Minnesota Safety Belt and Motorcycle Helmet Use: August, 2006

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Consultant's Report

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INTRODUCTION

It is now well established that the use of a safety belt will reduce the severity of injury, and the chances of a fatality, during a motor vehicle crash. In spite of this clear safety benefit, not all motorists use safety belts consistently. In order to encourage use of safety belts, states such as Minnesota have turned to legislation.

On August 1, 1986, the state of Minnesota enacted a mandatory safety belt use law (Insurance Institute for Highway Safety, IIHS, 2005a). Prior to the implementation of this law, observed belt use in Minnesota was only at about 20 percent (Minnesota Office of Traffic Safety, OTS, 2005a). Over the two decades since this legislation was passed, the use rate across the state is still under 85 percent (Eby, Vivoda, & Cavanagh, 2006). Although this rate is above the 2005 national belt use average of 80 percent (Glassbrenner, 2005a), many Minnesota residents are needlessly dying unbelted in traffic crashes.

When Minnesota first implemented the safety belt law, it included a provision known as secondary enforcement. This provision does not allow police officers to stop a motorist solely for safety belt non-use. A motorist can only be cited for failing to buckle up if they are stopped for some other infraction, and also are not wearing a safety belt. Secondary enforcement provisions were commonly included in safety belt legislation implemented in many states during the 1980s. However, as time passed, traffic safety professionals and legislators in some states began to push for a change in this provision from secondary to primary. As several states made this change in the mid 1990s and 2000s, these states experienced dramatic increases in safety belt use as a result of the change. In fact, nine of the first ten states that changed from secondary to primary enforcement saw increases that ranged from 8-22 percentage points. Currently, the National Highway Traffic Safety Administration (NHTSA) recognizes making this change as the single most efficient and cost effective means to increase safety belt use. While the observed belt use rate for Minnesota in 2003 was among the highest belt use rates for states with secondary enforcement (NHTSA, 2004a), there is still much work to be done. Currently, the states with the highest belt use rates all have primary enforcement provisions.

The safety belt goal for states set by NHTSA is 90 percent compliance. It is estimated that if the change to primary enforcement was made in Minnesota now, the use rate would likely increase immediately to about 93 percent belt use (OTS, 2005b). This increase would result in an estimated 55 additional lives saved and 1,000 additional injuries prevented (OTS, 2005b), not to mention the monetary savings. A belt use rate of 93 percent would also add Minnesota to a list of only six other states that have achieved a use rate higher than 90 percent.

While there is still important work to be done for Minnesota to achieve the safety belt use goal set by NHTSA, it is important to note the significant strides that have been made since the first implementation of the belt use law in 1986. Traffic safety professionals in Minnesota should continue to push to change the enforcement provision of the safety belt law in the state, but in the interim must also continue with intensive police enforcement and media campaigns. In addition to the challenges faced in trying to get the remaining motorists to buckle-up in Minnesota, other important traffic safety issues must also be addressed. One such challenge comes in the form of getting motorcycle riders to wear helmets on Minnesota roadways.

Under the current state law, only motorcycle permit holders and riders under the age of 18 must wear a DOT-approved helmet (OTS, 2005c). In states across the US that do not require helmet use, only about 28 to 40 percent of motorcyclists choose to wear them. However, in states with mandatory helmet laws, compliance is near 100 percent (IIHS, 2005b). Given a crash, the use of a motorcycle helmet is estimated to reduce the likelihood of a fatality by 37 percent (IIHS, 2005b). While there are fewer motorcyclists than other motor vehicle occupants, per mile traveled, there are an estimated 27 times the number of deaths for motorcyclists than those traveling in cars (IIHS, 2005b). The simplest way to increase helmet use among motorcyclists is to implement a mandatory helmet law.

The purpose of the current survey was to assess continuing efforts in Minnesota to increase safety belt use statewide. This survey wave will also provide additional information to track longitudinal changes in safety belt use in Minnesota by several demographic and vehicle characteristics. Finally, the current survey wave will collect information about how many motorcyclists are wearing helmets on Minnesota roadways. This information will provide a starting point for understanding the scope of this problem in the state.

METHODS

Sample Design

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 Minnesota, 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, 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 87 Minnesota counties were rank ordered by population (US Census Bureau, 2003) and the low population counties were eliminated from the sample space. This step reduced the sample space to 37 counties.

These 37 counties were then 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 examining results from three previous statewide safety belt surveys conducted in Minnesota. Since no historical data were available for 22 of the counties, belt use rates for these counties were estimated using multiple regression based on educational attainment for the other 15 counties (r^2 = .35; US Census Bureau, 2003).[1] This factor has been shown previously to correlate positively with belt use. Hennepin County was chosen as a separate stratum because of its disproportionately high VMT. 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, medium belt use, low belt use, and Hennepin County. Hennepin County VMT was slightly lower than the collective VMTs in the other strata (94%). Stratum boundaries for the sample space are shown in Table 1.

To achieve the NHTSA required precision of less than 5 percent relative error,

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

the minimum number of observation sites for the survey 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 number was then increased (N = 240) to get an adequate representation of belt use for each day of the week and for all daylight hours.

Because total VMT within each stratum was roughly equal, observation sites were evenly divided among the strata (60 each). In addition, since an estimated 29 percent of all traffic in Minnesota occurs on limited-access roadways (Federal Highway Administration, 2002), each stratum was further divided into two strata, one of which contained 17 limited access sites (exit ramps) to represent the 29% of VMT on limited access roadways and one that contained 43 roadway intersections. Thus, the sample design had a total of 8 strata.

Table 1: Listing of the Counties Within Each Stratum	
Stratum	**Counties**
High Belt Use **Stratum 1: intersections** **Stratum 5: exit ramps**	Carver, Dakota, Olmsted, Ramsey, Wright
Hennepin **Stratum 2: intersections** **Stratum 6: exit ramps**	Hennepin
Medium Belt Use **Stratum 3: intersections** **Stratum 7: exit ramps**	Beltrami, Blue Earth, Clay, Crow Wing, Freeborn, Goodhue, Kandiyohi, Nicollet, Rice, Scott, Sherburne, St. Louis, Steele, Washington
Low Belt Use **Stratum 4: intersections** **Stratum 8: exit ramps**	Anoka, Becker, Benton, Brown, Carlton, Cass, Chisago, Douglas, Isanti, Itasca, McLeod, Morrison, Mower, Otter Tail, Polk, Stearns, Winona

Within each intersection stratum, observation sites were randomly assigned to a location using a method that ensured each intersection within a stratum an equal probability of selection. Detailed, equal-scale road maps for each county within the sample space were obtained and a grid pattern was overlaid on the maps. The lines of the grid were separated by 1/4 inch, thus creating grid squares that were about 3/4 of a mile per side. The grid patterns were created by printing a grid design onto transparencies and uniquely identifying each grid square by two numbers, a horizontal (x) coordinate and a vertical (y) coordinate. Additional grid transparencies were printed until enough were available to cover all counties within the stratum. Each transparency was numbered to allow for a simpler grid square numbering scheme.

The 43 local intersection sites were chosen by first randomly selecting a transparency number and then a random *x* and a random *y* coordinate within the identified transparency grid sheet. 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 stratum, or there was no intersection within the square, then a new transparency number and *x*, *y* coordinate were randomly selected. If more than one intersection was 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 chosen. Thus, each intersection within the stratum had an equal probability of selection.

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 a given standing location 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.

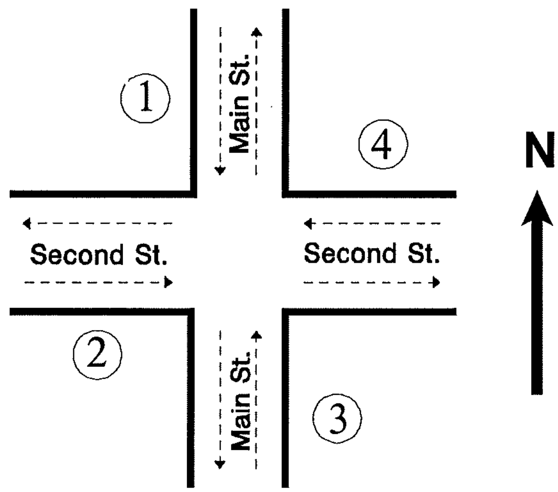

Figure 1. An Example "+" Intersection Showing 4 Possible Observer Locations.

For each primary intersection site, an alternate site was also selected. The alternate sites were chosen within a five square mile area around the grid square containing the original intersection. This was achieved by randomly picking an *x*, *y* grid coordinate within an alternate site grid transparency consisting of 7 squares horizontally by 7 squares vertically, centered around the primary site. Coordinates were selected until a grid square containing an intersection was found. The observer location at the alternate intersection was determined in the same way as at the primary site.[1]

The 17 freeway exit ramp sites for the exit ramp strata were also selected using a method that allowed equal probability of selection for each exit ramp within the stratum.[2] This was done by enumerating all of the exit ramps within a stratum and randomly selecting, without replacement, 17 numbers between 1 and the number of exit ramps in the stratum. For example, in the low belt use stratum there were a total of 75 exit ramps; therefore a random number between 1 and 75 was generated. This number corresponded to a specific exit ramp within the stratum. To select the next exit ramp, another random number between 1 and 75 was selected with the restriction that no

[1] 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/.

[2] 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.

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 the county or if it was already selected as a primary site, then the other direction of travel along the freeway was used.

After all sites and standing locations were randomly selected, all intersection and exit ramp sites were visited by a researcher prior to the beginning of data collection to determine their usability. If an intersection site had no traffic control device on the selected direction of travel, but had traffic control on the intersecting street, the researcher randomly picked a new standing location using a coin flip. If an exit ramp site had no traffic control on the selected direction of travel, the researcher randomly picked a travel direction and lane that had such a device.

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 - 6:00 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 one 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 a clockwise or counter-clockwise loop. The direction of the loop 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 observation interval was a constant duration (50 minutes) for each site. 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). These counts were used to estimate the number of possible observations so that sites could be weighted by traffic volume.

Data Collection

Data collection for the survey involved direct observation of shoulder belt use, estimated age, and sex. Trained field staff observed shoulder belt use of drivers and front-right passengers traveling in passenger cars, sport-utility vehicles, vans/minivans, and pickup trucks during daylight hours August 4-19, 2006. Observations of safety belt use, sex, age, vehicle type, and vehicle purpose (commercial or noncommercial) were conducted when a vehicle came to a stop at a traffic light or a stop sign. Vehicles were included without regard to the state in which the vehicle was registered.

Data Collection Forms

Data were collected using personal digital assistants (PDAs). For a more detailed description of the PDA data collection process, see Appendix A. To begin, an electronic form was developed for data collection containing: a site description section and a safety belt observation section. For each site surveyed, separate electronic copies of the form were created in advance. The site description form section 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 also furnished for observers to electronically sketch the intersection and to identify observation location. Finally, a comments section was 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 safety belt observation section of the form was used to record safety belt use or motorcycle helmet use, passenger information, and vehicle information. For each vehicle surveyed, shoulder belt use or helmet use, sex, and estimated age of the driver and the front-outboard passenger (or motorcycle 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. The observer also recorded whether the vehicle was commercial or noncommercial. A commercial vehicle is 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 one hour. Upon arriving at a site, the observer determined whether observations were possible at the site. If observations were not possible (e.g., due to construction), the observer proceeded to the alternate site. Otherwise, the observer completed the site description form and then moved to their observation position near the traffic control device. Observers were instructed to observe only vehicles in the lane immediately adjacent to the curb, regardless of the number of lanes present.

