APPENDIX A. Annotated Bibliography

ANNOTATED BIBLIOGRAPHY

1. Bligh, R.P., "Review of Test Matrices and Conditions," Transportation Research Circular Issue 486, Transportation Research Board, Washington D.C., 1998, pp 1-5.

2. Cirillo, J.A., "Limitations of the Current NASS System as Related to FHWA Accident Research," Transportation Research Circular Issue 256, Transportation Research Board, Washington D.C., 1983, pp 20-21.

3. Cooper, P.J., "Analysis of Roadside Encroachment Data from Five Provinces and Its Application to an Off-Road Vehicle Trajectory Model," March 1981.

4. Council F., and J. Stewart, "Development of Severity Indices for Roadside Objects," FHWA Publication No. FHWA-RD-95-165, Federal Highway Administration, McLean VA, 1995.

5. Daily, K., W.E. Hughes, and H.W. McGee, "Experimental Plans for Accident Studies of Highway Design Elements: Encroachment Accident Study," Report No. FHWA-RD-96-081, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., January 1997.

6. O. Erinle, W. Hunter, M. Bronstad, F. Council, R. Stewart, and K. Hancock, "An Analysis of Guardrail and Median Barrier Accidents Using the Longitudinal Barrier Special Studies (LBSS) File," Final Report, Volumes 1 and 2, FHWA Publication No. FHWA-RD-92-098, Federal Highway Administration, McLean VA, February 1994.

7. Eskandarian, A., G. Bahouth, K. Digges, D. Godrick, and M. Bronstad, "Improving the Compatibility of Vehicles and Roadside Safety Hardware," Final Report, NCHRP Project 22-15, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., October 2002.

8. Fitzpatrick, M.S., K.L. Hancock, and M.H. Ray, "Videolog Assessment of Vehicle Collision Frequency with Concrete Median Barriers on an Urban Highway in Connecticut," Transportation Research Record 1690, Transportation Research Board, Washington, D.C., 1999, pp 59-67.

9. Hunter, W., "Data Collection and In-Service Evaluation Issues," Transportation Research Circular 416, Transportation Research Board, Washington, D.C., 1993.

10. Hunter, W.W., and F.M. Council, "Future of Real World Roadside Safety Data," Transportation Research Circular Issue 453, Transportation Research Board, Washington, D.C., 1996, pp 38-54.

11. Hutchison, J.W., and T.W. Kennedy, “Medians of Divided Highways By Frequency and Nature of Vehicle Encroachments,” Engineering Experiment Station Bulletin 487, University of Illinois, 1966.
12. Kent,R.W., and C.E. Strother, “Wooden Pole Fracture Energy in Vehicle Impacts,” Advances in Safety Technology, Society of Automotive Engineers, February 1998.

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37. Zegeer, C.V., and M.R. Parker, "Effect of Traffic and Roadway Features on Utility Pole Accidents," Transportation Research Record 970, Transportation Research Board, Washington, D.C., 1984, pp 65-76.

1. Bligh, R.P., "Review of Test Matrices and Conditions," Transportation Research Circular Issue 486, Transportation Research Board, Washington, D.C., 1998, pp 1-5.

This research circular is focused on issues that may warrant consideration in future updates of the guidelines contained in NCHRP Report 350 on evaluation of impact performance of roadside safety features. The areas pertaining to impact conditions discussed by the author include: impact speed, impact angle, impact energy considerations, accident data, and lateral offset relationship. The areas pertaining to the test matrices in NCHRP Report 350 discussed include: terminals/crash cushions, terminal/crash cushion transitions, truck mounted attenuators, optional tests, and side impact testing.

Impact speeds in NCHRP Report 350 test matrices do not exceed 100 km/h (62.2 mph) but the national speed limit of 89 km/h (55 mph) has since been revoked and many transportation agencies have raised speed limits. This change has raised questions regarding the appropriateness of the current test speeds. The author cautions that when contemplating a change in the test speeds, the consequences should be carefully examined. For redirection devices such as longitudinal barriers, the increased impact speed may be accompanied by a decrease in impact angle, such that the overall impact severity may remain the same.

