num	County	Primary Site Location	Alternate Site Location
54	Allegan	NB 62nd St. & 102nd Ave.	SB 52nd St. & 103rd Ave.
50	Allegan	WB 144th Ave. & 2nd St.	WB 142nd Ave. & 14th St.
47	Allegan	SB 6th St. & St. Hyw. 89	SB 7th St. & 109th Ave.
58	Allegan	NB 66th St. & 113th Ave.	WB 124th Ave. & 58th St.
84	Allegan	NBL US-31 & 58th St.	NBL US-31 & Washington Rd.
73	Allegan	EB 126th Ave. & 66th St.	EB 136th Ave. & 52nd St.
69	Allegan	WB 129th Ave. & 8th St.	EB 135th Ave. & 12th St.
44	Bay	NB Burns Rd. & Nebodish Rd.	SB Bangor Rd. & Marquette Ave.
61	Bay	NB 9 Mile Rd. & Seidlers Rd.	WB Prevo Rd. & Fraser Rd.
80	Bay	NBR I-75 & Wilder Rd.	SBL I-75 & Beaver Rd.
72	Bay	EB Cass Rd. & Farley Rd.	SB Madison Ave. & Youngs Ditch Rd.
74	Bay	NB Mackinaw Rd. & Mt. Forest Rd.	NB Seven Mile Rd. & Newburg Rd.
115	Berrien	WB Glenlord Ave & St. Hwy. 33	NB Kirk Rd. & Shanghai
120	Berrien	SBR I-94 & St. Hwy. 31	NBR I-94 & Pipestone Rd.
96	Berrien	EB Coloma Rd. & Kerlikowski Rd.	SB Yore Ave. & Meadowbrook Rd.
106	Berrien	WB GlenLord Rd. & Lincoln Ave.	NB Riverview Rd. & Brittan Ave.
103	Calhoun	SEB Michigan Ave. & 28 Mile Rd	WB M Dr. N & 21.5 Mile Rd.
88	Calhoun	NB 23 Mile Rd. & L Dr. N.	WB V Dr. N. & Old US 23
56	Eaton	SEB Kinneyville Rd. & Houston Rd.	SB Royston Rd. & Five Point Hwy.
63	Eaton	NB Ionia Rd. & Bismark Hyw.	NB Dow Rd. & Eaton Hwy.
68	Eaton	EB Five Point Hwy. & Pease Rd.	NB Stine Rd. & Kinsel Hwy.
70	Eaton	EB St. Hwy. 43 & Gates Rd.	NB Dow Rd. & St. Hwy. 50
97	Genesee	WB Hegal Rd. & Hendersen Rd.	WB Bristol Rd. & Atlas Rd.
85	Genesee	SB Van Slyke Rd. & Maple Ave	EB Hill Rd & Center Rd.
60	Grn Traverse	EB Riley Rd. & St. Hwy 137	WB St. Hwy. 113 & Hannah Rd.
59	Grn Traverse	NB Silver Lk. Rd. & Boone Rd.	EB Cedar Run Rd. & Barney Rd.
25	Ingham	WB Fitchburg Rd. & Haynes Rd.	NEB Kirby Rd. & Race Rd.
8	Ingham	SB Searles Rd. & Iosco Rd.	EB Grand Riv. Rd. & Elm Rd.
15	Ingham	EB Haslett Rd. & Marsh Rd.	EB Bell Oak Rd. & Morrice Rd.
12	Ingham	NB Shaftsburg Rd. & Haslett Rd.	EB Rowley Rd. & Webberville Rd.
75	Jackson	EBR I-94 & US-127	EBL US-127 & Country Farm Rd.
66	Jackson	SWB Horton Rd. & Park Rd.	NB Chapel Rd. & Michigan Ave.
52	Jackson	NB Mt. Hope Rd. & Waterloo-Munith Rd.	SB Coon Hill Rd. & Kennedy Rd.
46	Jackson	SB Benton Rd. & Brooklyn Rd.	SB Meridian Rd. & White Rd.
83	Jackson	WBR I-94 & Sargent Rd.	WBL I-94 & Mt. Hope Rd.
32	Kalamazoo	EB T Ave & 27th St.	EB RS Ave. & 26th St.
2	Kalamazoo	EB S. Ave. & 32nd St.	NB 34th St. & V Ave.
18	Kalamazoo	SB 8th St. & Texas Dr.	WB Centre Ave. & Cox's Dr.
9	Kalamazoo	WB D Ave. & Riverview Dr.	EB DE Ave. & 32nd St.

