UMTRI-2005-27

Direct Observation of Safety Belt Use in Michigan: Fall 2005

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16. Abstract

A direct observation survey of safety belt use in Michigan was conducted in the fall of 2005. In this study, 13,677 occupants traveling in four vehicle types (passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks) were surveyed between September 1 and 16, 2005. Belt use was estimated for all commercial/noncommercial vehicle types combined (the statewide safety belt use rate) and separately for each vehicle type. The current survey was designed to provide data for comparison with surveys conducted in previous years. Within and across each vehicle type, belt use by age, sex, road type, day of week, time of day, and seating position were calculated. Statewide belt use was 87.9 percent. Safety belt use was 90.3 percent for passenger cars, 86.8 percent for sport-utility vehicles, 88.1 percent for vans/minivans, and 82.2 percent for pickup trucks. For all vehicle types combined, belt use was higher for females than for males. In general, belt use was the highest during the morning commute and about the same throughout the rest of the day. Belt use did not vary systematically by day of week. Belt use was lowest among 16-to-29 year olds, and highest for the 60-and-older age group.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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INTRODUCTION

Motor vehicle injuries and fatalities continue to be a major health concern both at the national and state level. Motor vehicle traffic crashes account for a considerable proportion of all fatalities due to unintentional injury. In fact, the National Highway Traffic Safety Administration (NHSTA) reports that in 2002 motor vehicle traffic crashes were the leading cause of death for people age 3 through 33 (Subramanian, 2005). For these ages, traffic crashes were responsible for 24.7 percent of all unintentional deaths. Preliminary data based on the Fatality Analysis Reporting System (FARS) shows that motor vehicle crashes resulted in 42,636 fatalities and 2,788,000 injuries in 2004 (NHTSA, 2005a). Proper use of a safety belt reduces the risk of fatal injury to front seat passenger car occupants by 45 percent, and the risk of moderate to critical injury by 50 percent (NHTSA, 2005c). Though modern technology has provided motorists with effective occupant protection devices that can greatly reduce the number of deaths and injuries that result from vehicle crashes, it is reported that 55 percent of those killed in passenger vehicles were not wearing safety belts (NHTSA, 2005a).

As of March 2005, 21 states and the District of Columbia have primary safety belt laws. Primary safety belt laws allow police officers to pull over a motorist and issue a citation exclusively for failure to wear a safety belt. Studies show that a state's safety belt use has markedly increased after upgrading from secondary to primary enforcement (see e.g. Eby & Vivoda, 2001). In 2004, the average safety belt use rate in states with a primary enforcement law was 11 percentage points higher than in states without primary enforcement laws. Safety belt use was 84 percent in primary law states versus 73 percent in states without primary enforcement (Glassbrenner, 2004a). Michigan has required the use of safety belts by front seat occupants of motor vehicles since 1985 and has allowed primary enforcement of this law since 2000. In addition to the standard enforcement provision, in 2000 Michigan also upgraded the child passenger portion of the law so that all children under 4 years of age must be in a federally approved child restraint device. The Michigan Vehicle Code also states that children 4-to-15 years of age must be properly restrained by a safety belt in all seating positions.

Safety belt use in Michigan has gradually increased since the mandatory safety belt law was introduced in 1985. By the end of the 1990s, safety belt use in Michigan had reached a plateau at around 70 percent. Following the implementation of standard enforcement, Michigan's safety belt use rate saw a net increase of about ten percentage points, resulting in a statewide belt use rate of approximately 80 percent (Eby & Vivoda, 2001). The goal for Michigan's belt use was to achieve 90 percent by the end of 2004 (Michigan Office of Highway Safety Planning, OHSP, 2004). In September 2004, Michigan accomplished this feat by attaining a statewide safety belt use rate of 90.5 percent. In doing so, Michigan became only the fifth state in the nation to achieve a belt use rate at or above 90 percent. Michigan was also the first state east of California to accomplish this goal, with the only others states being California, Hawaii, Washington, and Oregon. To add to this success, another milestone was also reached nationally. During 2004, safety belt use increased to a record 80 percent across the nation. Although this was only an increase of 1 percentage point since 2003, it is estimated that every percentage point increase in safety belt use yields an additional 270 lives saved each year (NHTSA, 2005b). According to NHTSA, 27 states had decreases in the absolute number of fatalities between 2003 and 2004. Michigan ranked second in the nation with a decrease of 124 fatalities from motor vehicle crashes. Despite the marked decrease in fatalities, there were still 1,159 people killed in car crashes in Michigan (OHSP, 2005a).

Strong occupant protection laws coupled with high visibility enforcement campaigns are the most effective ways to increase safety belt use (NHTSA, 2004). The *Click It or Ticket* (CIOT) campaign is one of the most recognized programs aimed at increasing safety belt use in the nation. In Michigan, *Buckle Up or Pay Up* was added to the CIOT slogan to reinforce the fact that a monetary loss will be incurred for failure to wear a safety belt. The fine for not complying with the safety belt law is $25, plus court costs and surcharges (Glassbrenner, 2004b). During the 2005 Labor Day holiday weekend, 3,406 citations were issued to motorists over the age of 15 for failure to wear a safety belt (OHSP, 2005b). This translates to $85,150 strictly for fines and does not include court fees. The last safety belt mobilization in Michigan was conducted between May 23 and June 5, but law enforcement officials continue to maintain their zero-tolerance policy when motorists fail to buckle-up.

Reaching 90.5 percent belt use was a great achievement for Michigan. Despite significant efforts aimed at increasing belt use on the statewide level, there are still hundreds of thousands of people that do not buckle-up. While the improvement noted in the past year is encouraging, it is necessary for safety belt programs to continue. It is also important for public awareness to be maintained in order for the number of fatalities and injuries due to motor vehicle crashes to be reduced.

The purpose of the current study is to determine the level of compliance with the state's mandatory safety belt use law and to continue to track changes in safety belt use rates. Each year since 1984, the University of Michigan Transportation Research Institute (UMTRI) has conducted a survey of safety belt use centered around the Labor Day holiday weekend. The present survey is a continuation of that longitudinal project and represents the thirty-ninth wave in this series. As such, data from the current study will provide another point of analysis to compare with the previous surveys conducted by UMTRI over the last twenty-one years.

METHODS

Sample Design

The sample design for the present survey was closely based upon the one used by Streff, Eby, Molnar, Joksch, and Wallace (1993). While the entire sampling procedure is presented in the previous report, it is repeated here for completeness, with modifications noted.

The goal of this sample design was to select observation sites that accurately represent front-outboard vehicle occupants in eligible commercial and noncommercial vehicles (i.e., passenger cars, vans/minivans, sport-utility vehicles, and pickup trucks) in Michigan, while following federal guidelines for safety belt survey design (NHTSA, 1992, 1998). 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, NHTSA guidelines allow states to omit from their sample space the lowest population counties, provided these counties collectively account for 15 percent or less of the state's total population. Therefore, all 83 Michigan counties were rank ordered by population (U.S. Census Bureau, 1992), and the low population counties were eliminated from the sample space. This step reduced the sample space to 28 counties. In order to account for shifts in the population of Michigan counties (U.S. Census Bureau, 2003), three additional counties were added to the present design bringing the total number of counties in the sample space to 31.

The original counties 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 University of Michigan Transportation Research Institute (UMTRI) surveys (Wagenaar & Molnar, 1989; Wagenaar, Molnar, & Businski, 1987b, 1988). 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. Census Bureau, 1992).[1] These factors have been shown previously to correlate positively with belt use (e.g., Wagenaar, Molnar, & Businski, 1987a). Wayne County was chosen as a separate stratum because of its disproportionately high VMT, and because we wanted to ensure that observation sites were selected within this county. Three other strata were constructed by rank ordering each county by historical belt use rates and then adjusting the stratum boundaries until the total VMT was roughly equal within each stratum. The stratum boundaries were high belt use (stratum 1), medium belt use (stratum 2), low belt use (stratum 3), and Wayne County. The additional counties for the present survey became part of stratum 3 and all sites in this stratum were re-selected and rescheduled following the procedures described below. The counties comprising each stratum can be found in Table 1.

Table 1. Listing of Michigan Counties by Stratum

Stratum Number	Counties
1	Ingham, Kalamazoo, Oakland, Washtenaw
2	Allegan, Bay, Eaton, Grand Traverse, Jackson, Kent, Livingston, Macomb, Midland, Ottawa
3	Berrien, Calhoun, Clinton, Genesee, Ionia, Isabella, Lapeer, Lenawee, Marquette, Monroe, Muskegon, Saginaw, Shiawassee, St. Clair, St. Joseph, Van Buren
4	Wayne

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 on an estimated 50 vehicles per 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 for all daylight hours.

[1] Educational attainment was defined as the proportion of population in the county over 25 years of age with a bachelor degree.

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), 10 of the sites (24 percent) 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 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 (*x*) coordinate and a vertical (*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.[2] 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 were 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 were randomly selected. If more than one intersection was within the grid square, the grid square was subdivided

[2] 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.

into four equal sections, and a random number between 1 and 4 was selected until one of the intersections was chosen. This happened for only two of the sites.

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, there would then be four possible combinations of street and direction of traffic flow to be observed (observers watched traffic only on the side of the street on which they were standing). In Figure 1, observer location number one indicates that the observer would watch southbound traffic and stand next to Main Street. For observer location number two, the observer would watch eastbound traffic and stand next to Second Street, 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 upon 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.