Regarding impact angle, the author indicates that tests have identified problems with stability and severity criteria rather than with the 25-degree angle, which is currently specified in NCHRP Report 350. As for energy considerations, it is pointed out that for end-on impacts with terminals and crash cushions, the impact severity is simply defined as the kinetic energy of the impacting vehicle and the energy that must be managed by absorbing devices increases with the square of the impact speed. Regarding accident data, the author points out that most of the available information on impact speed and distribution is based on accident data which were collected under 89 km/h (55 mph) conditions. There are no data available to determine if and how much the distributions of impact conditions have changed as a result of higher speed limits.

The author reviews the test matrices in NCHRP Report 350 and identifies some issues that require clarification or additional research. These include additional information required on specification of critical impact point (CIP) in Test 34 (small car redirection test), the requirements of conducting Test 39 (reverse direction impact for guardrail), and the appropriateness of the 2000P as the design test vehicle (e.g., the 820C may be more critical for guardrail terminals using a cable anchor assembly due to its increased propensity for under riding the rail). Since Test 32 (15 degree angle impacts on the nose of a terminal or crash cushion) is generally considered to be more critical than Test 33 (utilizing 2000P), it may be appropriate to eliminate Test 33. An additional test may be needed because NCHRP Report 350 is unclear on the transition of a terminal or crash cushion to a standard barrier section. The author also raises issues regarding tests on truck-mounted attenuators.

<u>Limitations and Use for NCHRP 17-22</u>

This article provides useful information on issues related to impact conditions and test matrices for consideration in future updates of the crash test and evaluation procedures presently recommended in NCHRP Report 350. Guidance can be obtained from this article for research to be conducted under NCHRP 17-22 on improving state-of-the-knowledge on accident impact conditions.

2. Cirillo, J.A., "Limitations of the Current NASS System as Related to FHWA Accident Research," Transportation Research Circular Issue 256, Transportation Research Board, Washington, D.C., 1983, pp 20-21.

The author provides useful insights into limitations and capabilities of the NASS system from a highway safety researcher's viewpoint. Five major limitations listed by the author include: 1) non-availability of statewide estimates of the accident problem, 2) inability to link accident data to exposure measures, 3) disparity among FHWA and NHTSA interests, 4) problems with accident reconstruction processes used with barrier crashes and multiple-hit situations, and 5) problematic definitions for some of the collected data elements.

Regarding the first limitation, according to the author, the NASS sampling scheme is designed to produce national estimates and is not setup to provide estimates within states. Regarding the second, the author cites that there is no way to link the accident data collected with any exposure data. Therefore, rates involving million vehicle miles or other highway-related measures cannot be calculated. On the third limitation, the author states that rates which are of interest to the NHTSA are not necessarily the same as those of interest to the FHWA. Since NASS has only information on accidents, a bias exists for the researcher interested in studying countermeasures that prevent accidents. On the fourth limitation, the author cites problems with accident reconstruction computer programs and that the emphasis has been on vehicle and driver. It is for this reason that highway barrier programs are not as adequate as they might be. Lastly, definitions of some of the data elements are not clear and the example of intersections with raised channelization being recorded as Adivided highway@ is given.

Next, information is provided on the capabilities of the NASS data. The main accomplishments possible are provision of national estimates and help with performance evaluations of highway hardware under certain conditions. Adequate national estimates may be obtained for type of accidents, accident severity, etc. However, in carrying out performance evaluations, the researcher must be aware of the basic issue of sample size and numerous factors (e.g., speed of impact, vehicle size, shoulder width, etc.) that must be controlled. Sample size will increase greatly with increasing factors that the research must control. The solution is to initiate special studies, such as the Longitudinal Barrier Special Study (LBSS), but these studies are expensive and time consuming. The researcher must also define data items very carefully, train field data collectors, and ensure high data quality during collection.