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. 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.

Observer Training

Prior to data collection, members of the Minnesota Department of Public Safety, Office of Traffic Safety staff were trained on field data collection procedures. The training of OTS staff included both classroom review of data collection procedures and practice field observations. Field observers were then hired and trained by OTS staff on the proper procedures for data collection. Each observer received a training manual containing detailed information on field procedures for observations, data collection forms, 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 B for a listing of the sites). During data collection, observers were spot checked in the field by a field supervisor to ensure adherence to study protocols.

Descriptive Statistics

Table 2 shows descriptive statistics for the survey. As shown in this table, the observations were fairly well distributed over day of week. Observations were also well distributed by time of day except for the earliest and latest time periods. 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 the majority of sites observed were the primary sites and that observations were mostly conducted during sunny or cloudy conditions. A small number of observations were conducted during rain, and none during snow.

Table 2. Descriptive Statistics for the 240 Observation Sites

Day of Week		Observation Period		Site Choice		Weather	
Monday	12.6%	7-9 a.m.	8.8%	Primary	97.9%	Sunny	63.2%
Tuesday	17.6%	9-11 a.m.	27.6%	Alternate	2.1%	Cloudy	30.1%
Wednesday	9.2%	11-1 p.m.	22.6%			Rain	6.7%
Thursday	13.8%	1-3 p.m.	19.7%			Snow	0.0%
Friday	20.5%	3-5 p.m.	16.7%				
Saturday	10.0%	5-7 p.m.	4.6%				
Sunday	16.3%						
TOTALS	100.0%		100.0%		100.0%		100.0%

Data Processing and Estimation Procedures

The safety belt data were entered into PDAs directly, so no additional data entry was required. For each site, computer analysis programs determined the number of observed vehicles, belted and unbelted drivers, belted and unbelted passengers, and use and nonuse of motorcycle helmets for drivers and 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 Minnesota based on VMT. As also discussed, not all eligible vehicles passing the observer could be included in the survey. To correct for this limitation, the vehicle count information was used to weight the observed traffic volumes so that an estimate of traffic volume at the site could be derived.

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. 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 is 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. All analyses reported are based upon the weighted values.

Estimation of Safety Belt Use Rates

The overall safety belt use rate for Minnesota was calculated utilizing the following procedure. The safety belt use rate for each stratum was calculated using the following formula:

$$R_s = \sum \frac{est_i}{obs_i} belted_i \Big/ \sum \frac{est_i}{obs_i} occs_i$$

Where R_s is the use rate for a stratum, i is a site in the stratum, est_i is the estimated number of possible observations had every eligible vehicle been recorded (based on the vehicle counts), obs_i is the actual number of people observed, $belted_i$ is the number of people observed using a safety belt, and $occs_i$ is the number of occupants.

Because the number of intersections among the first four strata and the number of exit ramps among the last four strata differed, the probability of an intersection or exit ramp being randomly selected differed between strata. Therefore, we painstakingly counted all intersections in the first four strata and all exit ramps in the last four strata and used these counts to weight use rates when combining them. The first four strata (intersections) were combined using the following formula:

$$R_i = \frac{\frac{4N_1}{N_{all}}R_1 + \frac{4N_2}{N_{all}}R_2 + \frac{4N_3}{N_{all}}R_3 + \frac{4N_4}{N_{all}}R_4}{\frac{4N_1}{N_{all}} + \frac{4N_2}{N_{all}} + \frac{4N_3}{N_{all}} + \frac{4N_4}{N_{all}}}$$

$$R_i = \frac{N_1R_1 + N_2R_2 + N_3R_3 + N_4R_4}{N_1 + N_2 + N_3 + N_4}$$

where R_i is the combined use rate for the first four strata (intersections), N_1 is the total number of intersections in stratum 1 and so on, and N_{all} is the total number of intersections among all four strata. The use rate for the exit ramp strata (strata 5-8) was calculated using the following formula:

$$R_e = \frac{\frac{4N_5}{N_{all}}R_5 + \frac{4N_6}{N_{all}}R_6 + \frac{4N_7}{N_{all}}R_7 + \frac{4N_8}{N_{all}}R_8}{\frac{4N_5}{N_{all}} + \frac{4N_6}{N_{all}} + \frac{4N_7}{N_{all}} + \frac{4N_8}{N_{all}}}$$

$$R_e = \frac{N_5R_5 + N_6R_6 + N_7R_7 + N_8R_8}{N_5 + N_6 + N_7 + N_8}$$

where R_e is the combined use rate for strata 5-8 (exit ramps), N_5 is the total number of exit ramps in stratum 5 and so on, and N_{all} is the total number of exit ramps among all four strata.

Because only statewide VMT for limited access roadways was available and because only 29 percent of Minnesota travel is on limited access roadways, the statewide safety belt rate was determined weighting R_e and R_i by their VMT using the following equation:

$$R_{MN} = \frac{VMT_i R_i + VMT_e R_e}{VMT_i + VMT_e}$$

Estimation of Variance

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

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

where *var(r$_i$)* equals the variance within a stratum, *n* is the number of observed intersections, g_i is the weighted number of vehicle occupants at intersection *I*, g_k is the total weighted number of occupants at all 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 was negligible and was dropped in the variance calculations as is common practice.

Again because the number of intersections and exit ramps differed among the strata, when the variances were combined, they were weighted by the number of intersection/exit ramps within each strata. The variances for the first four (intersection) strata were combined using the following formula:

$$\text{var}(Ri) = \left(\frac{N_1}{N_{all}}\right)^2 \text{var}(R_1) + \left(\frac{N_2}{N_{all}}\right)^2 \text{var}(R_2) + \left(\frac{N_3}{N_{all}}\right)^2 \text{var}(R_3) + \left(\frac{N_4}{N_{all}}\right)^2 \text{var}(R_4)$$

The variance for the exit ramp strata were combined using the following formula:

$$\text{var}(\text{Re}) = \left(\frac{N_5}{N_{all}}\right)^2 \text{var}(R_5) + \left(\frac{N_6}{N_{all}}\right)^2 \text{var}(R_6) + \left(\frac{N_7}{N_{all}}\right)^2 \text{var}(R_7) + \left(\frac{N_8}{N_{all}}\right)^2 \text{var}(R_8)$$

The overall variance was determined by weighting the intersection and exit ramp variances relative to the statewide VMT for these types of roadways using the following equation:

$$\mathrm{var}(R) = \frac{(VMT_i)^2 \mathrm{var}(R_i) + (VMT_e)^2 \mathrm{var}(R_e)}{(VMT_i + VMT_e)^2}$$

The 95 percent confidence band was calculated using the formula:

$$95\% ConfidenceBand = R \pm 1.96\sqrt{\mathrm{var}(R)}$$

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

$$RelativeError = \frac{SE}{R}$$

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

RESULTS

This survey reports statewide safety belt use for four vehicle types combined (passenger cars, vans/minivans, sport-utility vehicles, and pickup trucks) and use rates for occupants in each vehicle type separately. In addition, motorcycle helmet use data are reported on all occupants riding motorcycles. Following NHTSA (1998) guidelines, the survey included commercial vehicles. Thus, all rates shown in this report include occupants from both commercial and noncommercial vehicles.

Overall Safety Belt Use

Table 3 shows that the estimated safety belt use rate in Minnesota for all front-outboard occupants traveling in either passenger cars, sport-utility vehicles, vans/minivans, or pickup trucks in the front-outboard positions in Minnesota during August 2006 was **83.3 ± 1.9** percent. The "±" value following the use rate indicates a 95 percent confidence interval around the percentage. The relative error for the statewide safety belt use rate of 1.16 percent was well below the 5 percent maximum level required by NHTSA.

Table 3: Safety Belt Use Rates and Unweighted Ns as a Function of Survey, Stratum, Roadway Type, and Overall Statewide Safety Belt Use

	Percent Use	Unweighted N
Stratum 1 (High, Intersections)	83.7	1,853
Stratum 2 (Hennepin, Intersections)	87.0	3,331
Stratum 3 (Medium, Intersections)	83.9	1,133
Stratum 4 (Low, Intersections)	79.0	1,760
Stratum 5 (High, Exit Ramps)	87.3	1,762
Stratum 6 (Hennepin, Exit Ramps)	87.4	1,987
Stratum 7 (Medium, Exit Ramps)	81.9	1,226
Stratum 8 (Low, Exit Ramps)	87.5	909
Minnesota, Intersections	82.0	8,077
Minnesota, Exit Ramps	86.4	5,884
STATE OF MINNESOTA	**83.3 ± 1.9%**	**13,961**

Safety Belt Use by Subcategory

Vehicle Type and Stratum. Estimated belt use rates and unweighted numbers of occupants by stratum and vehicle type are shown in Tables 4a through 4d. Within each vehicle type we find little systematic differences in safety belt use by stratum. However, comparing across vehicle types and strata, we find that safety belt use is lower for pickup truck occupants in nearly all cases. Thus, enforcement and public information and education (PI&E) programs should continue to target pickup truck occupants.

Table 4a. Percent Shoulder Belt Use by Stratum (Passenger Cars)

	Percent Use	Unweighted N
Stratum 1	82.8	825
Stratum 2	88.5	1,762
Stratum 3	83.1	527
Stratum 4	79.3	826
Stratum 5	86.6	880
Stratum 6	89.0	1,094
Stratum 7	80.2	587
Stratum 8	87.8	425
STATE OF MINNESOTA	**83.2 ± 2.7%**	6,926

Table 4b. Percent Shoulder Belt Use by Stratum (Sport-Utility Vehicles)

	Percent Use	Unweighted N
Stratum 1	88.4	389
Stratum 2	86.8	718
Stratum 3	85.7	208
Stratum 4	86.1	274
Stratum 5	89.7	362
Stratum 6	86.1	442
Stratum 7	82.8	226
Stratum 8	90.8	168
STATE OF MINNESOTA	**86.6 ± 2.1 %**	2,787

Table 4c. Percent Shoulder Belt Use by Stratum (Vans/Minivans)		
	Percent Use	Unweighted N
Stratum 1	90.6	255
Stratum 2	88.2	446
Stratum 3	90.1	173
Stratum 4	83.3	259
Stratum 5	89.3	244
Stratum 6	90.1	232
Stratum 7	87.9	201
Stratum 8	94.5	149
STATE OF MINNESOTA	**88.1 ± 4.6%**	1,959

Table 4d. Percent Shoulder Belt Use by Stratum (Pickup Trucks)		
	Percent Use	Unweighted N
Stratum 1	75.7	384
Stratum 2	78.1	405
Stratum 3	78.8	225
Stratum 4	70.2	401
Stratum 5	85.2	276
Stratum 6	79.1	219
Stratum 7	80.7	212
Stratum 8	76.9	167
STATE OF MINNESOTA	**76.4 ± 2.1%**	2,289

Site Type. Estimated safety belt use by type of site, vehicle type, and all vehicles combined is shown in Table 5. For all vehicles combined and for each vehicle type, safety belt use was higher for exit ramp sites than for local intersection sites, indicating the belt use for freeway travel was higher than for travel on local roads.

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. Little systematic difference in belt use was found by time of day.

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 2-week period. Belt use clearly varied from day to day, few systematic differences were evident.

Weather. Estimated belt use by prevailing weather conditions, vehicle type, and all vehicles combined is shown in Table 5. Very few sites were conducted during rainy weather conditions, yet these sites showed extremely low use of safety belts. There was essentially no difference in belt use whether it was sunny or cloudy during data collection; a common finding in safety belt research.