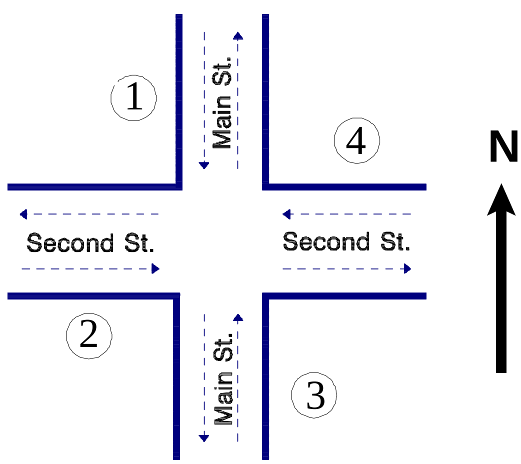

Figure 1. An Example "+" Intersection Showing 4 Possible Observer Locations

For each primary 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.[3]

The 10 freeway exit ramp 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 10 numbers between 1 and the number of exit ramps in the stratum. For example, in the high belt use stratum there were 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 sides of the 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 if it was already selected as a primary site, then the other direction of travel along the freeway was used. If the exit ramp had no traffic control device on the selected direction of travel, then a researcher visited the site and randomly picked a travel direction and lane that had such a device.

[3] For those interested in designing a safety belt survey for their county or region, a guidebook and software for selecting and surveying sites for safety belt use is available (Eby, 2000) by contacting UMTRI-SBA, 2901 Baxter Rd., Ann Arbor, MI 48109-2150, or accessing http://www-personal.umich.edu/~eby/sbs.html/.

[4] An exit ramp is defined here as egress from 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.

The day of week and time of day for site observations were quasi-randomly assigned to sites in such a way that all days of the week and all daylight hours (7:00 am - 7:00 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 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 dark, 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 observations would take place. The observer then visited sites following the loop in either a clockwise or counterclockwise direction (whichever direction left them closest to UMTRI at the end of the day). This direction was determined by the project manager prior to sending the observers into the field. Because of various scheduling limitations (e.g., observer availability, number of hours worked per week) 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 for observations at the sites were not correlated with belt use at a site. This quasi-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.[3] Thus, the number of vehicles observed at a 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, since all vehicles passing an observer could not be surveyed, a vehicle count of all eligible vehicles (i.e., passenger cars, vans/minivans, sport-utility vehicles, and pickup trucks) on the traffic leg under observation was conducted for a set duration (5 minutes) immediately prior to and immediately following the observation period (10 minutes total).

[3] 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 shows descriptive statistics for the 168 observation sites. As shown in this table, the observations 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 every site observed was the primary site and that observations were mostly conducted during sunny and cloudy weather conditions, with a small percentage conducted during rainy weather. No observations were conducted during snow.

Table 2. Descriptive Statistics for the 168 Observation Sites

Day of Week		Observation Period		Site Choice		Weather	
Monday	13.1%	7-9 a.m.	10.1%	Primary	100.0%	Sunny	85.1%
Tuesday	11.3%	9-11 a.m.	19.1%	Alternate	0.0%	Cloudy	11.3%
Wednesday	11.3%	11-1 p.m.	16.7%			Rain	3.6%
Thursday	16.7%	1-3 p.m.	23.2%			Snow	0.0%
Friday	19.6%	3-5 p.m.	20.2%				
Saturday	13.7%	5-7 p.m.	10.7%				
Sunday	14.3%						
TOTALS	100.0%		100.0%		100.0%		100.0%

Data Collection

Trained field staff observed shoulder belt use, sex, age, vehicle type, and vehicle purpose (commercial or noncommercial) of drivers and front-right passengers during daylight hours only. Motorists traveling in passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks were included. Observations were conducted when a vehicle came to a stop at a traffic light or stop sign.

Data Collection Form

Data were collected during the survey using personal digital assistants (PDAs). For a more detailed description of the PDA data collection process, see Appendix C. One electronic form containing site description categories as well as observation categories was developed for data collection. For each site surveyed, one copy of the electronic data collection form was created in advance. The site description portion of the form allowed observers to provide descriptive information including the site location, site type (freeway exit ramp or intersection), site choice (primary or alternate), observer number, date, day of week, time of day, weather, and a count of eligible vehicles traveling on the proper traffic leg. A place on the form was furnished for observers to electronically sketch the intersection and to identify observation location. A comments section was also available 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 observation categories of the data collection form were used to record safety belt use, passenger information, and vehicle information. For each vehicle surveyed, shoulder belt use, sex, and estimated age of the driver and the front-outboard passenger were recorded along with vehicle type. Children riding in child restraint devices (CRDs) were recorded but not included in any part of the analysis. Occupants observed with their shoulder belt worn under the arm or behind the back were noted but considered belted in the analysis. Based upon NHTSA (1999) guidelines, the observer also collected data from commercial vehicles, and noted this in the electronic form. A commercial vehicle was defined as a vehicle that is used for business purposes and may or may not contain company logos. This classification includes vehicles marked with commercial lettering or logos, or vehicles with ladders or other tools on them.

Procedures at Each Site

All sites in the sample were visited by one observer for a period of 1 hour, with the exception of sites in the city of Detroit. To address potential security concerns, these sites were visited by two-person observer teams for a period of 30 minutes. Observations at other sites scheduled to be observed on the same day as Detroit sites were also completed by two observers. Because each team member at these sites recorded data for different lanes of traffic, the total amount of data collection time was equivalent to that at one-observer 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 categories of the form and then moved to their observation position near the traffic control device.

Observers were instructed to observe only the vehicles in the lane immediately adjacent to the curb, regardless of the number of lanes present. At sites visited by two-person teams, team members observed different lanes of the same traffic leg with one observer on the curb and one observer on the median (if there was more than one traffic lane and a median). If no median was present, observers were instructed to stand on diagonally opposite corners of the intersection.

At each site, observers conducted a 5-minute count of all eligible vehicles in the designated traffic leg before beginning safety belt 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 eligible vehicles as they could observe. If traffic flow was heavy, observers were instructed to record data for the first eligible vehicle they saw, and then look up and record data for the next eligible vehicle they saw, continuing this process for the remainder of the observation period. At the end of the observation period, a second 5-minute vehicle count was conducted at one observer sites.

Observer Training

Prior to data collection, field observers participated in 5 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, PDA use, and administrative policies and procedures. A site schedule identifying the location, date, time, and traffic leg to be observed for each site was included in the manual (see Appendix A for a listing of the sites).

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 the locations of the practice sites were the same as sites observed during the study. Training at practice sites focused on PDA use, completing the electronic form, determining where to stand and which lanes to observe, conducting the vehicle count, recording safety belt use, and estimating age and sex. Observers worked in teams of two, observing the same vehicles, but recording data independently on their own PDA. The data were then compared for accuracy. Teams were rotated throughout the training to ensure that each observer was paired with every other observer. Each observer pair practiced recording safety belt use, sex, age, and vehicle type until there was an inter-observer reliability of at least 85 percent for all measures on drivers and front-right passengers for each pair of observers.

Each observer was provided with an atlas of Michigan county maps and all necessary field supplies. Observers were given time to locate 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 of locations 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 telephone calls to report progress and discuss problems encountered in the field, e-mails to the field supervisor from each observer's PDA containing data from the preceding day, text messages to the observer's PDAs to alert them to any important information, and visits to the UMTRI office to deliver expense forms and timesheets. Field staff were instructed to call the field supervisor's home or cellular phone if problems arose during evening hours or on weekends.

Incoming data files were examined by the field supervisor and problems (e.g., missing data, discrepancies between the data collection form and site listing or schedule) were noted and discussed with field staff. Comments in the site description portion of the data collection form about site-specific characteristics that might affect future surveys (e.g., traffic flow patterns, traffic control devices, site access) were noted.

Data Processing and Estimation Procedures

The accuracy of electronic data was verified by checking for inconsistent codes (e.g., the observation end time occurring before the start time; "no passenger" marked, when passenger data were present) and missing data. Any errors noted during this process were corrected.

For each site, a computer analysis program determined the number of observed vehicles, belted and unbelted drivers, and belted and unbelted passengers. Separate counts were made for each independent variable in the survey (i.e., site type, time of day, day of week, weather, sex, age, seating position, and vehicle type). This information was combined with the site information to create a file used for generating study results.

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 vehicles 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.

This weighting was done by first adding each of the two 5-minute counts and then multiplying this number by five so that it would represent a 50-minute duration.[4] The resulting number was the estimated number of vehicles passing through the site if all eligible vehicles had been included in the survey during the observation period at that site. The estimated count for each site was divided by the actual number of vehicles observed there to obtain a volume weighting factor for that site. These weights are then applied to the number of actual vehicles of each type observed at each site to yield the weighted N for the total number of drivers and passengers, and total number of belted drivers and passengers for each vehicle type. Unless otherwise indicated, all analyses reported are based upon the weighted values.

[4] As mentioned previously, the Detroit sites were visited by pairs of observers for half as long. For these sites, the single 5-minute counts were combined to represent the 25-minute observation period.

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

$$r_i = \frac{Total\ Number\ of\ Belted\ Occupants,\ weighted}{Total\ Number\ of\ Occupants,\ weighted}$$

where r_i refers to the belt use rate within 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 83 percent as large as the total VMT for the other three strata. In order to represent accurately safety belt use for Michigan by VMT, the Wayne County stratum was multiplied by 0.83 during the averaging to correct for its lower total VMT. The overall belt use rate was determined by the following formula:

$$r_{all} = \frac{r_1 + r_2 + r_3 + (0.83 * r_4)}{3.83}$$

where r_i is the belt use rate for a certain vehicle type within each stratum and r_4 the Wayne County stratum.

The estimates of variance and the calculation of the confidence bands for the belt use estimates are complex. See Appendix B for a detailed description of the formulas and procedures. The same use rate and variance equations were utilized for the calculation of use rates for each vehicle type separately.