Num	County	Primary Site Location	Alternate Site Location
21	Kalamazoo	NEB Ravine Rd. & Owen Dr.	NB Westnedge Ave & F Ave.
31	Kalamazoo	EB H Ave. & 3rd St.	WB G Ave. & 7th St.
28	Kalamazoo	SB Douglas & C Ave.	NB 5th St. & D Ave.
37	Kalamazoo	EBL I-94 & Portage Rd.	EBR I-94 & Westnedge Ave.
35	Kalamazoo	SBL US-131 & St. Hwy. 43	SBL US-131 & Stadium Dr.
39	Kalamazoo	WBL I-94 & 9th St.	WBL I-94 & US-131
41	Kalamazoo	NBL US-131 & W Ave.	SBL US-131 & VW Ave.
42	Kalamazoo	NBR US-131 & YZ Ave.	SBL US-131 & XY Ave.
76	Kent	NBR US-131 & 100th St.	NBL US-131 & 84th St.
53	Kent	WB Cascade Rd. & Quiggle Ave.	WB 68th St. & & Cherry Valley Ave.
55	Kent	NB Sorenson Rd. & Maston Lk. Rd.	NB Myers Ave. & 15 Mile Rd.
62	Kent	SB Ramsdell Dr. & Swem St.	NB Lincoln Lk. Rd & 18 Mile Rd.
48	Kent	EB 36th St. & Snow Ave.	WB Conservation St. & Honey Crk.
78	Kent	NBL US-131 & Hall St.	SBL US-131 & Burton St.
67	Kent	SB Belmont Ave. & Rogue Riv. Dr.	EB Knapp ST. & Honey Crk. Ave.
119	Lapeeer	EBL I-69 & Lake Pleasant Rd.	WBL I-69 Five Lakes Dr.
118	Lapeer	WBR I-96 & Nepessing	WBR I-69 & Elba Rd.
98	Lapeer	SB St Hwy 53 & County 36	NB County 9 & County 17
93	Lapeer	SB Flint Riv. Rd. & Peters Rd.	NB Booth Rd. & St. Hwy. 90
116	Lenawee	NB S. Piotter Hwy & Deer Field Rd.	NWB Cemetary Rd. & Silberhorn Hwy.
90	Lenawee	WB Slee Rd. & Marr Hwy.	WB Sandy Beach Rd. & Hallenbeck Hwy.
100	Lenawee	SWB Pixley Rd & Deer Field Rd.	EB Moore Rd. & St. Hwy 52
65	Livingston	NB Old US 23 & Grand Riv. Rd.	NB Hamburg Rd. & St. Hwy. 36
49	Livingston	NB Fowlerville Rd. & & Vogt Rd.	SB Robb Rd. & Hayner Rd.
43	Livingston	WB Sexton Rd. & Country-Farm Rd.	NB Pettysville Rd. & Rush Lk. Rd.
81	Livingston	EBR I-96 & Fowlerville Rd.	EBL I-96 & Highland Rd.
51	Livingston	EB Coon Lk. Rd & Cedar Lk. Rd.	EB Swartout Rd. & Chilson Rd.
45	Macomb	SB Camp Ground Rd. & 31 Mile Rd.	EB Irwin Rd. & Capac Rd.
82	Macomb	SBL I-94 & 11 Mile Rd.	WBL I-696 & Gratiot Rd.
79	Macomb	SBL St. Hwy. 53 & 26 Mile Rd.	NBR St. Hwy. 53 & 23 Mile Rd.
57	Macomb	SB Memphis Rdg. Rd. & School Sec. Rd.	WB 32 Mile Rd & Pashalk Rd.
64	Macomb	EB 23 Mile Rd & Romeo Plank Rd.	NEB ST. Hwy. 97 & Harrington Rd.
108	Monroe	NEB Teal Rd. & Sylvania-Petersburg Rd.	EB Goetz Rd. & Lake Rd.
86	Monroe	NB Bacon Rd. & Morocco Rd.	WB St. Hwy. 223 & Sylvania-Petersburg Rd.
117	Monroe	SBR I-75 & Front St.	NBL I-75 & Plaisance Rd.
105	Monroe	EB Oakville Rd. & Carleton West Rd.	NB Grafton Rd. & Carleton-Rockwood Rd.
126	Monroe	NBL US-23 & McCarthy West Rd.	NBL US-23 & Ida Dixon Rd.
107	Muskegon	EB Meinert Rd. & Old 99 Rd.	EB Hancock Rd. & Indian Bay Rd.
123	Muskegon	NBR US-31 & St. Hwy. 46	SBL US-31 & Marquette Ave.