Sex. Estimated safety belt use by occupant sex, type of vehicle, and all vehicles combined is shown in Table 5. Estimated safety belt use is higher for females than for males for all vehicle types combined and for each separate vehicle type. It is notable that female belt use in pickup trucks was 90 percent, as high as belt use for women in other vehicle types.

Age. Estimated safety belt use by age, vehicle type, and all vehicle types combined is shown in Table 5. As there were very few 0-10-year olds observed in the current study, the estimated safety belt use rate for this age group is not meaningful. Excluding this group, we found that belt use was high for the 11-15-year olds. Belt use rates for the 16-29-year old age group were consistently the lowest, while rates for the 30-64-year old age group are generally below those of occupants older than 64 years of age. This pattern shows that new drivers and young drivers (16-29 years of age) should 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 there was little systematic difference in belt use by seating position.

Age and Sex. Table 6 shows estimated safety belt use rates and unweighted numbers (N) of occupants for all vehicle types combined by age *and* sex. The belt use rates for the two youngest age groups should be interpreted with caution, and will be excluded form the following discussion, because the unweighted number of occupants is quite low. 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 most notable difference was found in the 16-29-year old age group where the estimated belt use rate was 16.0 percentage points higher for females than for males. These results argue strongly for statewide efforts to continue to be directed toward persuading young males, and males in general, to wear their safety belts.

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	83.3	13,961	83.2	6,926	86.6	2,787	88.1	1,959	76.4	2,289
Site Type										
Intersection	82.0	8,077	81.8	3,940	86.3	1,589	87.2	1,133	74.7	1,415
Exit Ramp	86.4	5,884	86.5	2,986	87.5	1,198	90.5	826	80.5	874
Time of Day										
7 - 9 a.m.	84.2	1,615	88.8	853	93.3	304	91.6	206	67.5	252
9 - 11 a.m.	83.7	2,958	85.9	1,387	82.9	616	90.1	443	74.6	512
11 - 1 p.m.	84.0	2,914	88.1	1,433	84.1	564	92.0	410	69.7	507
1 - 3 p.m.	81.8	3,568	81.9	1,846	88.9	746	81.0	471	78.4	505
3 - 5 p.m.	84.1	2,439	82.8	1,202	87.8	477	91.3	349	76.6	411
5 - 7 p.m.	86.3	467	91.6	205	92.6	80	85.9	80	74.5	102
Day of Week										
Monday	85.3	1,180	83.3	554	82.9	228	97.7	169	81.2	229
Tuesday	82.2	1,788	85.8	812	87.7	317	87.7	274	72.5	385
Wednesday	76.5	1,645	75.3	788	83.0	316	82.6	256	70.6	285
Thursday	83.9	2,489	88.7	1,250	75.0	536	94.4	327	69.0	376
Friday	86.5	4,273	88.6	2,292	83.3	852	89.4	584	79.4	545
Saturday	82.7	1,544	85.7	776	94.3	336	92.1	202	66.9	230
Sunday	80.5	1,042	81.6	454	82.8	202	92.3	147	66.8	239
Weather										
Sunny	83.7	8,963	83.3	4,407	86.9	1,787	89.7	1,267	76.7	1,502
Cloudy	85.5	4,578	87.9	2,323	83.2	943	91.3	623	74.6	689
Rainy	54.4	420	50.5	196	66.0	57	52.9	69	56.7	98
Sex										
Male	79.4	7,864	79.4	3,516	83.4	1,423	86.4	996	73.3	1,929
Female	88.1	6,055	86.8	3,389	89.8	1,358	90.1	955	90.1	353
Age										
0 - 10	87.1	126	85.7	56	81.8	26	95.7	25	96.4	19
11 - 15	92.7	199	96.2	68	84.2	51	93.5	69	100.0	11
16 - 29	74.1	3,679	75.4	2,311	84.2	596	82.8	254	58.0	518
30 - 64	85.5	8,265	86.1	3,485	86.4	1,923	87.2	1,350	81.2	1,507
65 - Up	88.6	1,683	88.7	1,002	94.5	188	95.6	260	78.4	233
Position										
Driver	83.5	11,269	83.7	5,671	86.3	2,258	87.9	1,488	76.8	1,852
Passenger	82.2	2,692	81.1	1,255	87.2	529	87.8	471	74.4	437

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 - 10	96.0	75	69.5	49
11 - 15	92.2	111	95.2	87
16 - 29	66.0	1,928	82.0	1,742
30 - 64	82.6	4,813	89.5	3,428
65 - up	83.5	934	94.0	748

Safety Belt Use Trends

The current survey marks the seventh full statewide survey that has utilized the survey designed approved by NHTSA in 2003. In addition to the full surveys, the authors have also conducted several mini-surveys that yielded overall statewide belt use estimates only. This section examines trends in Minnesota belt use since August 2003.

Statewide Belt Use: Figure 2 shows the estimated overall statewide safety belt use rate for Minnesota from August, 2003 to the present survey conducted in August, 2006. As can be seen in this figure, safety belt use has not increased appreciably in the last two years. Based on the best fitting trend line (shown by a dashed line), if belt use in Minnesota continues to increases at the same rate as it has since 2003, belt use in the state will not reach 90 percent until 2012.

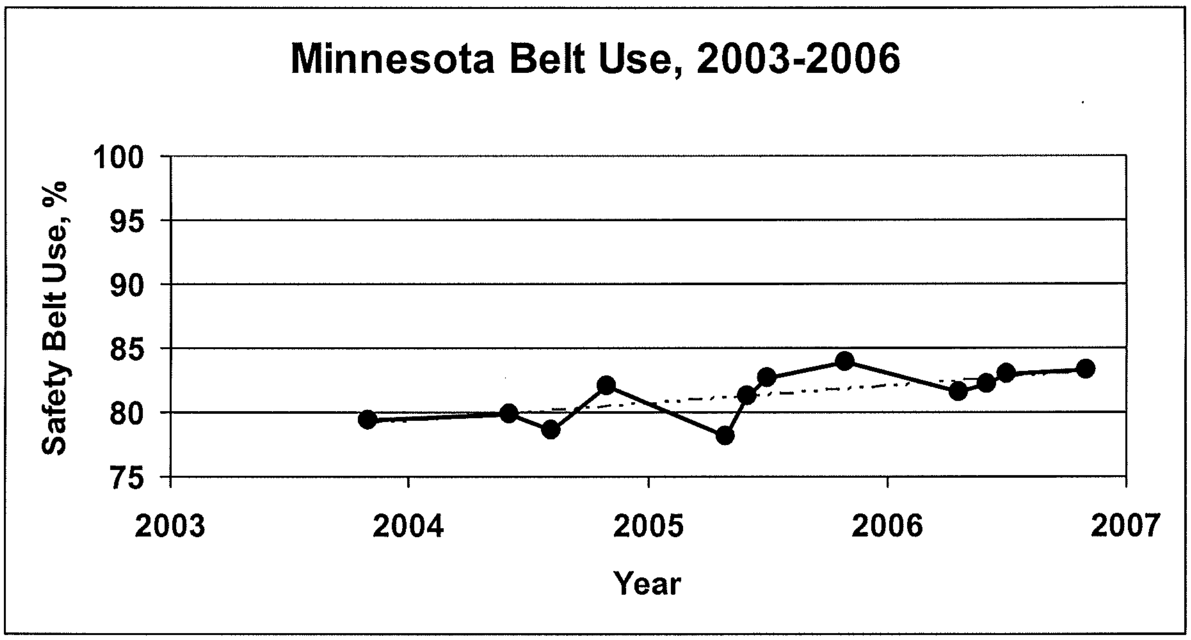

Figure 2: Minnesota safety belt use from 2003 to 2006 and best fitting trend line.

Site Type: Figure 3 shows the estimated statewide safety belt use rate by site type for Minnesota since 2003. Only data from full surveys have been included in this graph, since the mini-surveys have too few observations to make solid estimates of belt use by this variable. As can be seen in this figure, safety belt use at exit ramps has been consistently higher than use at intersections. Although there has been a fair amount of variability from survey-to-survey, belt use at both types of sites has increased gradually at about the same rate since 2003.

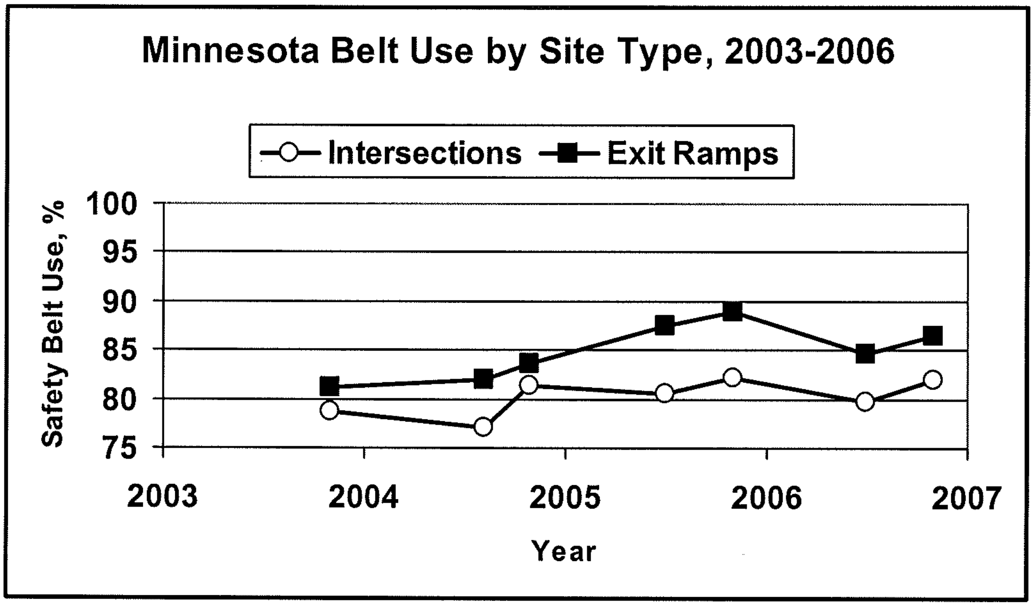

Figure 3: Minnesota safety belt by type of site, 2003-2006.

Sex: Figure 4 shows the estimated statewide safety belt use rate by sex for Minnesota since 2003. As can be seen in this figure, safety belt use for females has been consistently higher than use for males, a common finding in the occupant protection device use literature. Belt use for both sexes appears to have increased at the same rate since 2003.

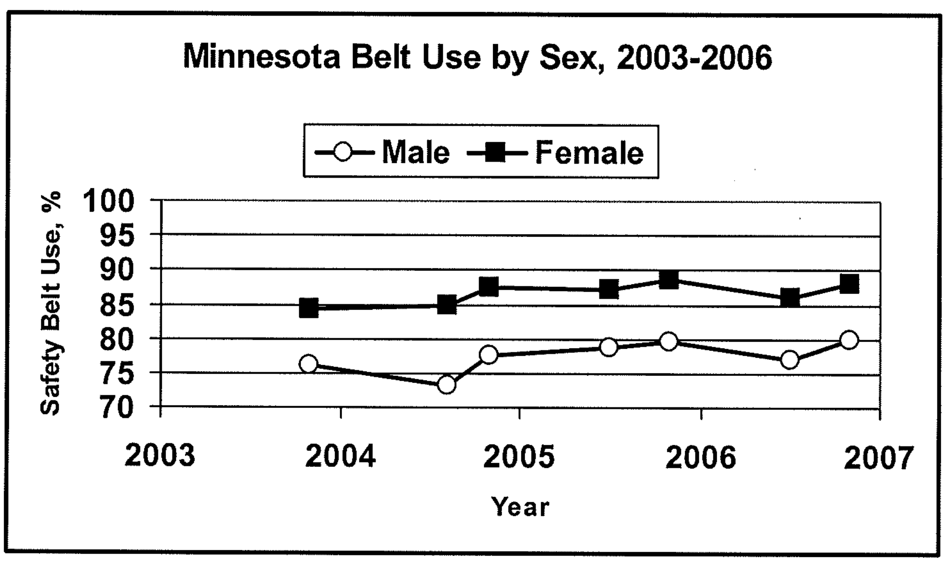

Figure 4: Minnesota safety belt by sex, 2003-2006.