In view of the limitations, the author concludes that the NASS system may be of limited use to the highway accident researcher. Suggested changes to make it more useful include incorporation of exposure data, monitoring of highways rather than accidents, and periodic review for removal of unneeded data elements.

<u>Limitations and Use for NCHRP 17-22</u>

This article provides useful insights into the limitations and capabilities of the NASS data. NCHRP 17-22 data collection efforts must be planned to avoid some of the pitfalls discussed in

this article. These include: careful planning of data collection, considerations of sample size and factors to be controlled in the analysis, precise definitions of data elements and data collector training, and data quality control during collection.

3. Cooper, P.J., "Analysis of Roadside Encroachment Data from Five Provinces and Its Application to an Off-Road Vehicle Trajectory Model," March 1981.

Cooper performed an analysis of data acquired by Transport Canada over a five-month period from June to October 1978. Data was acquired from visual identification of encroachments on the roadside.

Encroachment data was collected from various types of roadways, including two-lane undivided and four-lane divided highways with ADTs from 700 to 29,300 vpd and totaling 4560 km (2833 mi). Statistical analysis was performed to determine the encroachment rates, distances, and angles.

Cooper attempted to address many of the problems found with the Hutchison and Kennedy data. Primarily, Cooper addressed intentional encroachments by recording encroachments where the vehicle track formed a continuous arc from the point of departure to the point of re-crossing the shoulder with no apparent discontinuities in the path.

Limitations and Use for NCHRP Project 17-22

Analysis of the Cooper study by McGinnis showed the importance of documentation of every minute detail of data collection and analysis. The importance of well-trained personnel performing both data collection and reconstruction was also identified.

The results of the Cooper study were statistically similar to the Hutchison and Kennedy's results once adjustments are made for study conditions.

4. Council F., and J. Stewart, "Development of Severity Indices for Roadside Objects," FHWA Publication No. FHWA-RD-95-165, Federal Highway Administration, McLean, VA, 1995.

This study was an attempt to develop severity indices (SI) for various fixed objects impacted by vehicles in run-off-the-road accidents. SI is the average, or typical, severity of the impact of a vehicle with a given object or the injury sustained by a vehicle occupant. The authors first reviewed pertinent literature indicating the gaps in knowledge. Briefly, the gaps included the need for multi-state accident databases, identification of crashes in which the occupant injury could be directly attributed to the fixed object struck, the need for a methodology that provided not only an average measure of the SI, but a measure of the possible variability of the measure, and a need for SIs that are specific to a large array of crash locations and circumstances. Finally, the issue of change in vehicle fleet (e.g., airbag equipped vehicles) on SI values was afforded some attention.

The authors' first attempted to utilize crash test data with police reported accident data for SI development. However, this was not successful because of limited variability in the crash test conditions, the lack of information on impact angle and speed in the police data, and the need to define a better composite measure of occupant risk in the crash test measurements. Thus, the final SI development was based on the police reported data only.

Using accident data from North Carolina and Illinois, two SIs were developed for a wide range of crash situations: the first was a severe injury SI while the second was a cost-based SI. For consistency, driver injury as opposed to most severe injury, which could be experienced by any occupant in a vehicle, was chosen in the SI development. The Classification and Regression Trees (CART) procedure was used to define the control variables that produced significant differences in the SIs for a given object. Overall, the SIs were moderately consistent between the two states, and findings from the two databases were consistent to a significant degree with SIs developed by Mak, et al., using data from Texas. Also, the analysis indicated that airbags appeared to significantly reduce the value of SI, and that the reduction could range from 30-70 percent. The cost-based SI figures provided a wider range of values for indices, and they appeared to provide a more accurate index of relative hazardousness for impact attenuators. However, when small samples were compared, it appeared that the severe injury index was superior in that it was less sensitive to random fluctuations of fatalities.