RESULTS

As discussed previously, the current direct observation survey of safety belt use in Michigan reports statewide belt use for four vehicle types combined (passenger cars, vans/minivans, sport-utility vehicles, and pickup trucks), in addition to reporting use rates for occupants in each vehicle type separately. Following NHTSA (1999) guidelines, this survey included commercial vehicles. All rates shown in this report include occupants from both commercial and noncommercial vehicles together.

The purpose of the survey was to continue to track Michigan safety belt use in order to assess longitudinal changes in statewide belt use over the past 12 years. The present survey was conducted at the same time of year and used the same methodology and weighting scheme that has been used in Michigan since 1993. As such, the survey provides a new data point for comparison with previous years. Results from the current survey alone will be presented first. These results will be combined and presented with historical data since 1994. Note that in 1993, only data from passenger vehicles were collected and are, therefore, not representative of Michigan safety belt use.

Overall Safety Belt Use

As shown in Figure 2, 87.9 ± 1.1 percent of all front-outboard occupants traveling in passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks in Michigan between September 1 and 16, 2005 were restrained with shoulder belts. The "±" value following the use rate indicates a 95 percent confidence interval around the percentage. When compared with the use rate of 90.5 ± 0.9 percent observed one year ago in September 2004 (Eby & Vivoda, 2004), we find that belt use has ***decreased*** significantly.

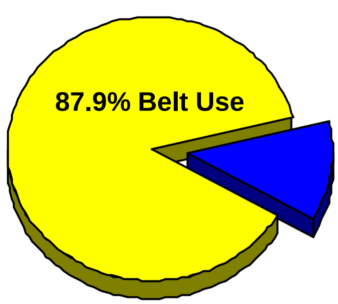

Figure 2. Front-Outboard Shoulder Belt Use in Michigan (All Vehicle Types and Commercial/Noncommercial Combined).

Estimated belt use rates and unweighted numbers of occupants (N) by stratum are shown in Table 3. Safety belt use was not significantly different across any of the four strata.

Estimated belt use rates and unweighted numbers of occupants by stratum and vehicle type are shown in Tables 4a through 4d. Within passenger cars and pickup trucks, belt use is slightly lower in Stratum 4. Comparisons across vehicle types reveal that belt use is slightly lower for occupants traveling in sport-utility vehicles compared to those in passenger cars and vans/minivans. As is usually found in safety belt use research, belt use is the lowest for occupants of pickup trucks (Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002).

Table 3. Percent Shoulder Belt Use by Stratum (All Vehicle Types)

	Percent Use	Unweighted N
Stratum 1	89.6 ± 1.9	3,797
Stratum 2	87.7 ± 2.2	2,738
Stratum 3	87.7 ± 2.5	1,908
Stratum 4	86.2 ± 2.0	5,234
STATE OF MICHIGAN	**87.9 ± 1.1%**	**13,677**

Table 4a. Percent Shoulder Belt Use by Stratum (Passenger Cars)		
	Percent Use	Unweighted N
Stratum 1	91.9	1,863
Stratum 2	90.5	1,230
Stratum 3	90.6	850
Stratum 4	87.5	2,896
STATE OF MICHIGAN	**90.3 ± 1.1%**	6,839

Table 4b. Percent Shoulder Belt Use by Stratum (Sport Utility Vehicles)		
	Percent Use	Unweighted N
Stratum 1	88.1	762
Stratum 2	86.0	560
Stratum 3	86.0	340
Stratum 4	87.5	1,012
STATE OF MICHIGAN	**86.8 ± 2.0%**	2,674

Table 4c. Percent Shoulder Belt Use by Stratum (Vans/Minivans)		
	Percent Use	Unweighted N
Stratum 1	88.8	572
Stratum 2	88.9	398
Stratum 3	87.3	298
Stratum 4	87.3	723
STATE OF MICHIGAN	**88.1 ± 2.1%**	1,991

Table 4d. Percent Shoulder Belt Use by Stratum (Pickup Trucks)		
	Percent Use	Unweighted N
Stratum 1	84.2	600
Stratum 2	81.5	550
Stratum 3	83.4	420
Stratum 4	79.1	603
STATE OF MICHIGAN	**82.2 ± 2.6%**	2,173

Safety Belt Use by Subgroup

Site Type. Estimated safety belt use by type of site is presented in Table 5 as a function of vehicle type and all vehicles combined. As is typically found in safety belt use surveys in Michigan (Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002), use was higher for occupants in vehicles leaving limited access roadways (exit ramps) than for occupants in vehicles traveling on surface streets.

Time of Day. Estimated safety belt use by time of day, vehicle type, and all vehicles combined is shown in Table 5. Note that these data were collected only during daylight hours. For all vehicles combined, belt use was about the same throughout the day, with slightly higher levels observed during the morning commute.

Day of Week. Estimated safety belt use by day of week, vehicle type, and all vehicles combined is shown in Table 5. Note that the survey was conducted over a 3-week period that included Labor Day. Belt use clearly varied from day to day, but no systematic differences were evident.

Weather. Estimated belt use by prevailing weather conditions, vehicle type, and all vehicles combined is shown in Table 5. There was essentially no difference in belt use observed during sunny or cloudy weather conditions. However, for those traveling in passenger cars or pickup trucks, belt use appears to be quite low during rainy conditions. Due to a low number of occupants in rainy conditions, these results should be interpreted with caution.

Sex. Estimated safety belt use by occupant sex, type of vehicle, and all vehicles combined is shown in Table 5. Estimated safety belt use was higher for females than for males in all four vehicle types studied, and for all vehicle types combined. Similar results have been found in every Michigan safety belt survey conducted by UMTRI (see e.g., Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002).

Age. Estimated safety belt use by age, vehicle type, and all vehicle types combined is shown in Table 5. As there were only five 0-to-3 year olds observed in the current study, the estimated safety belt use rate for this age group is not meaningful.

Additionally, the unweighted number of 4-to-15 year olds was also quite low (404), so these results should also be interpreted with caution. Excluding the youngest age groups, the lowest level of safety belt use was observed among 16-to-29 year olds and increased with age. These results suggest that new and young drivers (16-to-29 years of age) should continue to be a focus of safety belt use messages and programs.

Seating Position. Estimated safety belt use by position in vehicle, vehicle type, and all vehicles combined is shown in Table 5. This table shows that for all vehicle types combined, safety belt use was essentially the same for drivers and front-right passengers in cars and vans/minivans. Driver belt use was higher in sport-utility vehicles and slightly higher in pickup trucks.

Table 5. Percent Shoulder Belt Use and Unweighted N by Vehicle Type and Subgroup										
	All Vehicles		Car		SUV		Van/Minivan		Pickup Truck	
	Percent Use	N	Percent Use	N	Percent Use	N	Percent Use	N	Percent Use	N
Overall	87.9	13,677	90.3	6,839	86.8	2,674	88.1	1,991	82.2	2,173
Site Type										
Intersection	87.3	9,338	90.2	4,711	85.0	1,809	89.4	1,371	80.3	1,447
Exit Ramp	89.4	4,339	91.1	2,128	90.3	865	87.0	620	85.0	726
Time of Day										
7 - 9 a.m.	90.9	1,303	94.6	696	93.2	249	91.0	176	75.0	182
9 - 11 a.m.	86.9	1,966	89.3	912	85.5	366	90.2	280	81.7	408
11 - 1 p.m.	85.6	1,532	87.6	726	84.3	298	87.1	247	78.9	261
1 - 3 p.m.	88.1	3,216	91.7	1,541	85.4	655	88.4	500	80.2	520
3 - 5 p.m.	87.6	3,617	88.8	1,859	87.1	691	87.3	505	84.9	562
5 - 7 p.m.	84.1	2,043	67.2	1,105	92.2	415	80.9	283	87.5	240
Day of Week										
Monday	83.3	2,124	88.0	1,300	84.5	369	84.6	260	61.8	195
Tuesday	91.5	1,658	95.3	813	87.1	321	90.8	225	86.2	299
Wednesday	83.6	1,506	86.6	723	84.1	261	78.4	232	76.0	290
Thursday	87.7	2,119	90.1	938	88.7	416	91.1	350	78.5	415
Friday	88.8	3,444	88.4	1,694	89.7	679	91.5	534	84.9	537
Saturday	88.9	1,190	90.1	518	91.2	262	90.1	168	82.7	242
Sunday	92.4	1,636	94.3	853	89.2	366	94.7	222	89.4	195
Weather										
Sunny	88.5	12,046	90.7	6,087	87.7	2,342	88.8	1,768	82.6	1,849
Cloudy	86.1	1,462	88.1	679	85.1	307	87.1	195	81.5	281
Rainy	68.3	169	59.2	73	90.9	25	91.5	28	52.3	43
Sex										
Male	84.5	7,241	87.3	3,212	82.8	1,284	84.6	1,041	80.5	1,704
Female	91.9	6,428	92.9	3,623	90.6	1,389	91.8	949	88.5	467
Age										
0 - 3	87.3	5	64.7	3	100.0	1	100.0	1	---	0
4 - 15	88.6	404	91.1	177	81.0	89	93.2	82	86.8	56
16 - 29	86.0	3,396	89.0	2,061	83.3	573	80.9	268	79.7	494
30 - 59	87.8	8,032	90.0	3,554	88.0	1,734	87.9	1,335	82.1	1,409
60 - Up	91.8	1,834	93.3	1,043	89.9	275	92.6	304	86.5	212
Position										
Driver	88.1	10,759	90.3	5,400	88.0	2,091	88.0	1,494	82.5	1,774
Passenger	87.0	2,918	90.2	1,439	82.8	583	88.6	497	80.6	399

Age and Sex. Table 6 shows the estimated safety belt use rates and unweighted numbers (N) of occupants for all vehicle types combined by age and sex. As described earlier, the unweighted number of occupants is quite low for the two youngest age groups, and will therefore be excluded from the following discussion. Belt use for females in all age groups was higher than for males. However, the absolute difference in belt use rates between sexes varied depending upon the age group. The largest differences were found in the 16-to-29 and 30-to-59 year old age groups, where the estimated belt use rate is 8.2 percentage points higher for females than for males. In fact, the belt use rate for the lowest female age group (16-to-29 year olds) was higher than the rate for any of the male age groups. These results argue strongly for statewide efforts to be directed toward persuading young males, and males in general, to wear safety belts.