Age: Figure 5 shows the estimated statewide safety belt use rate by age for Minnesota since 2003. As can be seen in this figure, safety belt use for the 16-29-year olds is consistently the lowest of any age group and is showing a downward trend. Belt use for the two lowest age groups show considerable variability among survey waves. This effect is largely due to the low number of vehicle occupants in these age groups. Disregarding the two youngest age groups, belt use across survey waves was directly related to age.

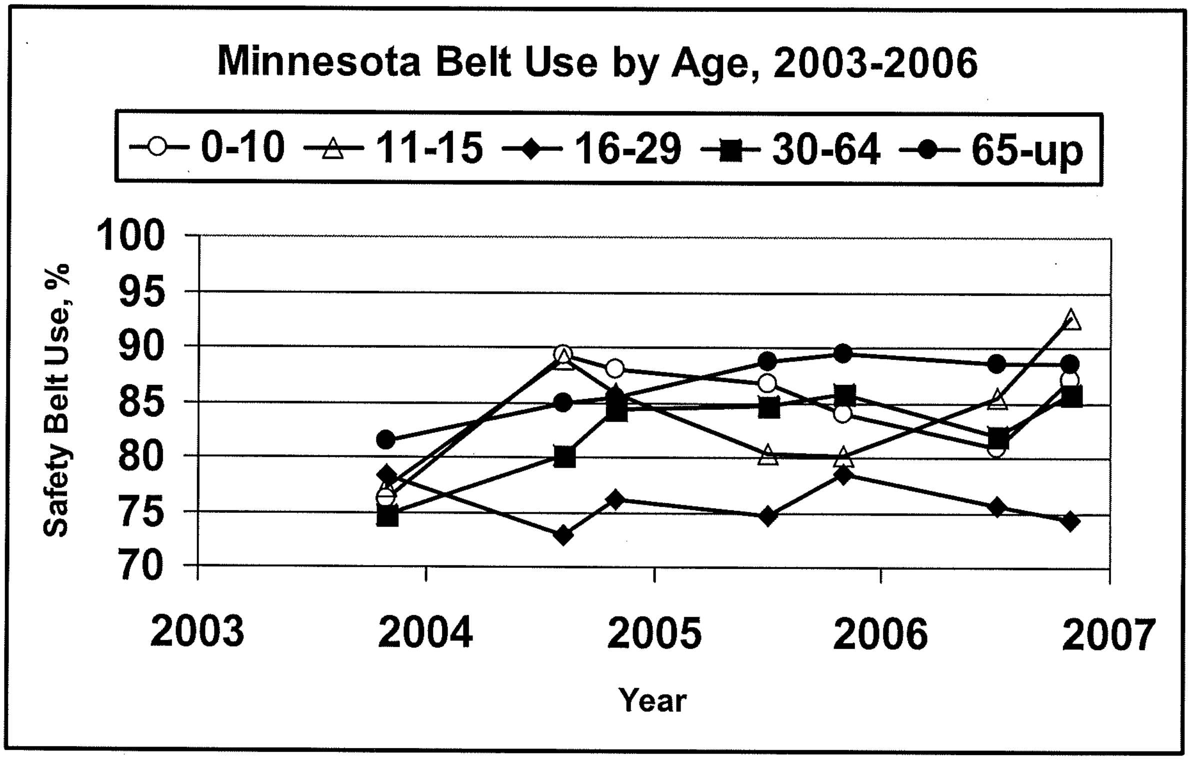

Figure 5: Minnesota safety belt by age, 2003-2006.

Seating Position: Figure 6 shows the estimated statewide safety belt use rate by seating position for Minnesota since 2003. Safety belt use for drivers has been slightly, but consistently, greater than or equal to the safety belt use of front-outboard passengers in all survey waves.

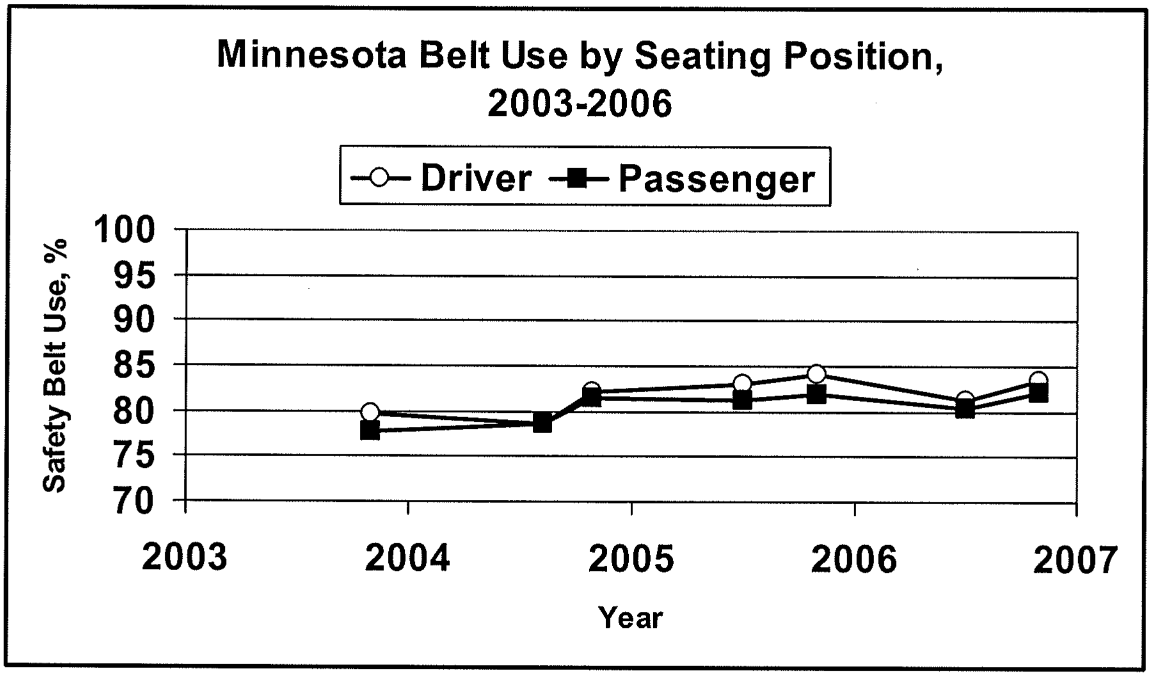

Figure 6: Minnesota safety belt use by Seating Position, 2003-2006.

Vehicle Type: Figure 7 shows the estimated statewide safety belt use rate by type of vehicle for Minnesota since 2003. As can be seen in this figure, belt use for cars, SUVs, and van/minivans were roughly the same during each survey wave. Safety belt use in pickup trucks, however, has been consistently lower than for other vehicle types. One positive note is that safety belt use for pickup trucks occupants has been increasing at a faster rate than for the other three vehicle types.

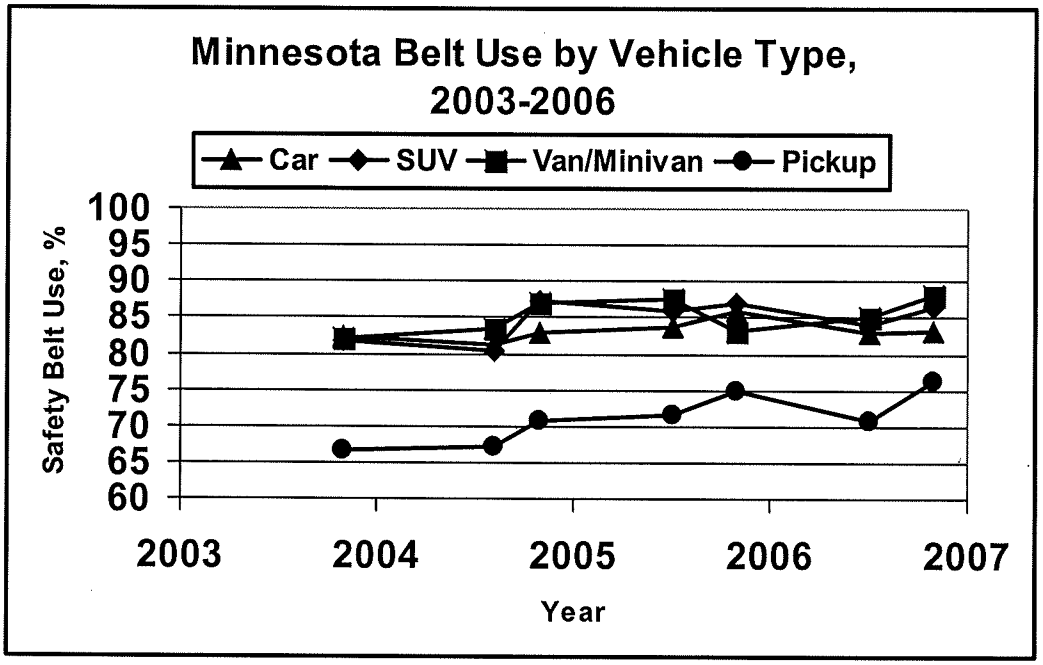

Figure 7: Minnesota safety belt use by vehicle type, 2003-2006.

Motorcycle Helmet Use

The current survey recorded helmet use of motorcycle occupants that happen to be observed during the safety belt data collection. Because the safety belt survey design was based on travel patterns of passenger vehicles in Minnesota instead of motorcycle patterns and the low number of motorcycle riders seen in the survey (145 motorcycle riders observed), no weighting of these data were performed. Instead, we present the unweighted helmet use rates so that a picture of the helmet use patterns in Minnesota can be realized. The results are summarized in Table 7.

Table 7: Motorcycle Helmet Use in Minnesota by Demographic Variables

	Percent Use	N
Overall	43.5	145
Time of Day		
7 - 9 a.m.	66.7	9
9 - 11 a.m.	38.5	13
11 - 1 p.m.	47.6	21
1 - 3 p.m.	41.8	51
3 - 5 p.m.	43.2	44
5 - 7 p.m.	28.6	7
Day of Week		
Monday	45.5	11
Tuesday	37.5	16
Wednesday	31.6	19
Thursday	36.4	22
Friday	61.0	41
Saturday	50.0	10
Sunday	30.8	26
Weather		
Sunny	40.0	115
Cloudy	60.7	28
Rainy	0.0	2
Sex*		
Male	44.8	116
Female	33.3	24
Age†		
0 - 10	---	0
11 - 15	---	0
16 - 29	52.2	23
30 - 64	40.2	112
65 - Up	0.0	2
Position		
Driver	44.8	125
Passenger	35.0	20

* There were 5 occupants where sex was not identified.
† There were 8 occupants where age was not identified.