<u>Limitations and Use for NCHRP 17-22</u>

This study provides useful information on development of severity indices for roadside objects. It has some limitations including non-reporting of accidents and the use of data from only two states. Even the data utilized in the study were not consistent across the two states. The potential use of this information in NCHRP 17-22 is somewhat limited.

5. Daily, K., W.E. Hughes, and H.W. McGee, "Experimental Plans for Accident Studies of Highway Design Elements: Encroachment Accident Study," Report No. FHWA-RD-96-081, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., January 1997.

This study examines the feasibility of using accident data to derive estimates of: (1) encroachment rates on level, tangent sections of rural two-lane highways, and (2) percentage of unreported accidents.

A pilot study involving 56 km (35 mi) of tangent sections of rural two-lane highways in Idaho were conducted. Data collected included detailed roadside, accident, and traffic data. Encroachment rates were estimated from the collected accident data and found to be in the same order of magnitude as previous research. It was concluded that the methodology is feasible, although it is limited by the current state-of-the-knowledge with respect to data on the trajectories of vehicles involved in ran-off-the-road, fixed-object accidents.

An experimental plan for future research that would produce improved estimates of encroachment rates was developed, but not recommended for immediate implementation.

Limitations and Use for NCHRP Project 17-22

This study has no direct bearing on the current study, but could be of interest in future data collection efforts. Data on encroachment rates are almost 25 years old and may be outdated in light of the significantly changed conditions in the intervening years, including improvements made to the safety design of highways (e.g., clear zone concept and improved barriers and terminals) and vehicles (e.g., front and side airbags, anti-lock brakes, and crush management) and other safety countermeasures (e.g., mandatory seatbelt law, tightened blood alcohol content law). If a major data collection effort is to be implemented in future, encroachment data may be one of the objectives.

6. O. Erinle, W. Hunter, M. Bronstad, F. Council, R. Stewart, and K. Hancock, "An Analysis of Guardrail and Median Barrier Accidents Using the Longitudinal Barrier Special Studies (LBSS) File," Final Report, Volumes 1 and 2, FHWA Publication No. FHWA-RD-92-098, Federal Highway Administration, McLean, VA, February 1994.

The Longitudinal Barrier Special Study (LBSS) was one of three studies initiated within the National Accident Sampling System (NASS) to provide in-depth knowledge of specific types of crashes. Under this special study, additional data was collected on accidents involving longitudinal barriers. In order to be eligible for inclusion, the accident must involve a vehicle striking a guardrail or median barrier, be reported by the police, and the following data had to be available: (1) barrier damage, (2) vehicle trajectory, and (3) vehicle damage. The data collection was conducted in a prospective mode such that the additional elements could be identified during the initial accident investigation. In addition to data collected under NASS, supplemental data elements were collected, including detailed information about the barrier that was struck and terrain traversed during the accident. Barrier information included type of system and measurements of the damaged section of barrier.

Data was collected from 1982 to 1986. Onward from mid-1983, accidents involving vehicle-to-vehicle impacts prior to the guardrail or median barrier impact were not included. A total of 1,146 accidents met the acceptance criteria and were included in the study.

Under this study by Erinle, et. al., the NASS LBSS data file was cleansed and reviewed. This involved recoding portions of the data for consistency and correcting erroneous data. Also, barrier impacts were separated by length-of-need and impact severity as well as barrier type. The accidents were then reconstructed to determine vehicle speed, angle, and vehicle orientation at impact. The reconstruction procedure involved determining energy losses during each stage of the accident, ranging from pre-impact skidding to secondary impacts with vehicles or other objects. Energy dissipated during an impact was estimated based on vehicle and barrier damage. Vehicle crush energy was estimated from measured damage profiles using vehicle stiffness parameters derived from the New Car Assessment Program (NCAP) crash tests. Barrier damage energy was estimated using computer simulations that correlated barrier deformation to energy dissipation. Damage associated with other types of impacts, including secondary vehicular impacts and other fixed object crashes, were estimated based largely on vehicle crush measurements.