Table 6. Percent Shoulder Belt Use and Unweighted N by Age and Sex (All Vehicle Types Combined)

Age Group	Male		Female	
	Percent Use	Unweighted N	Percent Use	Unweighted N
0 - 3	82.1	3	100.0	2
4 - 15	92.5	197	84.8	207
16 - 29	82.3	1,811	90.5	1,583
30 - 59	83.9	4,270	92.1	3,759
60 - Up	89.2	956	94.7	877

Historical Trends

The current direct observation survey is the twenty-fourth statewide survey that utilizes the sampling design and procedures implemented in 1993 (Streff, Eby, Molnar, Joksch, & Wallace, 1993). As such, it is possible to investigate safety belt use trends over these years. The annual survey in 1993, however, only included passenger vehicles, so that survey is only included in the historical trends section relating safety belt use by vehicle type.

Overall Belt Use Rate. Figure 3 shows the statewide safety belt use rate for all vehicles combined over the last 12 years. The safety belt use rate has shown a general increase over this time. It is too early to tell whether or not the recent decrease in statewide belt use is a downward trend or a temporary "dip" in belt use as has occurred several times in the past five years.

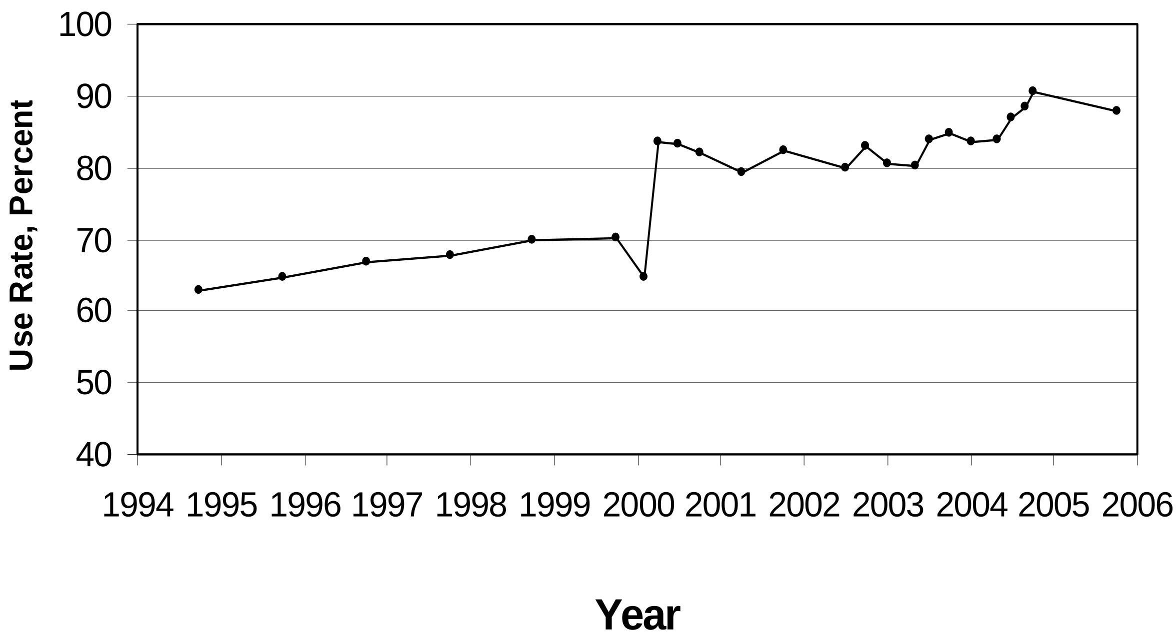

Figure 3. Front-Outboard Shoulder Belt Use by Year (All Vehicle Types Combined).

Overall Belt Use Rate by Stratum. Figure 4 shows the statewide safety belt use rate for all vehicles combined since 1994 by stratum. For all strata, there is a general upward trend in safety belt use from 1994 to 2005, with the greatest increase in use found in Stratum 4. Stratum 4 also experienced the largest increase in belt use immediately following the implementation of primary enforcement. Notwithstanding the current survey, overall increases in belt use rates continue to be observed in all strata. However, to maintain the current rate of high belt use, it continues to be necessary to develop and implement new strategies for programs designed to increase the belt use rate.

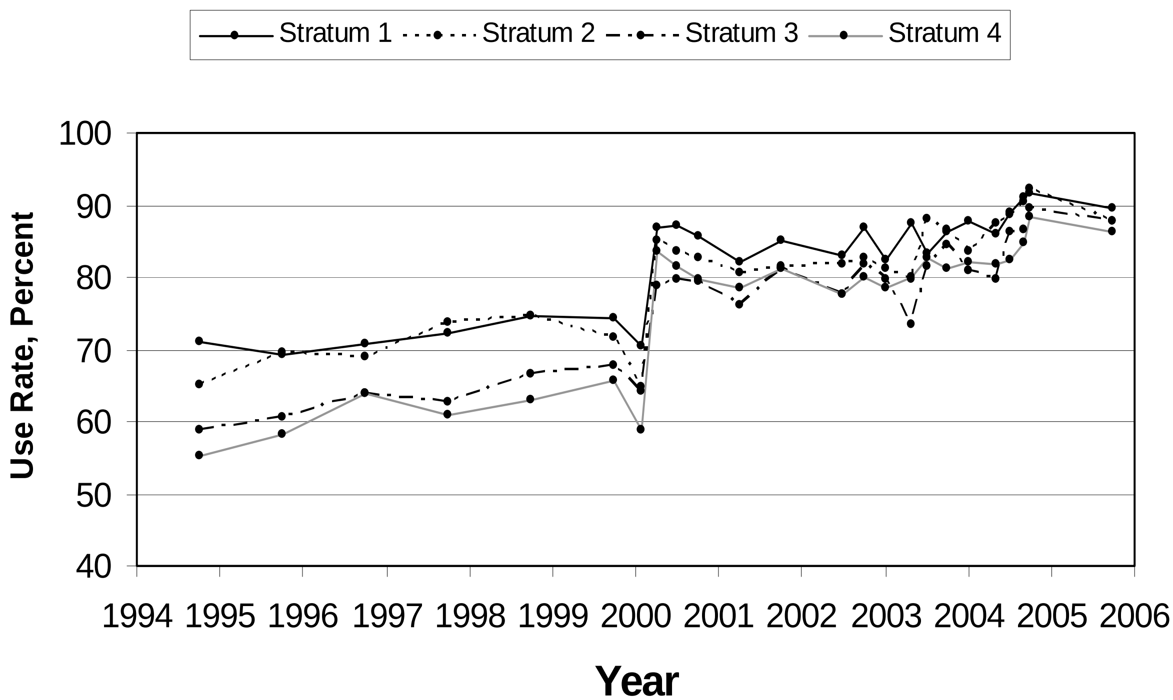

Figure 4. Front-Outboard Shoulder Belt Use by Year and Stratum (All Vehicle Types Combined).

Belt Use by Site Type. Figure 5 shows the estimated safety belt use rates for all vehicles combined as a function of whether the site was a freeway exit ramp or a local intersection. This effect has generally remained consistent since 1994, with higher belt use observed at freeway exit ramp sites, but the overall difference in belt use observed at the two types of sites has fluctuated from study to study.

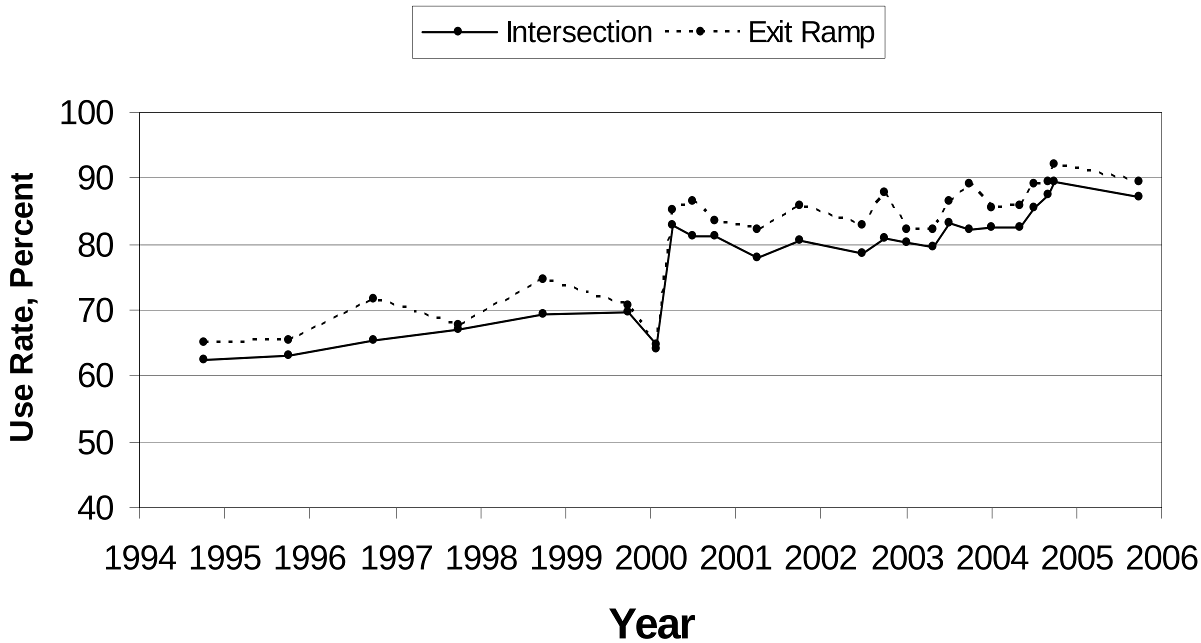

Figure 5. Front-Outboard Shoulder Belt Use by Site Type and Year (All Vehicle Types Combined).