DISCUSSION

This report has three purposes: (1) to present the results of a full statewide survey of safety belt use, conducted in August 2006; (2) to report and interpret safety belt use trends in Minnesota since August 2003; and (3) to report rates of motorcycle helmet use in Minnesota. All data for the study were collected through direct observation.

The statewide safety belt use survey showed that Minnesota belt use has remained about the same over the past year. The current rate of 83.3 percent is above the national average (Glassbrenner, 2005a), yet below NHTSA's goal of 90 percent belt use nationwide. If the small belt use increase seen over the past three years continues (Figure 2), Minnesota will not reach 90 percent belt use until about 2012. In order to more rapidly increase belt use, Minnesota needs to redouble its efforts. The single most effective effort to increase safety belt use statewide would be to change the enforcement provision of Minnesota's safety belt law from secondary to primary enforcement. As discussed in a recent article (Eby, Vivoda, & Fordyce, 2002), nine of the first ten states to make such a change found 8-22 percentage point increases with primary enforcement.

Analysis of safety belt use by the various subgroups showed that there are several areas on which Minnesota should continue to focus efforts to increase safety belt use. The lowest use group discovered was young people. While this group has historically been found to have lower safety belt use than other groups, it is also the group in which the biggest gains in traffic-crash-related-injury reduction can be found. On a per population basis, young drivers in the US had the highest rate of involvement in fatal crashes of any age group in 2001 and their fatality rate based on vehicle miles traveled was four times greater than the comparable rate for drivers age 26 to 65 (NHTSA, 2002). Teenage drivers have by far the highest fatal crash involvement rate of any age group based on number of licensed drivers. Motor vehicle injury rates also show that teenagers continue to have vastly higher rates than the population in general.

We discovered large differences in safety belt use between males and females. Understanding why there is a difference in belt use between males and females is very important. In the current survey there is a belt use difference of nearly 10 percentage points between the sexes. According to the Motor Vehicle Occupant Safety Survey, when safety belt non-users and part-time users were asked why they did not wear belts, males and females give different reasons (Block, 2000). Females state "I forgot to put it on" as the most important reason for non-use, while males list "I'm only driving a short distance" as the reason most important to them. An analysis of the types of answers given for non-use by sex revealed that males tend to report reasons that are related to a lower perception of risk (e.g. low probability of a crash or receiving a citation), while more of the answers given by female non-users and part-time users are related to discomfort and forgetting. Traffic safety professionals in Minnesota could use this information for the development of programs aimed at increasing belt use among males.

Occupants of pickup trucks also define a unique population that historically exhibits low safety belt use in Minnesota, and may therefore benefit from specially designed programs. Research has shown that the main demographic differences between the driver/owners of pickup trucks and passenger cars is that driver/owners of pickup trucks are more likely to be male, have higher household incomes, and lower educational levels (Anderson, Winn, & Agran, 1999). Recent focus group work by the Center for Applied Research (NHTSA, 2004b) with rural pickup truck drivers explored why these occupants wear, or do not wear, safety belts. The following reasons were given for nonuse of safety belts: vehicle size protects them from serious injury; safety belt not needed for short or work trips; fear of being trapped in vehicle after a crash; inconsistency between belt law and motorcycle helmet law; and opposition to government mandate. Reasons given for use were: presence of family or friends; travel on interstate highways, travel during inclement weather; and when not traveling in their pickup truck. This information provides a starting point for the development of programs designed to influence pickup truck occupant safety belt use, as efforts to encourage belt use by occupants of pickup trucks are warranted. The Center for Applied Research (NHTSA, 2004b) study also suggests passage of mandatory motorcycle helmet use law might also increase belt use among pickup truck drivers.

The good news about pickup truck occupants for this year was that belt use by females in pickup trucks was 90 percent. This use rate was the highest observed for females in any vehicle type and shows that women, at least, are getting the message to use safety belts regardless of the type of vehicle in which they are traveling.

Our analyses of helmet use showed that only about 44 percent of motorcycle occupants were using helmets—a rate that was about the same as last year. This use rate is significantly lower that the national helmet use rate of 58 percent and slightly lower than the use rate of 48 percent for states with no mandatory helmet use law (Glassbrenner, 2005b).

While helmet use is low in Minnesota, the safety implications of this use rate may be magnified even more. Based on national data (Glassbrenner, 2005b), it is likely that about 6-16 percent of those recorded as wearing helmets, are using helmets that do not meet Federal Motor Vehicle Safety Standard 218. This standard states sets minimum requirements for the construction and crashworthiness of helmets. The two main issues are the helmet thickness and the durability of the chin strap. Many riders purchase helmets that do not meet these requirements which are sold as "novelty" helmets. Novelty helmets do not provide proper protection in a crash. Future surveys of helmet use in Minnesota should attempt to distinguish between legal and novelty helmets during data collection to further explore this issue.

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APPENDIX A:
PDA Data Collection Details

In the current study all data collection was conducted using Personal Digital Assistants (PDAs). The 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, electronic versions of the *Site Description Form* and *Observation Form* were developed (these have since been combined into a single electronic form). 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 electronic forms that were 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, used the PDA's calendar function for date entry, and included high resolution color on the screens. The site description form portion of the data collection form is divided into five screens. The first screen (Figure 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.

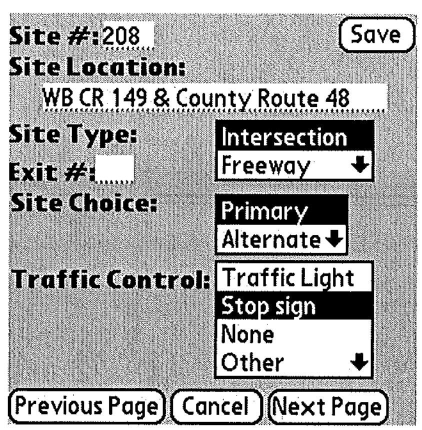

Figure 2. Site Description Form – Screen 1.

Screens 2 and 3 are shown in Figure 3. 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. Screen 3 allows users to sketch in the intersection and show where they are standing, and to record the start time for the site.

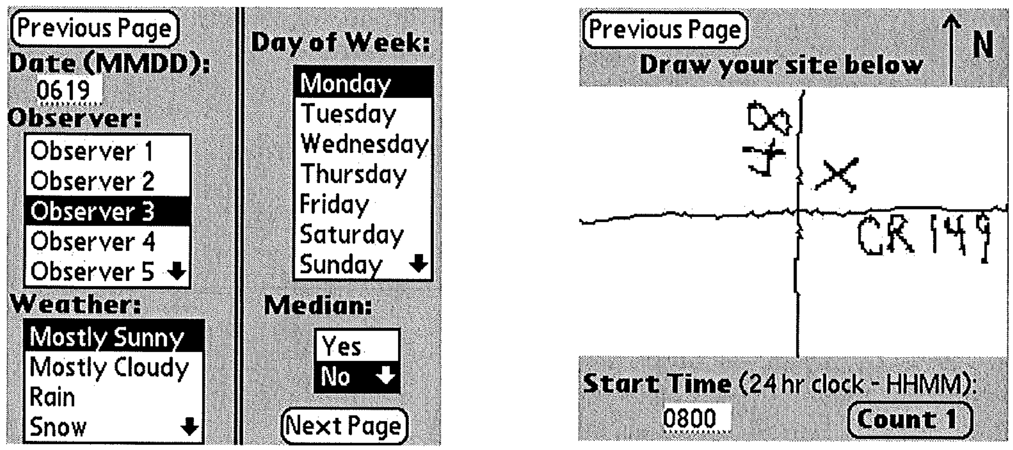

Figure 3. Site Description Form - Screens 2 and 3

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 site description portion of the data collection form[1]. Figure 4 shows an example of the electronic traffic counter (Screen 4). 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 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.

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

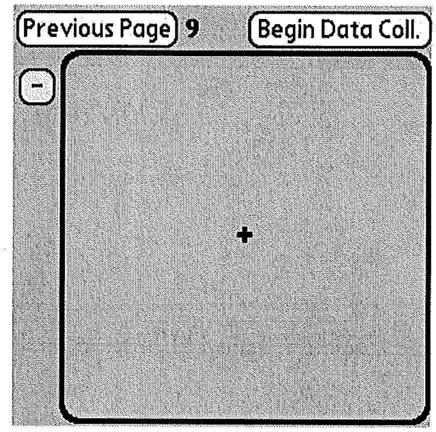

Figure 4. Site Description Form – Screen 4

The last screen of the electronic *Site Description Form*, shown in Figure 5, allows the user to enter the end time of the site observation and interruption (if any). Finally, observers can type in any comments regarding the site or traffic flow that may be important.

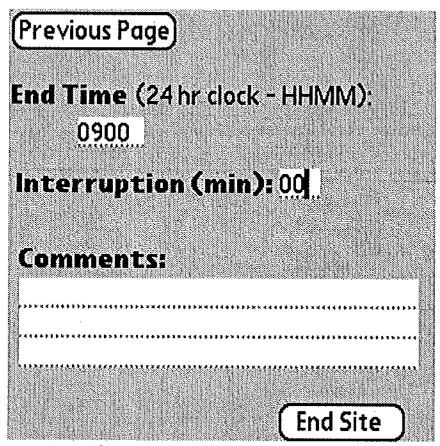

Figure 5. Site Description Form - Screen 5

To allow for easier data entry, the observation 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 6, 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, driver screen blue, and passenger screen green. As shown below, the first screen that appears in the form is the vehicle screen. Each category of data, along with the choices for each category, are displayed on the screen. As in the Site Description Form, 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 vehicles are not used for commercial purposes, "Not Commercial" is already highlighted as a default. If the vehicle is commercial, that choice can be selected from the list.

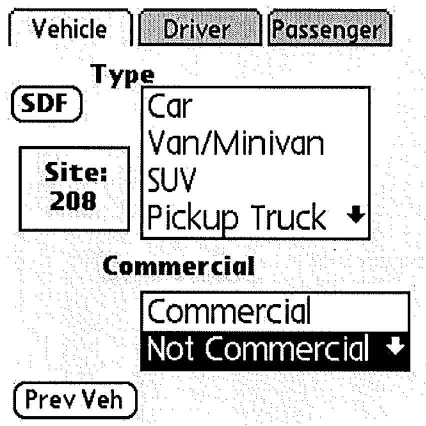

Figure 6. Observation Form - Vehicle Screen

Figure 7 shows the driver and passenger screens. Since most motorists are not actively talking on a cellular phone while driving, "No Cell Phone" is already highlighted as the default. If no passenger is present, users tap on the "No Passenger" area of the passenger screen to put a check mark in that box. Once data are complete for one vehicle, observers tap the "Next Vehicle" button to continue collecting data.