Length-of-need (LON) impacts were reconstructed using conservation of energy and summing the energy losses from vehicle crush, barrier deformation, and vehicle trajectory. A relationship between maximum dynamic barrier deflection and impact severity was used to estimate energy losses from barrier deformation. Barrier end impacts were reconstructed for W-beam turndowns, W-beam blunt ends, and Breakaway Cable Terminals (BCTs). The authors used vehicle drag, crush, trajectory, vehicle/barrier damage, occupant injuries, and yaw marks, as well as crash test experience to reconstruct the accident.

The main conclusions from the study were:

- Weak-post barriers were less associated with driver injury than other barrier types.

- Driver injury rates were higher for vehicles redirected to the roadway than vehicles remaining on the roadside, penetrating the barrier, or remaining in contact with the barrier.
- Blunt and turndown ends were more dangerous than LON impacts.
- Reconstructed values of longitudinal barrier impact speed typically had an error margin of 10 mph.
- Unusual circumstances were commonly present when a barrier reportedly failed.

Limitations and Use for NCHRP 17-22

This study provides useful information on a study that generated impact conditions for longitudinal barriers. The same general approach is proposed for Project 17-22 with the exception that it will not be limited to longitudinal barriers. Procedures utilized to reconstruct the longitudinal barrier accidents will be very similar to what will be needed in Project 17-22. Further, problems associated with representativeness of the accident data should be avoided if possible.

The study also highlighted the importance of discerning between types of guardrail "failure." In many cases, "failure" was not an accurate description of the guardrail behavior and was recoded in the LBSS file. Systematic investigations of every data variable are critical and verification that photographic evidence matches database coding is essential. The study also noted that the end terminal type must be verified from photographic evidence, since miscoding and misidentification in the file had occurred.

Although this study developed a great deal of information on accidents involving roadside and median barriers, it does have some representativeness problems. The authors were not able to utilize the data to obtain distributions of impact conditions for ran-off-road accidents. Further, because the study was limited to longitudinal barriers, it was not possible to generalize any of the information to accidents involving other roadside objects.

7. Eskandarian, A., G. Bahouth, K. Digges, D. Godrick, and M. Bronstad, "Improving the Compatibility of Vehicles and Roadside Safety Hardware," Final Report, NCHRP Project 22-15, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., October 2002.

The objectives of this study were to: (1) identify current and future vehicle characteristics that are incompatible with existing roadside hardware; (2) evaluate the possibility of improving compatibility; and (3) provide the automotive industry and roadside hardware developers with an increased awareness of these compatibility issues.

Preliminary findings suggest that pickup trucks may not be a good surrogate for SUVs, impacts with concrete barriers tend to be more serious, and there is a good correlation between certain vehicle characteristics and injury outcome. Of particular interest to Project 17-22 is a list of suggested data elements for use with the current NASS CDS program. These data elements pertain to struck feature design characteristics, pre-impact conditions, impact conditions, and assessment of impact performance of feature.

Limitations and Use for NCHRP Project 17-22

While the suggested data needs pertain mostly to the issue of compatibility between vehicle design and roadside safety features, the information would be helpful to establishing the data needs for the data collection effort under Project 17-22.

8. Fitzpatrick, M.S., K.L. Hancock, and M.H. Ray, "Videolog Assessment of Vehicle Collision Frequency with Concrete Median Barriers on an Urban Highway in Connecticut," Transportation Research Record 1690, Transportation Research Board, Washington, D.C., 1999, pp 59-67.

In-service performance evaluation of concrete median barriers (CMB) in Connecticut is the focus of this paper. The authors concentrate on determining how often CMBs are struck and how often such collisions are reported to police. They used repeated videologs of a selected highway to collect information on CMB collisions and then compared those to police reported crashes. A ratio of 23% between the total number of collisions and those reported to the police was found. Collision rate on curved segments was approximately three times greater than that on tangent segments. Neither the Roadside model nor the RSAP model provided accurate predictions of the collision frequency observed on the study section. Roadside under predicted while RSAP over predicted the number of collisions. The authors concluded that the differences could be due to the variation in characteristics of their study segment and those of the data sets used in the development of the two encroachment models. Finally, the authors indicated that the character and nature of vehicle encroachments and collision rates on high-volume, high-speed highways in urban areas are not well understood.