Belt Use by Sex. Figure 6 shows front-outboard safety belt use by sex since 1994. In every survey, safety belt use by females is significantly higher than for males. Significant increases in belt use, related to the introduction of primary enforcement legislation, were observed within both sexes. The difference between the two groups has declined somewhat over recent years as overall belt use compliance gets closer to 100 percent. Clearly, work still needs to be done to encourage males to use safety belts more frequently.

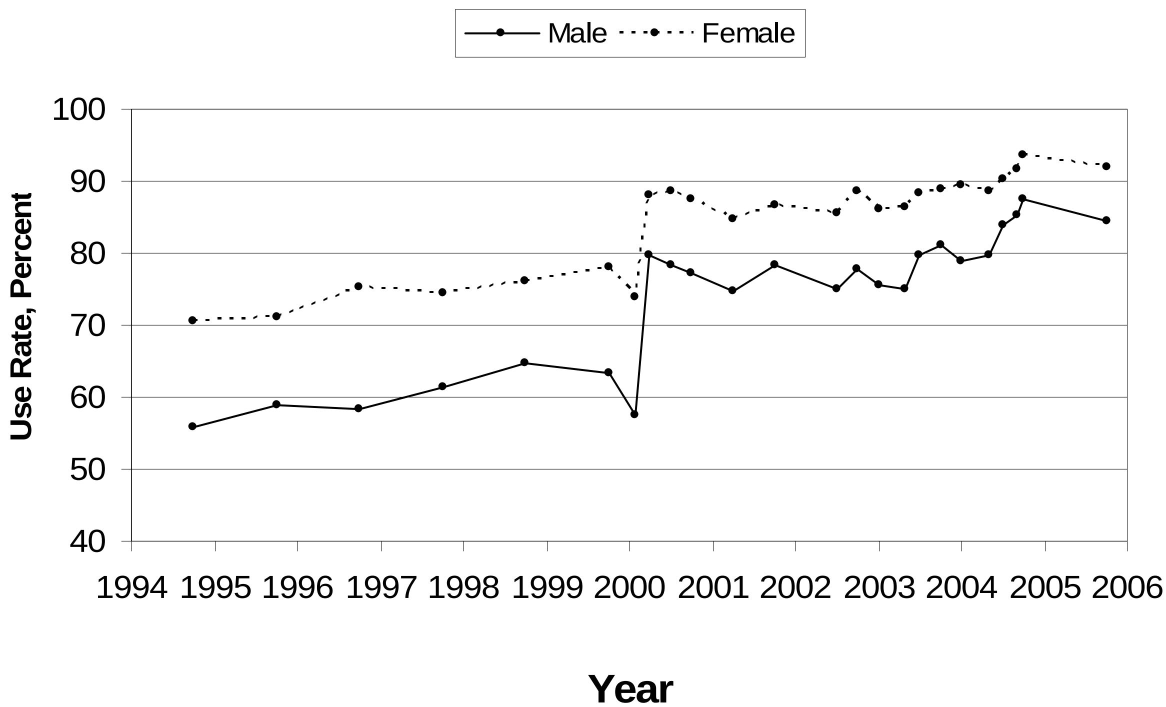

Figure 6. Front-Outboard Shoulder Belt Use by Sex and Year (All Vehicle Types Combined).

Belt Use by Seating Position. Figure 7 shows front-outboard safety belt use by seating position and year. Safety belt use by drivers has been consistently higher than front-outboard passengers since 1994. This difference, however, has consistently decreased over time indicating the effectiveness of Michigan's safety belt promotion programs.

Figure 7. Front-Outboard Shoulder Belt Use by Seating Position (All Vehicle Types Combined).

Belt Use by Age. Figure 8 shows front-outboard safety belt use by age group since 1994 for all vehicles combined. The youngest age group is typically excluded from comparisons due to the very small numbers in our sample. Conclusions about the 4-to-15-year-old age group should also be made with caution as the number of occupants within this age group is quite low. Excluding these age groups, the use rates by age have been ordered consistently each year with the 16-to-29 year old age group having the lowest safety belt use rates, followed by the 30-to-59 year olds. The highest belt use is typically observed within the 60-and-older age group.

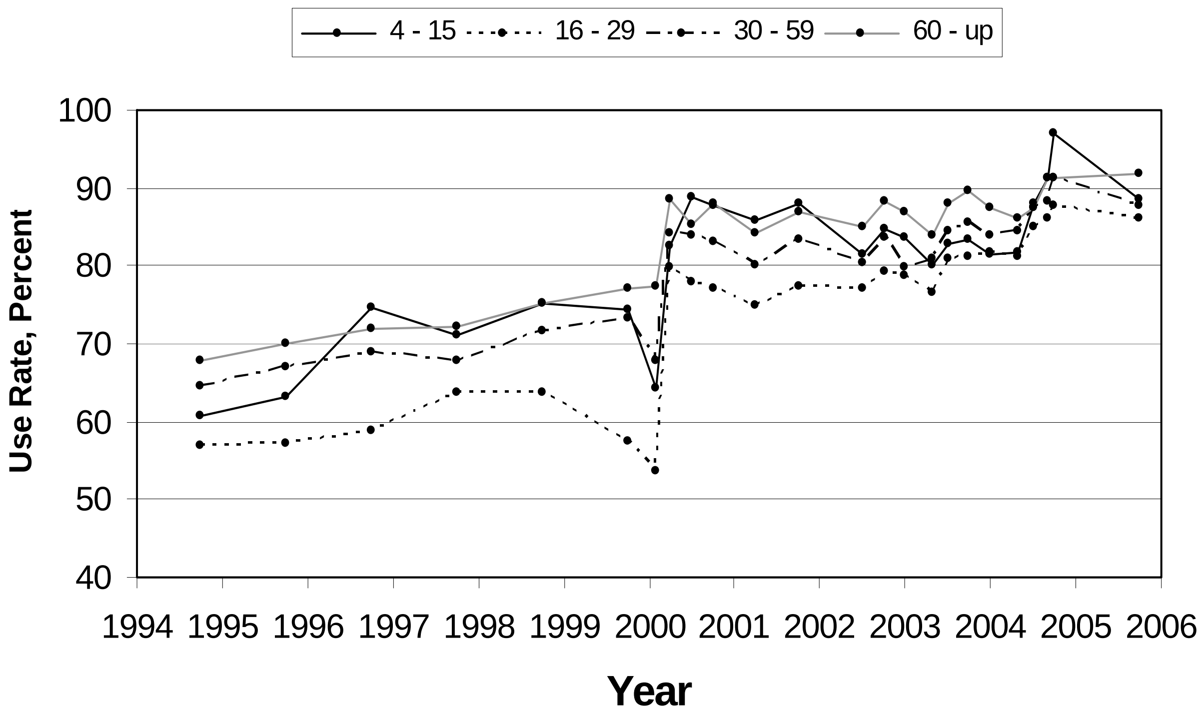

Figure 8. Front-Outboard Shoulder Belt Use by Age and Year (All Vehicle Types Combined).

Belt Use by Vehicle Type and Year. Figure 9 shows motor vehicle occupant belt use by the type of vehicle since 1993. Belt use for 1993 only shows passenger vehicles because only this vehicle type was observed in that year. Figure 9 reveals that significant increases have been observed in safety belt use rates for occupants in all vehicle types. The most notable increase has been observed in the belt use rates of pickup truck occupants. However, these occupants continue to be significantly less likely to use a safety belt than occupants of other vehicle types.

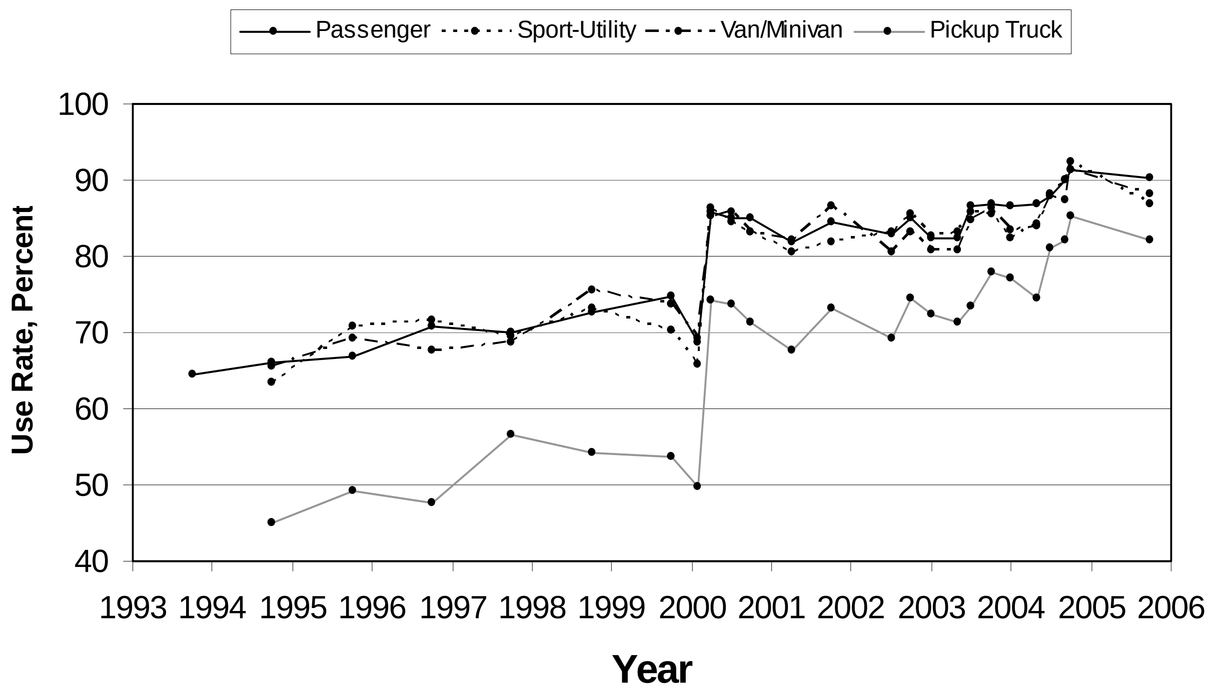

Figure 9. Front-Outboard Shoulder Belt Use by Vehicle Type and Year.