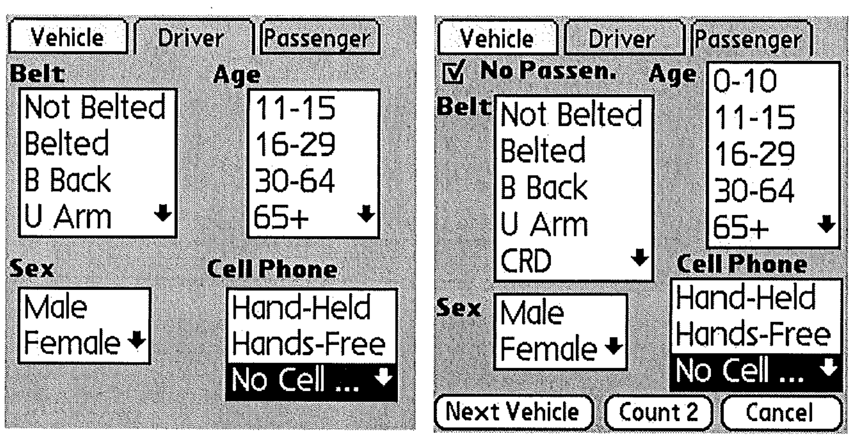

Figure 7. Observation Form - Passenger and Vehicle Screens

Each PDA also had a built-in cellular phone as well as wireless e-mail capability. At regular intervals, observers e-mailed completed data directly from the PDA to the project supervisor. Data collection forms 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 field supervisor to immediately check data for errors, and begin to compile a data analysis file as the project progressed.

APPENDIX B:
Site Listing

Survey Sites By Number

No.	County	Site Location
001	Dakota	EB 135th St/Co. Rd. 38 & Blaine Ave/County Rout 71/Rich Valley Blvd
002	Olmsted	EB CR 112/County Route 12 & CR 112
003	Carver	EB 150th St/County Route 50 & County Route 41
004	Carver	EB 70th St/County Route 30 & State Route 25/Ash
005	Carver	NB Yancy Ave & State Route 7
006	Carver	SB Little Ave & 102nd St
007	Dakota	EB W 136th St & Nicollet Ave
008	Wright	WB CR 123 & County Route 7/CR 106
009	Olmsted	EB CR 120 & County Route 20
010	Wright	EB CR 118/CR18/50th St. & County Route 35/Main St.
*011	Dakota	NB CR 21/Guam Ave & 307th St/CR 90
012	Wright	EB 14th St/CR 112 & State Route 25
013	Dakota	EB 240th St West & Cedar Ave/County Route 23
*014	Dakota	NB Johnny Cake Ridge Rd & Coutny Route 32/Cliff Rd
015	Olmsted	SB County Route 3 & County Route 4
*016	Olmsted	EB CR 137 & CR 136
017	Dakota	EB 80th St & Concord Blvd/County Route 56
018	Dakota	EB 220th St East & Nicolai/County Route 91
019	Dakota	SB Fairgreen Ave & 280th St West/County Route 86
020	Wright	NB County Route 12 & County Route 37
021	Olmsted	WB County Route 9 & County Route 10
*022	Dakota	EB Wescott Rd & Lexington Ave
023	Dakota	NB Hogan Ave/County Route 85 & 220th St East
*024	Wright	SB US 12/County Route 16 & Babcock Blvd/County Route 30
025	Wright	EB County Route 38/Harrison St. (Near Oak St/CR 24) & State Route 55/State Route 24
026	Dakota	NB Blaine Ave/CR 79 & 245th St East/County Route 80
*027	Olmsted	SB CR 119 & County Route 9
*028	Dakota	EB County Route 88/290th Street East & Northfield Blvd/County Route 47
*029	Ramsey	NB Hodgson Rd/County Route 49 & Turtle/County Route 3/CR 1
030	Carver	SB Yale Ave/Yancy Ave & County Route 30
031	Olmsted	NB CR 125/Maywood Rd. SW & County Route 25/Salem Rd. SW
032	Olmsted	EB CR 154/85th St. NW & US 52
*033	Wright	SB County Route 12 & State Route 55
*034	Carver	WB 62nd St & County Route 33
*035	Ramsey	EB Minnehaha Ave/State Route 5 & White Bear Ave/County Route 65
*036	Olmsted	SB CR 128 & State Route 247/County Route 12
037	Dakota	SB CR 51/County Route 80/Biscayne Ave & 280th St West/County Route 86
*038	Olmsted	NB CR 132/County Route 32 & County Route 9
039	Dakota	SB Inga Ave & State Route 50/240th St East
*040	Dakota	EB County Route 14/Grand Ave. & Concord St/State Route 156
041	Dakota	NB Goodwin Ave & State Route 55
042	Ramsey	NB Rice St & Maryland Ave
043	Dakota	SB Emery Ave & 190th St East/County Route 62
044	Ramsey	NBP I-35 W & Old Hwy 8/Anoka Cutoff (Exit 26)
*045	Ramsey	NBD I-35 E & County Route 23 (Exit 112)
046	Olmsted	WBP I-90 & County Route 10 (Exit 229)
*047	Dakota	SBD I-35 & County Route 50/County Route 5(Exit 85)
048	Ramsey	WBP State Route 36 & Hamline Ave
*049	Dakota	SBD US-52 & Thompson Ave
*050	Ramsey	SBD I-35 E & St. Clair
*051	Dakota	WBD I-494 & Robert St (Exit 67)
052	Dakota	NBD I-35 E & State Route 110/Mendota Rd (Exit 101)
*053	Olmsted	EBD I-90 & State Route 42 (Exit 224)
054	Ramsey	SBD I-35 E & Randolph Ave
055	Ramsey	EBD State Route 36 & Lexington Ave/County Route 51
056	Ramsey	EBD US-12/US-52/I-94 & S. Cretin Ave
057	Ramsey	NBP County Route 280 & Energy Park Dr
058	Dakota	SBD US-52/Lafayette Frwy & Butler Ave
059	Ramsey	EBP I-694 & US-61/Maplewood Dr (Exit 48)
060	Ramsey	EBD US-12/US-52/I-94 & Lexington Parkway/County Route 51
061	Hennepin	SB Pineview Ave & 129th Ave

062	Hennepin	WB Olson Memorial Hwy/State Rotue 55 & County Route 102/Douglas Drive
*063	Hennepin	NB Mohawk Dr & Horseshoe Tr
064	Hennepin	SB County Route 60/Mitchell Rd & State Route 5
065	Hennepin	WB Gleason Lake Rd/County Route 15 & Vicksburg Lane
066	Hennepin	NEB State Route 7 & Chanhassen Rd/State Route 101
067	Hennepin	NB Brown Rd/County Route 146 & Watertown Rd
*068	Hennepin	NB Commerce Blvd & West Branch Rd/County Route 151
069	Hennepin	NB Chanhassen Rd/State Route 101 & Minnetonka Blvd/County Route 5
070	Hennepin	SB County Route 44 & Bartlett Blvd/County Route 110
071	Hennepin	SB Tucker Rd & County Route 116/CR 159/Territorial Rd.
*072	Hennepin	NEB Old Shakopee Rd/County Route 1 & Penn Ave.
073	Hennepin	NWB County Route 81 & 77th Ave North/County Route 152/Brooklyn Blvd.
*074	Hennepin	NB Belchtold Rd & 109th Ave North/County Route 117
075	Hennepin	NB County Route 34/Normandale Blvd & Old Shakopee Rd/County Route 1
*076	Hennepin	NB Penn Ave/County Route 2 & Olson Memorial Highway/State Route 55
077	Hennepin	WB Elm Creek Rd & Fernbrooke Ave/County Route 121
078	Hennepin	NB Pioneer Tr/County Route 113 & Woodland Tr/County Route 10
079	Hennepin	WB Rockford Rd/County Route 9 & Medicine Lake Dr/Larch Lane
*080	Hennepin	SB Lyndale Ave & West 50th St/County Route 21
081	Hennepin	NB Willow Dr & County Route 24
*082	Hennepin	WB 125th Ave North & Zanzibar Lane
083	Hennepin	SB Lyndale Ave & West 82nd St
084	Hennepin	NB Broadway Ave/CR 103/County Route 130 & 85th Ave North/County Route 109
*085	Hennepin	NB Mendelssohn Ave & 63rd Ave
*086	Hennepin	WB N 121st Ave & Fernbrooke/County Route 121
*087	Hennepin	WB Cedar Lake Rd/County Route 16 & Plymouth Rd/County Route 61
088	Hennepin	EB Nike Rd & Main Street/Country Route 92
089	Hennepin	NWB N Nobel Ave & 109th Ave
*090	Hennepin	SB Mohawk Dr & State Route 55
*091	Hennepin	NB County Route 32 & West 82nd Street
092	Hennepin	WB County Route 109/85th Ave N & Country Route 158/Rice Lake Rd.
093	Hennepin	SB Country Route 101 & County Route 42/Wayzata Blvd.
094	Hennepin	NB University Ave & County Route 23
*095	Hennepin	SB Country Route 116/Fletcher Lane & County Route 30/97th Ave N
096	Hennepin	EB County Route 53/66th St. & State Route 77
097	Hennepin	NB Winnetka Ave/County Route 156 & Medicine Lake Rd
098	Hennepin	SB Goose Lake Rd & Elm Creek Rd
*099	Hennepin	WB Medicine Lake Rd/26th St. & Medicine Lake Blvd
100	Hennepin	NB Budd Ave & Pagenkoph Rd
*101	Hennepin	EB Duck Lake Tr & Eden Prarie Rd/County Route 4
102	Hennepin	NB Eden Prarie Rd/County Route 4 & Excelsior Blvd/County Route 3
103	Hennepin	SEB County Route 152/Osseo Rd. & N. Penn/44th Ave.
104	Hennepin	SBD State Route 77 & County Route 1/Old Shakopee Rd
*105	Hennepin	NBD I-35 W & W 82nd St (Exit 8)
106	Hennepin	WBP State Route 62/Crosstown Hwy & Gleason
*107	Hennepin	SBD I-494 & County Route 10/Bass Lake Rd (Exit 26)
*108	Hennepin	WBP I-94/US-12/US-52 & S 25th Ave.
*109	Hennepin	NBP I-35 W & W 35th St/E 35th St
110	Hennepin	WBP I-94/US-52 & County Route 30/Dunkirk Lane (Exit 213)
111	Hennepin	SBD I-35 W & W 66th St/E 66th St
112	Hennepin	NBP US-169 & 36th Ave N
*113	Hennepin	EBP I-494 & Townline Rd/US-169
114	Hennepin	N/WBD I-494 & State Route 55/Olson Memorial Hwy
115	Hennepin	WBP State Route 62/Crosstown Hwy & Tracy Ave
116	Hennepin	SBP State Route 100 & Minnetonka Blvd/County Route 5/Vernon
117	Hennepin	SBP State Route 100 & W 50th St/County Route 21/County Route 158
*118	Hennepin	EBD State Route 62 & Portland Ave South
119	Hennepin	NBP US-169 & Valley View Rd
120	Hennepin	NBD US-169 & Plymouth Ave/13th Ave N
121	Sherburne	NB County Route 73/127th St./County Route 48 & CR 73/185th Ave.
122	St. Louis	WB State Route 135/County Route 102 & US 53/State Route 169
123	St. Louis	WB CR 791 & County Route 25
124	Rice	SB Culver Ave & 150th Street W/County Route 9
125	Beltrami	SB State Route 72/County Route 36 & County Route 41
*126	Washington	NB Manning & 70th St. S
127	Clay	EB State Route 34 & County Route 25