Num	County	Primary Site Location	Alternate Site Location
114	Muskegon	SB Riv. Rd. & Tyler Rd.	WB Ryerson Rd. & Brickyard Rd.
30	Oakland	NB Jossman Rd. & Grange Hall Rd.	NWB Groveland Rd. & Dixie Hwy.
29	Oakland	WB Walnut Lake Rd. & Haggerty Rd.	EB Grand Riv. Rd. & Taft Rd.
27	Oakland	SB Hickory Ridge Rd. & Commerce Rd.	WB Commerce Rd. & Duck Lk. Rd.
13	Oakland	NB Middlebelt Rd. & 9 Mile Rd.	SB Evergreen Rd. & 9 Mile Rd.
1	Oakland	EB Whipple LK. & Eston	EB Clarkson Rd. & Josylyn Rd.
38	Oakland	EBL I-696 & Telegraph Rd.	EBL I-696 & Orchard Lk. Rd.
6	Oakland	SB Rochester Rd. & 33 Mile Rd.	NB Townsend Rd. & Romeo Rd.
7	Oakland	SB Williams Lk. Rd. & Pontiac Lk. Rd	EB Davisburg Rd. & Bigelow Rd.
3	Oakland	SB Pontiac Trail & 10 Mile Rd.	EB 12 Mile Rd & South Hill Rd.
20	Oakland	SB Lasher Rd. & 11 Mile Rd.	EB 10 Mile Rd. & Livernois Rd.
33	Oakland	EBL I-96 & Wixom Rd.	WBR I-96 & Milford Rd.
5	Oakland	WB Drahner Rd. & Baldwin Rd.	WB Waldon Rd. & Clintonville Rd.
77	Ottawa	NBL I-196 & Byron Rd.	NBR I-196 & 32nd Ave.
71	Ottawa	WB Taylor Rd. & 72nd Ave.	SB 104th Ave. & Felch St.
99	Saginaw	NB Thomas Rd. & Swan Creek Rd.	EB Shatuck Rd. & Center Rd.
95	Saginaw	WB Rathbun Rd. & McClean Rd.	EB Birch Run & Moorish Rd.
89	Saginaw	WB Wadsworth Rd. & Portsmuth Rd.	SB Michigan Rd. & Crane Rd.
87	Saginaw	WB Baldwin Rd. & Fowler Rd.	NB Carr Rd. & Marion Rd.
111	Shiawassee	NB State Rd. & Lansing	WB Cole Rd. & Reed Rd.
113	Shiawassee	SB Geeck Rd. & Six Mile Crk. Rd	SB New Lothrup Rd. & Easton Rd.
104	St. Clair	WB Norman Rd. & Cork Rd.	WB Donald Rd. & Martin Rd.
109	St. Clair	WB Masters Rd. & St. Hwy. 19	EB Lambs Rd. & Wales Center Rd.
94	St. Joseph	NB Thomas Rd & St. Hwy. 12	WB Millers Mill Rd. & Quarterline Rd.
110	St. Joseph	SB Zinsmaster Rd. & St. Hwy. 60	NB Anglevine & River Run
125	St. Joseph	NBL US-131 & St. Hwy. 60	SBL US-131 & Millard Rd.
121	Van Buren	EBL I-94 & 64th St.	EBR I-94 & County 365
112	Van Buren	EB Celery Ctr. & County 215	SB 39th St. & 72nd Ave.
122	Van Buren	EBR I-94 & County 652	WBR I-94 & St. Hwy. 40
91	Van Buren	WB 36th Ave & St. Hwy. 40	NEB Red Arrow Hwy. & County 657
102	Van Buren	WB County 374 & Red Arrow Hyw.	EB 40th Ave & 52nd St.
101	Van Buren	NB County 665 & County 358	EB 46th Ave & St. Hwy 40
124	Van Buren	NBR I-196 & St. Hwy 140	SBL I-196 & County 378
92	Van Buren	EB 63rd Ave & 26th St.	NB County 657 & County 358
16	Washtenaw	NB Jordan Rd. & Willow Rd.	NB Stoney Crk. & Day Rd.
22	Washtenaw	EB Glacier Rd. & Fuller Rd.	SB Main Rd. & Stadium Blvd.
19	Washtenaw	WB 8 Mile Rd. & Chubb Rd.	NB Pontiac Tr. & 6 Mile Rd.
17	Washtenaw	SB St. Hwy. 52 & Werkner Rd	EB Scio Church Rd. & Fletcher Rd.
4	Washtenaw	EB Bethel Church Rd. & Alber Rd.	SB Moon Rd. & Ann-Arbor Saline Rd.