DISCUSSION

The estimated statewide safety belt use rate for front-outboard occupants of passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks combined was 87.9 ± 1.1 percent. This rate represents a significant decrease in statewide safety belt use since the same time last year. Further, this level of belt use drops Michigan below the goal set by OHSP (2004) to reach 90 percent belt use. These results show that Michigan should redouble its efforts to maintain the high levels of use it has previously achieved.

Analyses of safety belt use by the various subcategories in the current survey revealed that this decrease in safety belt use over the last year was largely a general trend, with decreases found in all categories except for the oldest age group where belt use slightly increased. When consistent effects are discovered over such a wide range of variables, it usually results from a statewide effect, such as implementation of a law or the cessation of a campaign. It is possible that something similar occurred in Michigan after the cessation of the *Click It or Ticket* campaign.

Comparing results over survey years indicates that even with the declining belt use found this year, progress has been made in increasing use among segments of Michigan's population that have traditionally been the least likely to wear safety belts; 16-to-29 year olds, pickup truck occupants, residents of Wayne County, and males. Since the introduction of primary enforcement, safety belt use among each of these groups reflects larger increases than their comparison groups. Belt use among motorists in these groups also reflects the largest increases since 1994. However, even with such increases, these groups continue to display lower belt use than the rest of the motoring public. The results suggest that efforts to increase belt use should continue to focus on these populations. In addition, efforts to understand why these groups wear safety belts less often would be helpful in the development of programs designed to increase safety belt use.

While it remains important to focus on increasing safety belt use rates for those groups that continue to fail to buckle up, it is also important to recognize the progress that has been made over the last 12 years. Of particular note during this time frame are two important factors. First, in March 2000, the enforcement provision of Michigan's safety belt law was changed from secondary to primary. This change (along with the accompanying media and police enforcement) resulted in a net increase of more than 10 percentage points, from around 70 percent to around 80 percent belt use. The second factor has been the sustained focus of several campaigns designed to increase the belt use rate in the state. These campaigns included recent mobilizations using the *Click It or Ticket: Buckle Up or Pay Up* theme and the implementation of safety belt enforcement zones. These efforts have generally been effective, and can continue to be effective, by influencing motorists' perceptions of the risk associated with failing to buckle up, which in turn led to the observed increases in the belt use rate.

While the decrease in statewide safety belt use may not indicate the start of a downward trend, it continues to be important to accurately monitor statewide safety belt use using a design, methods, and sites that will yield results that are comparable to past surveys. Seemingly minor changes to the design or weighting scheme can have large effects on the survey outcome making comparison with previous surveys inaccurate. For example, during site reselection, one could inadvertently use a map whose level of detail (regardless of scale) might not include low volume roads. The use of such a map would have the effect of replacing sites that have low traffic volumes with ones that have higher volumes. Such a change could artificially increase belt use rates because of the elimination of rural sites within non-rural counties. Nevertheless, it is important to understand the details of a survey design and methods in order to accurately interpret survey results.

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APPENDIX A

Site Listing

Survey Sites by Number

No.	County	Site Location	Type	Str
001	Oakland	EB Whipple Lake Rd. & Eston Rd.	I	1
002	Kalamazoo	EB S Ave. & 29th St.	I	1
003	Oakland	SB Pontiac Trail & 10 Mile Rd.	I	1
004	Washtenaw	SB Moon Rd. & Ann Arbor-Saline Rd./Saline-Milan Rd.	I	1
005	Oakland	WB Drahner Rd. & Baldwin Rd.	I	1
006	Oakland	SB Rochester Rd. & 32 Mile Rd./Romeo Rd.	I	1
007	Oakland	SB Williams Lake Rd. & Elizabeth Lake Rd.	I	1
008	Ingham	SB Searls Rd. & Iosco Rd.	I	1
009	Kalamazoo	WB D Ave. & Riverview Dr.	I	1
010	Washtenaw	EB N. Territorial Rd. & Dexter-Pinckney Rd.	I	1
011	Washtenaw	NB Schleeweis Rd./Macomb St. & W. Main St.	I	1
012	Ingham	NB Shaftsburg Rd. & Haslett Rd.	I	1
013	Oakland	NB Middlebelt Rd. & 9 Mile Rd.	I	1
014	Washtenaw	WB Packard Rd. & Carpenter Rd.	I	1
015	Ingham	EB Haslett Rd. & Marsh Rd.	I	1
016	Washtenaw	NB Jordan Rd./Monroe St. & US-12/Michigan Ave.	I	1
017	Washtenaw	SB M-52/Main St. & Old US-12	I	1
018	Kalamazoo	SB 8th St. & Q Ave.	I	1
019	Washtenaw	WB 8 Mile Rd. & Pontiac Trail	I	1
020	Oakland	SB Lahser Rd. & 11 Mile Rd.	I	1
021	Kalamazoo	NB Ravine Rd. & D Ave.	I	1
022	Washtenaw	EB Glacier Way/Glazier Way & Huron Pkwy.	I	1
023	Washtenaw	WB Bethel Church Rd. & M-52	I	1
024	Washtenaw	SB Platt Rd. & Willis Rd.	I	1
025	Ingham	WB Fitchburg Rd. & Williamston Rd.	I	1
026	Washtenaw	EB Merritt Rd. & Stoney Creek Rd.	I	1
027	Oakland	SB Hickory Ridge Rd. & M-59/Highland Rd.	I	1
028	Kalamazoo	SB Douglas Ave. & D Ave.	I	1
029	Oakland	WB Walnut Lake Rd. & Haggerty Rd.	I	1
030	Oakland	NB Jossman Rd. & Grange Hall Rd.	I	1
031	Kalamazoo	EB H Ave. & 3rd St.	I	1
032	Kalamazoo	EB TU Ave. & 24th St./Sprinkle Rd.	I	1
033	Oakland	WBD I-96 & Milford Rd. (Exit 155B)	ER	1
034	Washtenaw	WBP I-94 & Whittaker Rd./Huron St. (Exit 183)	ER	1
035	Kalamazoo	SBP US-131 & M-43 (Exit 38B)	ER	1

036	Washtenaw	SBD US-23 & N. Territorial Rd.	ER	1
037	Kalamazoo	EBP I-94 & Portage Rd.	ER	1
038	Oakland	EBP I-696 & Orchard Lake Rd. (Exit 5)	ER	1
039	Kalamazoo	WBP I-94 & 9th St. (Exit 72)	ER	1
040	Washtenaw	WBD I-94 & Jackson Rd.	ER	1
041	Kalamazoo	NBD US-131 & Stadium Dr./Business I-94	ER	1
042	Kalamazoo	NBP US-131 & Q Ave./Centre Ave.	ER	1
043	Livingston	SB County Farm Rd. & Coon Lake Rd.	I	2
044	Bay	WB Nebodish Rd. & Knight Rd.	I	2
045	Macomb	SB Camp Ground Rd. & 31 Mile Rd.	I	2
046	Jackson	SB Benton Rd./Moon Lake Rd. & M-50/Brooklyn Rd.	I	2
047	Allegan	SB 6th St. & M-89	I	2
048	Kent	EB 36th St. & Snow Ave.	I	2
049	Livingston	EB Chase Lake Rd. & Fowlerville Rd.	I	2
050	Allegan	WB 144th Ave. & 2nd St.	I	2
051	Livingston	SB Cedar Lake Rd. & Coon Lake Rd.	I	2
052	Jackson	NB Mt. Hope Rd. & Waterloo-Munith Rd.	I	2
053	Kent	WB Cascade Rd. & Thornapple River Dr.	I	2
054	Allegan	NB 62nd St. & 102nd Ave.	I	2
055	Kent	SB Meddler Ave. & 18 Mile Rd.	I	2
056	Eaton	SB Houston Rd. & Kinneville Rd.	I	2
057	Macomb	SB M-19/Memphis Ridge Rd. & 32 Mile Rd./Division Rd.	I	2
058	Allegan	NB 66th St. & 118th Ave.	I	2
059	Grand Traverse	NB Silver Lake Rd./County Rd. 633 & US-31	I	2
060	Grand Traverse	EB Riley Rd./Tenth St. & M-137	I	2
061	Bay	SB 9 Mile Rd. & Beaver Rd.	I	2
062	Kent	SB Ramsdell Dr. & M-57/14 Mile Rd.	I	2
063	Eaton	NB Ionia Rd. & M-50/Clinton Trail	I	2
064	Macomb	EB 23 Mile Rd. & Romeo Plank Rd.	I	2
065	Livingston	NB Old US-23/Whitmore Lake Rd. & Grand River Rd.	I	2
066	Jackson	SWB Horton Rd. & Badgley Rd.	I	2
067	Kent	SB Belmont Ave. & West River Dr.	I	2
068	Eaton	EB 5 Point Hwy. & Ionia Rd.	I	2
069	Allegan	WB 129th Ave. & 10th St.	I	2
070	Eaton	EB M-43 & M-100	I	2
071	Ottawa	WB Taylor St. & 72nd Ave.	I	2
072	Bay	EB Cass Rd. & Farley Rd.	I	2
073	Allegan	EB 126th Ave. & 66th St.	I	2