128	Kandiyohi	WB 255th Ave Northeast & County Route 9
129	St. Louis	EB County Route 16/CR 957 & US 53
130	Kandiyohi	EB CR 107/240th Ave. & 40th Street NE
131	Kandiyohi	WB 105 Ave SE & CR 136/165th St SE
132	Blue Earth	WB County Route 29/State Route 30 & State Route 22/State Route 30
133	Freeborn	NB US-69 & County Route 46
134	Clay	EB CR 105 & County Route 13/County Route 73/90th St. N
*135	St. Louis	WB State Route 194/Central Entrance & County Route 90/Arlington
136	Steele	SB County Route 3 & State Route 30
137	Blue Earth	WB County Route 13/County Route 38 & US-169
*138	Sherburne	SB US 169 & County Route 4
*139	Sherburne	EB CR 54/77th St. SE & State Route 25/125th Ave. SE
140	Freeborn	EB CR 115/County Route 23 & County Route 26
*141	Blue Earth	WB CR 167 & County Route 39
142	Sherburne	NWB US 10 & County Route 15
*143	St. Louis	EB State Route 194 & US 53
144	Freeborn	NB County Route 24/County Route 45/Independence Ave & County Route 31/CR 116/Main St.
*145	Goodhue	SB County Route 1 & State Route 60
*146	Freeborn	EB County Route 9/CR 78 & US 69
147	Blue Earth	NB County Route 30/CR 107 & County Route 22/CR 108
148	St. Louis	EB County Route 28/Sax Road & County Route 7
149	Nicollet	EB County Route 15/382nd St. & State Route 15
150	Blue Earth	EB Madison Ave/State Route 22 & State Route 22
*151	Steele	SB 7th Ave NE & County Route 8/Mineral Springs Rd.
152	Blue Earth	EB County Route 25/CR 138 & County Route 20
*153	Blue Earth	NB County Route 14/CR 173 & State Route 83
154	St. Louis	EB County Route 12/Roberg Rd & Lakewood Rd/CR 692
*155	Crow Wing	NB County Route 25/CR 144 & State Route 18
*156	Kandiyohi	WB 60th Ave SW & County Route 7/135th St.
*157	Scott	EB County Route 2/CR 54 & State Route 13/Langford Ave
*158	Blue Earth	SB State Route 60 & US 14/State Route 60
159	Goodhue	SB County Route 4 & County Route 10
160	Kandiyohi	SB CR 127/60th St. NE & County Route 26/60th Ave.
*161	Clay	EB 90th Ave./County Route 10 & 70th St./County Route 11/State Route 336
162	Nicollet	NB County Route 7/585TH St. & County Route 1/350th St.
163	Scott	EB CR 64/230th St W & State Route 21/Helena Blvd
164	Steele	SBD I-35 & County Route 4 (Exit 32)
165	St. Louis	SBP I-35 & US-53/Piedmont Ave
166	Freeborn	SBP I-35 & County Route 35 (Exit 22)
167	Clay	EBP I-94 & County Route 10 (Exit 15)
168	Washington	N/WBP I-694 & 10th St/County Route 10 (Exit 57)
*169	Clay	WBP I-94 & County Route 52 (Exit 2)
170	Rice	SBP I-35 & State Route 60 (Exit 56)
171	Steele	NBD I-35 & County Route 12 (Exit 48)
*172	Beltrami	EBP US-2/US-71 & US-71
173	Freeborn	EBD I-90 & State Route 13 (Exit 154)
174	Freeborn	SBD I-35 & State Route 251 (Exit 18)
*175	St. Louis	SBP I-35 & S 27th Ave. W (Exit 254)
*176	Washington	SBP I-35 & Central Ave. (Exit 252)
177	St. Louis	N/EBD I-35 & 46th Ave
178	Freeborn	NBD I-35 & County Route 46 ? (Exit 11)
*179	Washington	NBP US-10/US-61 & 80th St/Grange Blvd
*180	St. Louis	N/EBD I-35 & Skyline Pkwy/Boundary Dr. (Exit 249)
*181	Morrison	SB CR 264/205th Ave. & County Route 46/183rd St.
182	Douglas	SB County Route 6 & County Route 22
*183	McLeod	WB County Route 26/100th St. & State Route 15
184	Morrison	SB County Route 37 & County Route 26/Nature Rd.
185	Polk	NB County Route 63 & US-2
*186	Cass	WB County Route 29/CR 107/76th St. & County Route 1
*187	Becker	SB Little Toad Lake Rd/County Route 31 & State Route 87
188	Otter Tail	EB County Route 10 & US 59
189	Otter Tail	EB County Route 60/State Route 228 & US 10
190	Cass	WB County Route 34 & State Route 64
191	Brown	EB County Route 22/CR 102 & County Route 13
192	Morrison	SB County Route 6/90th Ave. & County Route 1/State Route 238

193	Mower	WB 115th St. & County Route 14/770th Ave.
194	Stearns	WB CR 146 & State Route 15
195	Cass	EB County Route 43/Twp 4/12th St. & State Route 84/County Route 44
*196	Polk	NB County Route 54 & County Route 11
197	Polk	EB CR 213 & CR 213/County Route 48
198	Winona	NEB County Route 44/Huff St. & US 14/US 61
*199	Morrison	EB CR 203/County Route 1 & County Route 2
200	Stearns	SB US 71 & State Route 55
*201	Douglas	EB State Route 27 & State Route 29
*202	Winona	WB County Route 22 extension (unmarked gravel road North of County Route 115) & County Route 37
*203	Anoka	SB CR 67 & County Route 22
204	Cass	EB County Route 66/122nd St. & State Route 371
*205	Benton	WB County Route 12/Pine Rd. & State Route 25
206	Becker	SB County Route 49/CR 119 & State Route 87
*207	Polk	NB County Route 65 & US-75
208	Stearns	WB CR 149 & County Route 48
209	Isanti	SB State Route 47 & County Route 8
210	Otter Tail	EB County Route 6 & County Route 59
*211	Stearns	WB Division St/County Route 75 & State Route 15
212	Itasca	EB US 2/4th St. & State Route 38/3rd Ave.
213	McLeod	SB County Route 25/CR 52/5th Ave. S. & US 212
214	Mower	EB County Route 1 & US 218
215	Benton	SB County Route 6 & County Route 4
216	Brown	WB 150th St./CR100 & County Route 2
*217	Anoka	SB County Route 5/CR 56 & Northern Blvd/County Route 5
218	Douglas	NB County Route 40 & County Route 82
219	Douglas	WB County Route 10 & County Route 3
*220	Winona	NEB County Route 7 & US 14/US 61
221	Stearns	SEB County Route 152 & County Route 10
222	Stearns	WB County Route 75 & County Route 2
223	Isanti	NB County Route 7/CR 57 & State Route 95
224	Carlton	SWBP I-35 & State Route 45 (Exit 239)
*225	Anoka	SBP I-35 W & County Route 23/Lake Dr (Exit 36)
226	Stearns	WBD I-94/US-52 & CR 159 (Exit 156)
227	Winona	EBD I-90 & State Route 43 (Exit 249)
228	Stearns	EBP I-94 & State Route 23 (Exit 164)
*229	Anoka	EBP US-10 & State Route 65
*230	Chisago	SBD I-35 & County Route 10 (Exit152)
231	Mower	WBP I-90 & State Route 56 (Exit 183)
232	Stearns	EBP I-94 & County Route 7 (Exit 171)
*233	Winona	WBP I-90 & State Route 76 (Exit 257)
*234	Otter Tail	W/NBP I-94 & US-59/County Route 52/County Route 88 (Exit 50)
235	Anoka	WBP US-10/State Route 610 & State Route 47
236	Douglas	EBD I-94 & State Route 79 (Exit 82)
237	Stearns	WBP I-94 & County Route 9 (Exit 153)
238	Stearns	WBD I-94 & County Route 11 (Exit 137)
239	Carlton	EBD I-35 & State Route 61 (Exit 245)
*240	Douglas	EBP I-94 & State Route 29 (Exit 103)

* indicates a site used in the mini survey.

APPENDIX C:
Text of Motor Vehicle Safety Standard 218

TITLE 49--TRANSPORTATION

CHAPTER V--NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

PART 571--FEDERAL MOTOR VEHICLE SAFETY STANDARDS--Table of Contents

Subpart B--Federal Motor Vehicle Safety Standards

Sec. 571.**218** Standard No. **218**; Motorcycle helmets.

S1. Scope. This standard establishes minimum performance requirements for helmets designed for use by motorcyclists and other motor vehicle users.

S2. Purpose. The purpose of this standard is to reduce deaths and injuries to motorcyclists and other motor vehicle users resulting from head impacts.

S3. Application. This standard applies to all helmets designed for use by motorcyclists and other motor vehicle users.

S4. Definitions.

Basic plane means a plane through the centers of the right and left external ear openings and the lower edge of the eye sockets (Figure 1) of a reference headform (Figure 2) or test headform.

Helmet positioning index means the distance in inches, as specified by the manufacturer, from the lowest point of the brow opening at the lateral midpoint of the helmet to the basic plane of a reference headform, when the helmet is firmly and properly positioned on the reference headform.

Midsagittal plane means a longitudinal plane through the apex of a reference headform or test headform that is perpendicular to the basic plane (Figure 3).

Reference headform means a measuring device contoured to the dimensions of one of the three headforms described in Table 2 and Figures 5 through 8 with surface markings indicating the locations of the basic, mid-sagittal, and reference planes, and the centers of the external ear openings.

Reference plane means a plane above and parallel to the basic plane on a reference headform or test headform (Figure 2) at the distance indicated in Table 2.

Retention system means the complete assembly by which the helmet is retained in position on the head during use.

Test headform means a test device contoured to the dimensions of one of the three headforms described in Table 2 and Figures 5 through 8 with surface markings indicating the locations of the basic, mid-sagittal, and reference planes.

S5. Requirements. Each helmet shall meet the requirements of S5.1, S5.2, and S5.3 when subjected to any conditioning procedure specified in S6.4, and tested in accordance with S7.1, S7.2, and S7.3.

S5.1 Impact attenuation. When an impact attenuation test is conducted in accordance with S7.1, all of the following requirements shall be met:

(a) Peak accelerations shall not exceed 400g;

(b) Accelerations in excess of 200g shall not exceed a cumulative duration of 2.0 milliseconds; and

(c) Accelerations in excess of 150g shall not exceed a cumulative duration of 4.0 milliseconds.

S5.2 Penetration. When a penetration test is conducted in accordance with S7.2, the striker shall not contact the surface of the test headform.

S5.3 Retention system.

S5.3.1 When tested in accordance with S7.3:

(a) The retention system or its components shall attain the loads specified without separation; and

(b) The adjustable portion of the retention system test device shall not move more than 1 inch (2.5 cm) measured between preliminary and test load positions.

S5.3.2 Where the retention system consists of components which can be independently fastened without securing the complete assembly, each such component shall independently meet the requirements of S5.3.1.

S5.4 Configuration. Each helmet shall have a protective surface of continuous contour at all points on or above the test line described in S6.2.3. The helmet shall provide peripheral vision clearance of at least 105 deg. to each side of the mid-sagittal plane, when the helmet is adjusted as specified in S6.3. The vertex of these angles, shown in Figure 3, shall be at the point on the anterior surface of the reference headform at the intersection of the mid-sagittal and basic planes. The brow opening of the helmet shall be at least 1 inch (2.5 cm) above all points in the basic plane that are within the angles of peripheral vision (see Figure 3).

S5.5 Projections. A helmet shall not have any rigid projections inside its shell. Rigid projections outside any helmet's shell shall be limited to those required for operation of essential accessories, and shall not protrude more than 0.20 inch (5 mm).

S5.6 Labeling.

S5.6.1 Each helmet shall be labeled permanently and legibly, in a manner such that the label(s) can be read easily without removing padding or any other permanent part, with the following:

(a) Manufacturer's name or identification.

(b) Precise model designation.

(c) Size.

(d) Month and year of manufacture. This may be spelled out (for example, June 1988), or expressed in numerals (for example, 6/88).