Limitations and Use for NCHRP 17-22

It appears that the study has limitations, some of which have not been taken into account. For example, 40 blocks of CMBs were excluded from the study because of lighting problems with the videolog equipment when passing under bridges. This could potentially introduce bias in the collected data especially since underpasses were systematically excluded. The study failed to collect information on collisions that did not mark CMBs and encroachments that did not result in a collision. Further, the study was limited to median barriers and differences in vehicle fleet mix across different lanes could potentially bias the data. Despite these limitations, the study provides useful information for calibrating impact frequency models.

9. Hunter, W., "Data Collection and In-Service Evaluation Issues," Transportation Research Circular 416, Transportation Research Board, Washington, D.C., 1993.

This paper presents an overview of relevant data issues for in-service evaluation of roadside safety management systems. The author stresses the need for in-service evaluations on a continual basis since the vehicle fleet is changing with time. The paper starts with inherent problems with crash evaluations. Some of the problems include variations in accident reporting thresholds, erroneous reporting on accident data collection forms, inaccurate location of accidents, and considerable delays in data processing in some areas. Some of the suggested sources for building an appropriate database include existing accident data files, manual surveys by maintenance personnel, photolog and videolog, and other automated or semi-automated methods of data collection. After this, the author focuses on in-service evaluation issues such as, "what is being measured?" and threats to validity. The suggestion is that investigators should clearly decide, "What is the treatment supposed to accomplish?" before embarking with the evaluation. Some treatments (e.g., warning signs, median barriers, etc.) attempt to reduce accident frequency while others (e.g., crash cushions) attempt to reduce collision severity. Regarding threats to validity, some of the issues highlighted are other things taking place at the same time (history), trends over time (maturation), regression to the mean, and data instability.

The next topic discussed is evaluation design. Probably the most common design in highway safety has been the simple before-after design, where data are compared before and after a treatment to evaluate safety impacts. Unfortunately, this simplistic approach is subject to several validity threats. A better design is the before and after study with randomized control groups. In the absence of randomized groups, a before and after study with a selected control site might be acceptable. Finally, the author presents suggestions on data elements and studies that may be utilized to fill gaps in existing knowledge. These include the use of LBSS data, data on real world barrier crashes (vehicle impact speed and angle, vehicle yawing angle or vehicle tracking, barrier impact point, subsequent vehicle trajectory, etc.)

<u>Limitations and Use for NCHRP 17-22</u>

The paper provides useful information on issues with in-service evaluations. As suggested in the paper, vehicle impact speed and angle data will be collected in NCHRP 17-22.

10. Hunter, W.W., and F.M. Council, "Future of Real World Roadside Safety Data," Transportation Research Circular Issue 453, Transportation Research Board, Washington, D.C., 1996, pp 38-54.

The issue of data adequacy to meet various evaluations of roadside safety hardware is the focus of this paper. It points to a number of goals related to roadside safety hardware including:

- Determine whether a new design can pass a "practical worst case" scenario
- Determine which roadside features to treat
- Determine whether what has been designed using crash tests and simulation works in the real world

The authors then attempt to examine the questions of whether adequate data exist to meet the above goals, and if not, what can be done to produce relevant data. They discuss the encroachment and accident-based models for roadside safety and indicate existing gaps in the available data for both models. Lack of current data availability on encroachments, lack of roadside inventory, and unreported accidents are some of the limitations mentioned by the authors. The authors also discuss limited data availability for development of injury indices.