074	Bay	NB Mackinaw Rd. & Cody-Estey Rd.	I	2
075	Jackson	EBD I-94 & Elm Ave. (Exit 141)	ER	2
076	Kent	NBD US-131 & 100th St. (Exit 72)	ER	2
077	Ottawa	NBD I-196 & Byron Rd.	ER	2
078	Kent	SBP US-131 & Hall St.	ER	2
079	Macomb	SBP M-53 & 26 Mile Rd.	ER	2
080	Bay	NBD I-75 & Wilder Rd. (Exit 164)	ER	2
081	Livingston	EBD I-96 & Fowlerville Rd. (Exit 129)	ER	2
082	Macomb	EBP I-94 & 12 Mile Rd. (Exit 231)	ER	2
083	Jackson	WBD I-94 & Sargent Rd. (Exit 145)	ER	2
084	Allegan	NBP US-31/I-196 & Washington Rd./Blue Star Hwy. (Exit 47A)	ER	2
085	Calhoun	EB O Dr. N. & 12 Mile Rd.	I	3
086	Berrien	EB Mayflower Rd. & Chicago Rd.	I	3
087	Marquette	SWB C.R. 456 & Sporley Lake Rd.	I	3
088	Lenawee	EB Munger Rd. & M-52	I	3
089	Genesee	EB Pierson Rd. & Elms Rd.	I	3
090	Clinton	NB Scott Rd. & M-21/State	I	3
091	Calhoun	WB R Dr. S. & 8 Mile Rd./Adolph Rd.	I	3
092	Calhoun	EB V Dr. N. & 20 Mile Rd.	I	3
093	Calhoun	NWB Dickman Rd./M-96 & Avenue A	I	3
094	St. Clair	WB Hewitt Rd. & Fargo Rd.	I	3
095	Monroe	SB Swan Creek Rd. & Labo Rd.	I	3
096	Muskegon	EB Sweeter Rd. & Maple Island	I	3
097	Calhoun	SB P Dr. N./Yawger Rd. & Hubbard Rd./5 Mile Rd.	I	3
098	St. Clair	WB Bryce Rd. & Cribbins Rd.	I	3
099	St. Clair	WB Lindsey Rd. & Palms Rd.	I	3
100	Van Buren	SB Broadway/M-140 & Phoenix Rd./BL I-196/C.R. 388	I	3
101	Ionia	SB Fisk Rd./Heffron Rd. & Montcalm Ave.	I	3
102	Clinton	EB Taft Rd. & Shepardsville Rd.	I	3
103	Calhoun	SB S. County Line Rd. & 23 Mile Rd.	I	3
104	Calhoun	NB Waubascon Rd./4 ½ Mile Rd. & Baseline Rd.	I	3
105	Monroe	WB Day Rd. & Ann Arbor Rd.	I	3
106	St. Joseph	WB Balk Rd./C.R. 139 & Grim Rd./Sherman Mills Rd.	I	3
107	Lapeer	EB Armstrong/C.R. 7 & M-53/Van Dyke Hwy.	I	3
108	Saginaw	SB Chapin N./Kane Rd. & Frost Rd.	I	3
109	St. Clair	SB Werner/Ellsworth & Gratiot	I	3
110	Lenawee	NB Ogden Hwy. & US-223	I	3

111	Lapeer	SB Wheeling Rd. & Bowers Rd./M-52	I	3
112	Saginaw	NB Raucholz Rd. & Ithaca Rd.	I	3
113	Shiawassee	NEB Winegar Rd. & Lansing Rd.	I	3
114	St. Joseph	SB Rosenbaugh Rd./40th St. & Michigan Ave./C.R. 120	I	3
115	Saginaw	NB East Rd. & Ditch Rd.	I	3
116	Muskegon	EB Heights-Ravenna Rd. & Sullivan Rd.	I	3
117	Saginaw	S/EBD I-675 & Veterans Memorial Parkway (Exit 1)	ER	3
118	Genesee	NBP I-475 & Bristol Rd./Hemphill/M-121 (Exit 4)	ER	3
119	Calhoun	EBP I-94 & 26 Mile Rd./25 ½ Mile Rd. (Exit 119)	ER	3
120	Berrien	WBD I-94 & M-239/La Porte (Exit 1)	ER	3
121	Van Buren	N/EBP US-31/I-196 & M-140 (Exit 18)	ER	3
122	Monroe	NBD I-75 & Huron River Dr. (Exit 26, to South Huron River Drive)	ER	3
123	Genesee	SBD US-23/I-75 & Mount Morris Rd. (Exit 126)	ER	3
124	Isabella	SBD US-27/US-127 & M-20	ER	3
125	Genesee	EBD I-69 & Belsay Rd. (Exit 141)	ER	3
126	St. Clair	WBD I-94/I-69 & Water St.	ER	3
127	Wayne	WB 8 Mile Rd. & Beck Rd.	I	4
128	Wayne	EB Warren Rd. & Wayne Rd.	I	4
129	Wayne	EB McNichols Rd. & Woodward Ave.	I	4
130	Wayne	NB Canton Center Rd. & Cherry Hill Rd.	I	4
131	Wayne	WB Ecorse Rd. & Pardee Rd.	I	4
132	Wayne	EB Michigan Ave. & Sheldon Rd.	I	4
*133	Wayne	EB Ecorse Rd. & Middlebelt Rd.	I	4
134	Wayne	NB M-85/Fort Rd. & Emmons Rd.	I	4
135	Wayne	WB Glenwood Rd. & Wayne Rd.	I	4
136	Wayne	NB Haggerty Rd. & 7 Mile Rd.	I	4
137	Wayne	WB 6 Mile Rd. & Inkster Rd.	I	4
138	Wayne	SB Inkster Rd. & Goddard Rd.	I	4
139	Wayne	SB Merriman Rd. & Cherry Hill Rd.	I	4
140	Wayne	SEB Outer Dr. & Pelham Rd.	I	4
141	Wayne	NB Meridian Rd. & Macomb Rd.	I	4
142	Wayne	WB Ford Rd. & Venoy Rd.	I	4
143	Wayne	SWB Vernor Rd. & Gratiot Rd.	I	4
144	Wayne	WB 5 Mile Rd. & Beck Rd.	I	4
145	Wayne	EB 7 Mile Rd. & Livernois Rd.	I	4
146	Wayne	NB Gunston/Hoover Rd. & McNichols Rd.	I	4
147	Wayne	SB W. Jefferson/Biddle Ave. & Southfield Rd.	I	4
148	Wayne	EB Goddard Rd. & Wayne Rd.	I	4

149	Wayne	WB 8 Mile Rd. & Kelly Rd.	I	4
150	Wayne	SB Merriman Rd. & US-12/Michigan Ave.	I	4
151	Wayne	SB Telegraph Rd. & Plymouth Rd.	I	4
152	Wayne	WB Sibley Rd. & Inkster Rd.	I	4
153	Wayne	NEB Mack Rd. & Moross Rd.	I	4
154	Wayne	WB Annapolis Rd. & Inkster Rd.	I	4
155	Wayne	SB Greenfield Rd. & Grand River Rd.	I	4
156	Wayne	EB Joy Rd. & Livernois Rd.	I	4
157	Wayne	SEB Conner Ave. & Gratiot Rd.	I	4
158	Wayne	NWB Grand River Rd. & Wyoming Ave.	I	4
159	Wayne	WBP I-96 & Evergreen Rd.	ER	4
160	Wayne	WBP I-94 & Haggerty Rd. (Exit 192)	ER	4
161	Wayne	NBD I-75 & Gibraltar Rd. (Exit 29)	ER	4
162	Wayne	SBP I-75 & Southfield Rd.	ER	4
163	Wayne	NBD I-275 & 6 Mile Rd. (Exit 170)	ER	4
164	Wayne	NBP I-275 & M-153/Ford Rd. (Exit 25)	ER	4
165	Wayne	NBD I-275 & Eureka Rd. (Exit 15)	ER	4
166	Wayne	NBP I-75 & Springwells Ave. (Exit 45)	ER	4
167	Wayne	WBD I-94 & Pelham Rd. (Exit 204)	ER	4
168	Wayne	SBD I-75 & Sibley Rd.	ER	4

APPENDIX B

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:

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

where $var(r_i)$ equals the variance within a stratum and vehicle type, n is the number of observed intersections, g_i is the weighted number of vehicle occupants at intersection I, g_k is the total weighted number of occupants for a certain vehicle type at all 42 sites (14 in the mini survey) 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 2.1×10^{-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 for each vehicle type was calculated using the formula:

$$\text{var}(r_{all}) = \frac{\text{var}(r_1) + \text{var}(r_2) + \text{var}(r_3) + 0.83^2 \times \text{var}(r_4)}{3.83^2}$$

The Wayne County stratum variance was multiplied by 0.83 to account for the similar weighting that was done to estimate overall belt use. The 95 percent confidence intervals were calculated using the formula:

$$95\%\ \textit{Confidence Band} = r_{all} \pm 1.96 \times \sqrt{\textit{Variance}}$$

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:

$$\text{Relative Error} = \frac{\text{Standard Error}}{r_{all}}$$

The federal guidelines (NHTSA, 1992, 1998) stipulate that the relative error of the belt use estimate must be under 5 percent.