(e) The symbol DOT, constituting the manufacturer's certification that the helmet conforms to the applicable Federal motor vehicle safety standards. This symbol shall appear on the outer surface, in a color that contrasts with the background, in letters at least \3/8\ inch (1 cm) high, centered laterally with the horizontal centerline of the symbol located a minimum of 1\1/8\ inches (2.9 cm) and a maximum of 1\3/8\ inches (3.5 cm) from the bottom edge of the posterior portion of the helmet.

(f) Instructions to the purchaser as follows:

(1) ``Shell and liner constructed of (identify type(s) of materials).

(2) ``Helmet can be seriously damaged by some common substances without damage being visible to the user. Apply only the following: (Recommended cleaning agents, paints, adhesives, etc., as appropriate).

(3) ``Make no modifications. Fasten helmet securely. If helmet experiences a severe blow, return it to the manufacturer for inspection, or destroy it and replace it.''

(4) Any additional relevant safety information should be applied at the time of purchase by means of an attached tag, brochure, or other suitable means.

S5.7 Helmet positioning index. Each manufacturer of helmets shall establish a positioning index for each helmet he manufactures. This index shall be furnished immediately to any person who requests the information, with respect to a helmet identified by manufacturer, model designation, and size.

S6. Preliminary test procedures. Before subjecting a helmet to the testing sequence specified in S7., prepare it according to the procedures in S6.1, S6.2, and S6.3.

S6.1 Selection of appropriate headform.

S6.1.1 A helmet with a manufacturer's designated discrete size or size range which does not exceed 6\3/4\ (European size: 54) is tested on the small headform. A helmet with a manufacturer's designated discrete size or size range which exceeds 6\3/4\, but does not exceed 7\1/2\ (European size: 60) is tested on the medium headform. A helmet with a manufacturer's designated discrete size or size range which exceeds 7\1/2\ is tested on the large headform.

S6.1.2 A helmet with a manufacturer's designated size range which includes sizes falling into two or all three size ranges described in S6.1.1 is tested on each headform specified for each size range.

S6.2 Reference marking.

S6.2.1 Use a reference headform that is firmly seated with the basic and reference planes horizontal. Place the complete helmet to be tested on the appropriate reference headform, as specified in S6.1.1 and S6.1.2.

S6.2.2 Apply a 10-pound (4.5 kg) static vertical load through the helmet's apex. Center the helmet laterally and seat it firmly on the reference headform according to its helmet positioning index.

S6.2.3 Maintaining the load and position described in S6.2.2, draw a line (hereinafter referred to as ``test line'') on the outer surface of the helmet coinciding with portions of the intersection of that service with the following planes, as shown in Figure 2:

(a) A plane 1 inch (2.5 cm) above and parallel to the reference plane in the anterior portion of the reference headform;

(b) A vertical transverse plane 2.5 inches (6.4 cm) behind the point on the anterior surface of the reference headform at the intersection of the mid-sagittal and reference planes;

(c) The reference plane of the reference headform;

(d) A vertical transverse plane 2.5 inches (6.4. cm) behind the center of the external ear opening in a side view; and

(e) A plane 1 inch (2.5 cm) below and parallel to the reference plane in the posterior portion of the reference headform.

S6.3 Helmet positioning.

S6.3.1 Before each test, fix the helmet on a test headform in the position that conforms to its helmet positioning index. Secure the helmet so that it does not shift position before impact or before application of force during testing.

S6.3.2 In testing as specified in S7.1 and S7.2, place the retention system in a position such that it does not interfere with free fall, impact or penetration.

S6.4 Conditioning.

S6.4.1 Immediately before conducting the testing sequence specified in S7, condition each test helmet in accordance with any one of the following procedures:

(a) Ambient conditions. Expose to a temperature of 70 deg.F(21 deg.C) and a relative humidity of 50 percent for 12 hours.

(b) Low temperature. Expose to a temperature of 14 deg.F(-10 deg.C) for 12 hours.

(c) High temperature. Expose to a temperature of 122 deg.F(50 deg.C) for 12 hours.

(d) Water immersion. Immerse in water at a temperature of 77 deg.F(25 deg.C) for 12 hours.

S6.4.2 If during testing, as specified in S7.1.3 and S7.2.3, a helmet is returned to the conditioning environment before the time out of that environment exceeds 4 minutes, the helmet is kept in the environment for a minimum of 3 minutes before resumption of testing with that helmet. If the time out of the environment exceeds 4 minutes, the helmet is returned to the environment for a minimum of 3 minutes for each minute or portion of a minute that the helmet remained out of the environment in excess of 4 minutes or for a maximum of 12 hours, whichever is less, before the resumption of testing with that helmet.

S7. Test conditions.

S7.1 Impact attenuation test.

S7.1.1 Impact attenuation is measured by determining acceleration imparted to an instrumented test headform on which a complete helmet is mounted as specified in S6.3, when it is dropped in guided free fall upon a fixed hemispherical anvil and a fixed flat steel anvil.

S7.1.2 Each helmet is impacted at four sites with two successive identical impacts at each site. Two of these sites are impacted upon a flat steel anvil and two upon a hemispherical steel anvil as specified in S7.1.10 and S7.1.11. The impact sites are at any point on the area above the test line described in paragraph S6.2.3, and separated by a distance not less than one-sixth of the maximum circumference of the helmet in the test area.

S7.1.3 Impact testing at each of the four sites, as specified in S7.1.2, shall start at two minutes, and be completed by four minutes, after removal of the helmet from the conditioning environment.

S7.1.4 (a) The guided free fall drop height for the helmet and test headform combination onto the hemispherical anvil shall be such that the minimum impact speed is 17.1 feet/second (5.2 m/sec). The minimum drop height is 54.5 inches (138.4 cm). The drop height is adjusted upward from the minimum to the extent necessary to compensate for friction losses.

(b) The guided free fall drop height for the helmet and test headform combination onto the flat anvil shall be such that the minimum impact speed is 19.7 ft./sec (6.0 m/sec). The minimum drop height is 72 inches (182.9 cm). The drop height is adjusted upward from the minimum to the extent necessary to compensate for friction losses.

S7.1.5 Test headforms for impact attenuation testing are constructed of magnesium alloy (K-1A), and exhibit no resonant frequencies below 2,000 Hz.

S7.1.6 The monorail drop test system is used for impact attenuation testing.

S7.1.7 The weight of the drop assembly, as specified in Table 1, is the combined weight of the test headform and the supporting assembly for the drop test. The weight of the supporting assembly is not less than 2.0 lbs. and not more than 2.4 lbs. (0.9 to 1.1 kg). The supporting assembly weight for the monorail system is the drop assembly weight minus the combined weight of the test headform, the headform's clamp down ring, and its tie down screws.

S7.1.8 The center of gravity of the test headform is located at the center of the mounting ball on the supporting assembly and lies within a cone with its axis vertical and forming a 10 deg. included angle with the vertex at the point of impact. The center of gravity of the drop assembly lies within the rectangular volume bounded by x = -0.25 inch (-0.64 cm), x = 0.85 inch (2.16 cm), y = 0.25 inch (0.64 cm), and y = -0.25 inch (-0.64 cm) with the origin located at the center of gravity of the test headform. The rectangular volume has no boundary along the z-axis. The x-y-z axes are mutually perpendicular and have positive or negative designations in accordance with the right-hand rule (See Figure 5). The origin of the coordinate axes also is located at the center of the mounting ball on the supporting assembly (See Figures 6, 7, and 8). The x-y-z axes of the test headform assembly on a monorail drop test equipment are oriented as follows: From the origin, the x-axis is horizontal with its positive direction going toward and passing through the vertical centerline of the monorail. The positive z-axis is downward. The y-axis also is horizontal and its direction can be decided by the z- and x-axes, using the right-hand rule.

S7.1.9 The acceleration transducer is mounted at the center of gravity of the test headform with the sensitive axis aligned to within 5 deg. of vertical when the test headform assembly is in the impact position. The acceleration data channel complies with SAE Recommended Practice J211 JUN 80, Instrumentation for Impact Tests, requirements for channel class 1,000.

S7.1.10 The flat anvil is constructed of steel with a 5-inch (12.7 cm) minimum diameter impact face, and the hemispherical anvil is constructed of steel with a 1.9 inch (4.8 cm) radius impact face.

S7.1.11 The rigid mount for both of the anvils consists of a solid mass of at least 300 pounds (136.1 kg), the outer surface of which consists of a steel plate with minimum thickness of 1 inch (2.5 cm) and minimum surface area of 1 ft \2\ (929 cm \2\ ).

S7.1.12 The drop system restricts side movement during the impact attenuation test so that the sum of the areas bounded by the acceleration-time response curves for both the x- and y-axes (horizontal axes) is less than five percent of the area bounded by the acceleration-time response curve for the vertical axis.

S7.2 Penetration test.

S7.2.1 The penetration test is conducted by dropping the penetration test striker in guided free fall, with its axis aligned vertically, onto the outer surface of the complete helmet, when mounted as specified in S6.3, at any point above the test line, described in S6.2.3, except on a fastener or other rigid projection.

S7.2.2 Two penetration blows are applied at least 3 inches (7.6 cm) apart, and at least 3 inches (7.6 cm) from the centers of any impacts applied during the impact attenuation test.

S7.2.3 The application of the two penetration blows, specified in S7.2.2, starts at two minutes and is completed by four minutes, after removal of the helmet from the conditioning environment.

S7.2.4 The height of the guided free fall is 118.1 inches (3 m), as measured from the striker point to the impact point on the outer surface of the test helmet.

S7.2.5 The contactable surface of the penetration test headform is constructed of a metal or metallic alloy having a Brinell hardness number no greater than 55, which will permit ready detection should contact by the striker occur. The surface is refinished if necessary before each penetration test blow to permit detection of contact by the striker.

S7.2.6 The weight of the penetration striker is 6 pounds, 10 ounces (3 kg).

S7.2.7 The point of the striker has an included angle of 60 deg., a cone height of 1.5 inches (3.8 cm), a tip radius of 0.02 inch (standard 0.5 millimeter radius) and a minimum hardness of 60 Rockwell, C-scale.

S7.2.8 The rigid mount for the penetration test headform is as described in S7.1.11.

S7.3 Retention system test.

S7.3.1 The retention system test is conducted by applying a static tensile load to the retention assembly of a complete helmet, which is mounted, as described in S6.3, on a stationary test headform as shown in Figure 4, and by measuring the movement of the adjustable portion of the retention system test device under tension.

S7.3.2 The retention system test device consists of both an adjustable loading mechanism by which a static tensile load is applied to the helmet retention assembly and a means for holding the test headform and helmet stationary. The retention assembly is fastened around two freely moving rollers, both of which have a 0.5 inch (1.3 cm) diameter and a 3-inch (7.6 cm) center- to-center separation, and which are mounted on the adjustable portion of the tensile loading device (Figure 4). The helmet is fixed on the test headform as necessary to ensure that it does not move during the application of the test loads to the retention assembly.

S7.3.3 A 50-pound (22.7 kg) preliminary test load is applied to the retention assembly, normal to the basic plane of the test headform and symmetrical with respect to the center of the retention assembly for 30 seconds, and the maximum distance from the extremity of the adjustable portion of the retention system test device to the apex of the helmet is measured.

S7.3.4 An additional 250-pound (113.4 kg) test load is applied to the retention assembly, in the same manner and at the same location as described in S7.3.3, for 120 seconds, and the maximum distance from the extremity of the adjustable portion of the retention system test device to the apex of the helmet is measured.