The authors discuss some databases that could potentially be utilized. These include: the HSIS database and the Longitudinal Barrier Special Study (LBSS). However, both have limitations; HSIS does not contain information on impact conditions (speed and angle) and not enough detail on specific hardware, while the LBSS data suffers from bias toward more severe accidents. Other sources mentioned are maintenance data and videolog data. The authors conclude that there are clear gaps in existing knowledge of roadside safety measures and gaps in the databases used to build this knowledge. They recommend proper targeting of funds and creative thought about new and existing data to overcome the gaps.

<u>Limitations and Use for NCHRP 17-22</u>

The paper is a good review of the existing gaps in knowledge of roadside safety and what might be done to fill those gaps. The existing databases mentioned in the paper (HSIS, LBSS, etc.) have limitations and their applicability to NCHRP 17-22 research is doubtful. Videolog data and in-service evaluations of hardware, although good sources for data, do not provide impact speed and angle data needed in NCHRP 17-22.

11. Hutchison, J.W., and T.W. Kennedy, "Medians of Divided Highways By Frequency and Nature of Vehicle Encroachments," Engineering Experiment Station Bulletin 487, University of Illinois, 1966.

Hutchinson and Kennedy encroachment data was used as the basis for AASHTO's Roadside Design Guide, providing the basis of analysis of off-road excursions. The frequency, nature, and causes of vehicle encroachments on medians of divided highways were investigated to obtain information needed to establish traffic safety criteria for median width and cross-section design. Many aspects of roadway design were examined, including median width, traffic volume, roadway alignment, weather, roadway signs, grade separation structures, and other departures. Relationships between traffic volume and the frequency and nature of vehicle encroachments on medians were examined.

Researchers analyzed the distances and angles of errant vehicles through visual inspection of the roadside. Encroachments with less than a 0.9-m (3-ft) lateral movement were ignored due to the difficulty detecting encroachments on stabilized shoulders.

The medians were frequently covered with snow during the data collection phase. However, encroachments during winter months were less than those for non-winter months.

Limitations and Use for NCHRP Project 17-22

Several issues exist with the data set, including the lack of adjustment for intentional encroachments and the differences due to changes in the deregulation of speed limits, the introduction of anti-lock brakes, and the other technological or sociological changes that have occurred in the past four decades. Encroachment data was biased towards low angle impacts, given that four-lane roadways were new to the public and medians provided an attractive area for picnics or pulling off of the road to rest. These changes must be taken into consideration when determining future data needs.

12. Kent, R.W., and C.E. Strother, "Wooden Pole Fracture Energy in Vehicle Impacts," Advances in Safety Technology, Society of Automotive Engineers, February 1998.

Fixed-object collisions, which account for less than 8% of all crashes, represent nearly 30% of all fatal crashes. Almost half (43%) of all fixed-object impacts are into a tree, pole, or post. This study performed a literature review, a series of one-eighth scale-model pole/pendulum impacts, and an analytical study using static analysis and dynamic finite element modeling of vehicle/pole impacts.

A methodology was developed correlating the scale-model testing of several species of wood to full-scale impacts. It was assumed that the pole or tree in question acts as a cantilevered beam when impacted with no significant base translation and/or rotation in addition to fracture.

The implementation of this methodology requires the following additional data be known during the reconstruction:

1. The geometry of the struck pole/tree (diameter and height).
2. Species of wood making up the pole or tree in question (however conservatively, the accident reconstructionist can assume the pole or tree was constructed of a material which will absorb a minimum amount of energy).
3. The likely moisture content of the pole or tree in question (poles can generally be assumed to be of low moisture content (i.e. less than six percent), trees generally have moisture contents greater than 20 percent).
4. The nature of damage to the pole or tree. This includes whether the fracture was complete and the height of the fracture.

<u>Limitations and Use for NCHRP Project 17-22</u>

This paper offers another methodology for reconstructing pole impacts. The specificity required to reconstruct the accidents, specifically wood species and moisture content, may be necessary should experience with crash reconstructions deem it necessary. However, the acquisition of this data would require expertise generally beyond that of the average technician unless specially trained to do so.