APPENDIX C

PDA Data Collection Details

During the current study, all data collection was conducted using Personal Digital Assistants (PDAs). The original transition from paper to PDA data collection was made primarily to decrease the time necessary to move from the end of the data collection phase of a survey to data analysis. With paper data, there is automatically two to three weeks of additional time built-in while the paper data are being entered into an electronic format. Before making this transition, a pilot study was conducted to compare data collection by PDA to paper. Several key factors were tested during the pilot study including accuracy, volume (speed), ease of use, mechanical issues (i.e. battery life), and environmental issues (i.e. weather, daylight). The pilot study found PDA use to be equal to, or better than paper data collection on every factor tested. Before making the change to PDA data collection, an electronic version of the *Site Description Form* and *Observation Form* was developed. The following pages show examples of the electronic form and discuss other factors related to using PDAs for safety belt data collection.

The goal of adapting the existing paper forms to an electronic format was to create an electronic form that was very similar to the paper forms, while taking advantage of the advanced, built-in capabilities of the PDA. As such, the electronic data collection form incorporated a built-in traffic counter and included high resolution color on the screens. Screens 1 and 2 are shown in Figure 10. Screen 1 shows the vehicle choice page, which is the first screen of the data collection form. Once at a site, observers tap on the site description form (SDF) button. This portion of the data collection form, shown in Screen 2, allows users to type in the site location (street names and standing location). Observers use the PDA stylus to tap on the appropriate choices of site type, site choice, and traffic control. If a mistake is made, the observer can change the data they have input, simply by tapping on the correct choice. All selected choices appear highlighted on the screen.

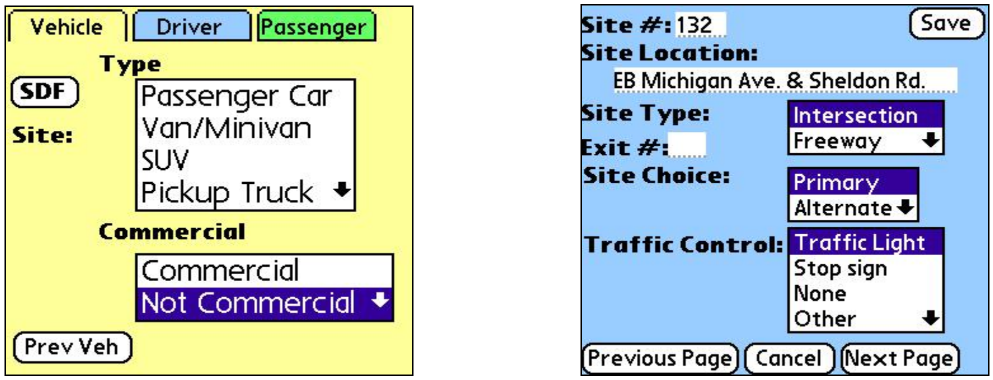

Figure 10. Data Collection Form - Screens 1 and 2

Screens 3 and 4 are shown in Figure 11. As seen in this figure, observers enter their observer number, the weather, day of week, and median information, simply by tapping the appropriate choice on the display list. The date is manually typed in using the buttons on the PDA keyboard. Screen 4 allows users to sketch in the intersection and show where they are standing, and to record the start time for the site.

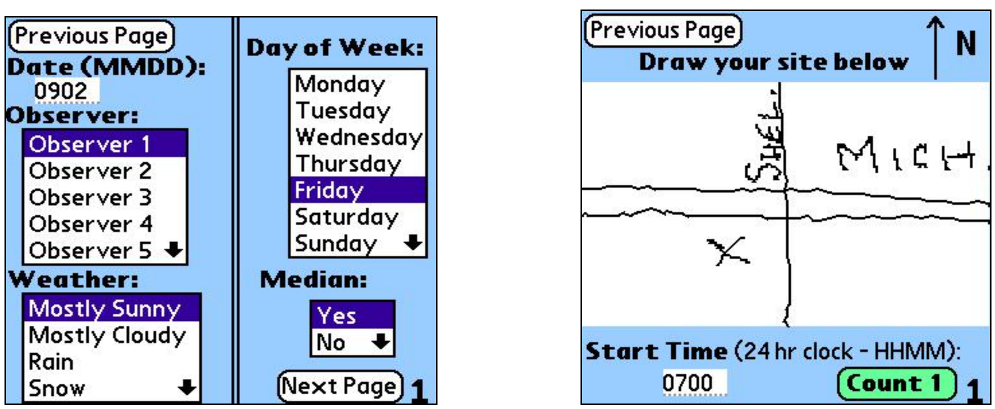

Figure 11. SDF portion of data collection form - Screens 3 and 4

In the past, observers had to put away their paper form, get out a mechanical traffic counter, and begin a traffic count after entering the start time. Using a PDA, it is possible to incorporate a traffic counter directly into the data collection form.[5] Figure 12 shows an example of the electronic traffic counter screen. To count each vehicle that passes, observers tap on the large "+" button. The size of this button allows the observer to tap the screen while keeping their eyes on the roadway. Each tap

[5] The PDA traffic counting method was compared with a mechanical counter during the pilot testing and no difference was found between the two methods.

increases the count that is displayed at the top of the screen. If a mistake is made, the observer can decrease the count by tapping on the small "-" button on the left of the screen.

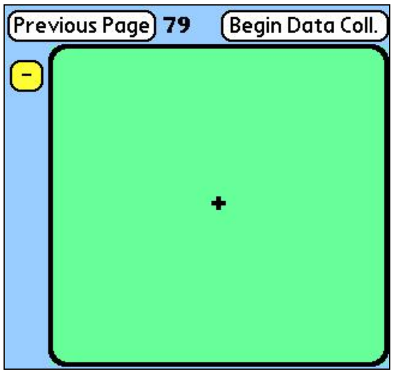

Figure 12. Traffic Counter Screen

After the traffic count has concluded, the user can simply tap on the "Begin Data Collection" button and begin observations. To allow for easier data entry, the observation form portion of the electronic data collection form was divided into three screens, one for vehicle information, one for driver information, and one for front-right passenger information. As shown in Figure 13, each screen is accessible by tapping on the appropriate tab along the top of the screen. The screens have also been designed with different colors, with the vehicle screen yellow, the driver screen blue, and the passenger screen green. The first screen that appears in the form is the vehicle screen. Users select the vehicle type by tapping in the appropriate place on the screen. "Not Commercial" is selected as a default on this screen since the majority of observed vehicles are not used for commercial purposes.

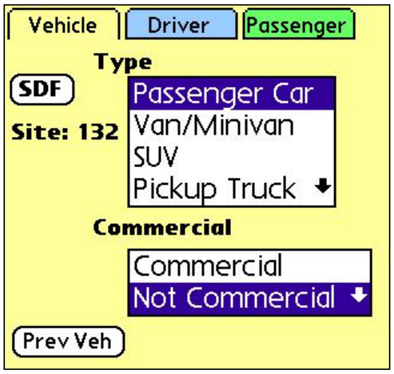

Figure 13. Data Collection Form - Vehicle Screen

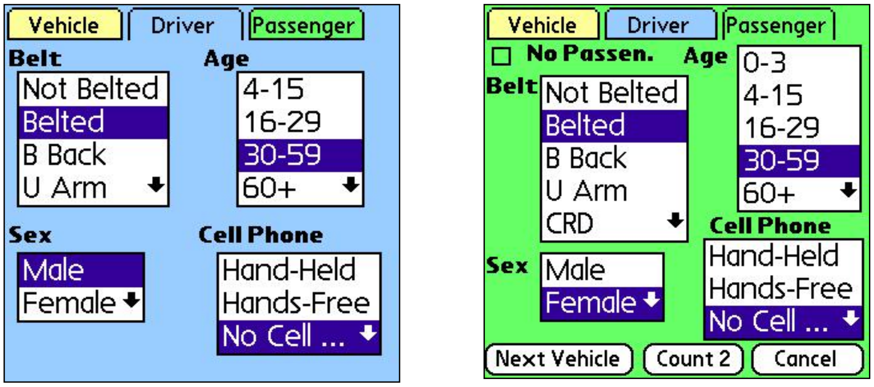

Figure 14. Data Collection Form - Driver and Passenger Screens

Figure 14 shows the driver and passenger screens from the data collection form. Each category of data, along with the choices for each category, are displayed on the screen. Users simply tap on the choices that correspond to the motorist that is being observed. These data then appear highlighted on the screen. Since most motorists are not actively using a cellular phone while driving, "No Cell Phone" is already highlighted as a default. If the motorist is using a cell phone, the proper choice can simply be selected from the list. There is also a "No Passenger" area that can be selected if there is no passenger present. If a passenger is present, users can leave the area unchecked and continue to enter passenger information. Once data are complete for one vehicle, observers tap the "Next Vehicle" button to continue collecting data. The last screen of the data collection form, shown in Figure 15, allows the user to enter the end time of the site observation and interruption (if any). Finally, the observers can type in any comments regarding the site or traffic flow that may be important.

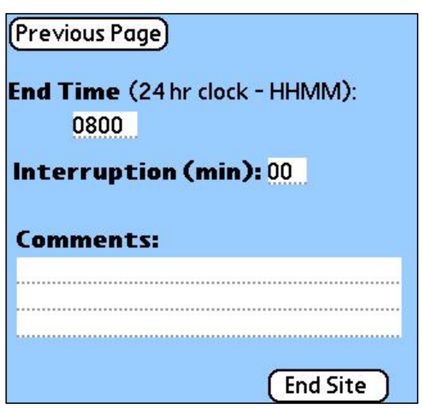

Figure 15. Data Collection Form - Final Screen

Each PDA also had a built-in cellular phone as well as wireless e-mail capability. At regular intervals, usually twice a day, observers e-mailed completed data directly from the PDA to the project supervisor. Data collection form files from completed sites were “zipped,” using a compression program, and then transmitted directly to a pre-determined e-mail account. The e-mailing of data allowed the project field supervisor to immediately check data for errors, and begin to compile a data analysis file as the project progressed. After data transmission, the observer transferred the site data from the internal memory of the PDA to a Secure Digital (SD) memory card.