Num	County	Primary Site Location	Alternate Site Location
26	Washtenaw	EB Merritt Rd. & Stoney Crk. Rd.	SB Ridge Rd. & Mott Rd.
10	Washtenaw	EB N. Territorial Rd. & Huron Riv. Dr.	SB Jennings Rd. & N. Territorial Rd.
24	Washtenaw	SB Platt Rd. & Willis Rd.	WB Textile Rd. & Maple Rd.
11	Washtenaw	NB Schleeweis Rd. & Sandborn Rd.	SB Sharon Rd. & Ely Rd.
14	Washtenaw	WB Packard Rd. & Carpenter Rd.	NB Newport Rd. & Miller Rd.
36	Washtenaw	SBR US-23 & N. Territorial Rd.	NBL US-23 & Whitmore Lk. Rd.
40	Washtenaw	EBR I-94 & Washtenaw Rd.	EBR I-94 & Ann Arbor-Saline Rd.
34	Washtenaw	WBR I-94 & Grove Rd.	WBL I-94 & Whittaker Rd.
23	Washtenaw	EB Bethel Church Rd. & Lima Center Rd.	SB Clinton Rd. & Austin Rd.
154	Wayne	WB Annapolis Rd. & Inkster Rd.	SB Vining Rd. & West Rd.
153	Wayne	NEB Mack Rd. & Moross Rd.	EB 7 Mile Rd. & Mound Rd.
155	Wayne	SB Greenfield Rd. & Grand River Rd.	EB McNichols Rd. & Wyoming Ave.
157	Wayne	SEB Conner Ave. & Gratoit Rd.	EB Michigan Ave & W. Grand Blvd.
156	Wayne	EB Joy Rd. & Livernois Rd.	SB Schaefer Rd. & Schoolcraft Rd.
149	Wayne	WB 8 Mile Rd & Kelly Rd.	NEB Jefferson Rd. & Whittier Rd.
148	Wayne	EB Goddard Rd. & Wayne Rd.	NB Howe Rd. & Annapolis Rd.
150	Wayne	SB Merriman Rd. & Michigan Ave.	EB Cherry Hill Rd. & John Hix Rd.
152	Wayne	WB Sibley Rd. & Beech-Daly Rd.	SB Grosse Ile Pkwy & Meridian Rd.
151	Wayne	SB Telegraph Rd. & Plymouth Rd.	WB Oakwood Rd. & Schaeffer Rd.
165	Wayne	WBR US-10 & Livernois Rd.	EBL US-10 & Wyoming Ave.
164	Wayne	WBR I-96 & Livernois Rd.	WBL I-96 & W. Grand Riv. Rd.
166	Wayne	NBL I-75 & ST. Hwy. 3	SBL I-75 & Clark Rd.
168	Wayne	SBR I-75 & Pennsylvania Rd.	NBL I-75 & Sibley Rd.
167	Wayne	WBR I-94 & Telegraph Rd.	EBR I-94 & Ecorse Rd.
160	Wayne	EBR I-94 & Rotunda Dr.	EBR I-94 & Michigan Ave.
158	Wayne	NWB Grand River Rd. & Wyoming Ave.	NEB Rotunda Dr. & Oakwood Rd.
161	Wayne	WBR I-96 & Inkster Rd.	WBR I-96 & Beech-Daly Rd.
163	Wayne	NBR I-275 & 6 Mile Rd.	NBL I-275 & 7 Mile Rd.
162	Wayne	NBR I-75 & Outer Drive	SBL I-75 & Southfield Rd.
147	Wayne	SB Biddle Ave. & Southfield Rd.	SB Warren Rd. & Evergreen Rd.
133	Wayne	EB Ecorse Rd. & Middlebelt Rd	SB Otter Rd. & Judd Rd.
132	Wayne	EB Michigan Ave. & Geddes Rd.	WB Palmer Rd. & Lilley Rd.
134	Wayne	NB ST. Hwy. 85 & Emmons Rd.	EB Wick Rd. & Morten View Rd.
136	Wayne	NB Haggerty Rd. & 7 Mile Rd.	WB Ford Rd. & Ridge Rd.
135	Wayne	WB Glenwood Rd. & Wayne Rd.	WB Joy Rd. & Middlebelt Rd.
128	Wayne	EB Warren Rd. & Wayne Rd.	NB Newburgh Rd. & Warren Rd.
127	Wayne	WB Eight Mile Rd. & Garfield Rd.	SB Warren Rd. & Canton Center Rd.
129	Wayne	NEB McGraw Rd. & Livernois Rd.	EB McNichols Rd. & Woodward Ave.
131	Wayne	WB Ecorse Rd. & Telegraph Rd.	WB Palmer Rd. & Venoy Rd.

Num	County	Primary Site Location	Alternate Site Location
130	Wayne	NEB Canton Center Rd. & Cherry Hill Rd.	NB Huron River Dr. & Goddard
143	Wayne	NEB Vernor Rd. & Gratiot Rd.	SEB Woodward Rd. & Caniff Rd.
142	Wayne	WB Ford Rd. & Venoy Rd.	SB Shelden Rd. & 6 Mile Rd.
144	Wayne	WB 5 Mile Rd. & Beck Rd.	WB Plymouth Rd. & Wayne Rd.
146	Wayne	NEB Mack Rd. & Chalmers Rd.	NB Hoover Rd. & McNichols Rd.
145	Wayne	EB 7 Mile Rd. & Livernois Rd.	NWB Dexter Rd. & Chicago Rd.
141	Wayne	NB E. Riv. Rd. & Island Dr.	EB Eureka Rd. & St. Hyw. 85
138	Wayne	WB Eureka Rd. & Vining Rd.	SB Inkster Rd. & Goddard Rd.
137	Wayne	WB 6 Mile Rd. & Inkster Rd.	EB 8 Mile Rd. & Evergreen Rd.
140	Wayne	SEB Outer Dr. & Pelham Rd.	WB Joy Rd. & Greenfield Rd.
139	Wayne	NB Middlebelt Rd. & Edward N. Hines Dr.	SB Merriman Rd. & Cherry Hill Rd.
159	Wayne	WBR I-96 & Wyoming Ave.	WBL I-96 & Evergreen Rd.

APPENDIX C

Calculation of Variances, Confidence Bands, and Relative Error

Calculation of Variances, Confidence Bands, and Relative Error

The variances for the belt use estimates were calculated using an equation derived from Cochran's (1977) equation 11.30 from section 11.8. The resulting formula was:

$$var(r) \approx \frac{n}{n-1}\sum_i \left(\frac{g_i}{\Sigma g_k}\right)^2 (r_i - r)^2 + \frac{n}{N}\sum_i \left(\frac{g_i}{\Sigma g_k}\right)^2 \frac{s_i^2}{g_i}$$

where $var(r_i)$ equals the variance within a stratum, n is the number of observed intersections, g_i is the weighted number of passenger car occupants at intersection i, g_k is the total weighted number of passenger car occupants at all 42 sites within the stratum, r_i is the weighted belt use rate at intersection i, r is the stratum belt use rate, N is the total number of intersections within a stratum, and $s_i = r_i(1-r_i)$. In the actual calculation of the stratum variances, the second term of this equation is negligible. If we conservatively estimate N to be 2000, the second term only adds 2.1 x 10^{-6} units to the largest variance (Stratum 4). This additional variance does not significantly add to the variance captured in the first term. Therefore, since N was not known exactly, the second term was dropped in the variance calculations. The overall estimated variance was calculated using the formula:

$$var(r_{all}) = \frac{var(r_1) + var(r_2) + var(r_3) + 0.88^2 \times var(r_4)}{3.88^2}$$

The Wayne County stratum variance was multiplied by 0.88 to account for the similar weighting that was done to estimate overall belt use. The 95 percent confidence bands were calculated using the formula:

$$95\%\,ConfidenceBand = r_{all} \pm 1.96 \times \sqrt{Variance}$$

where r is the belt use of interest. This formula is used for the calculation of confidence bands for each stratum and for the overall belt use estimate.

Finally, the relative error or precision of the estimate was computed using the formula:

$$RelativeError = \frac{StandardError}{r_{all}}$$

The federal guidelines (NHTSA, 1992) stipulate that the relative error of the belt use estimate must be under 5 percent.