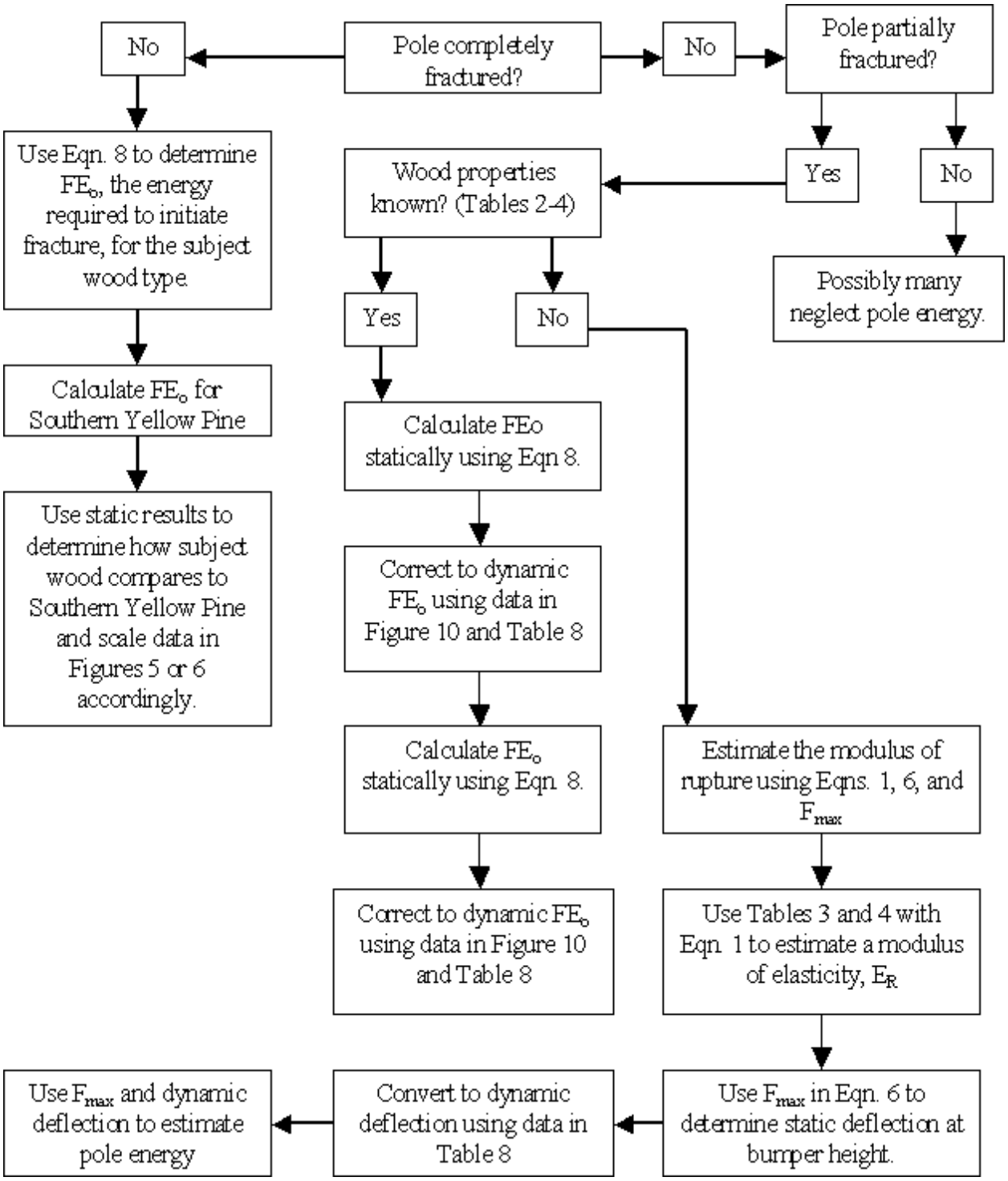


Figure A-1 Kent and Strother Methodology for Post Fractures

13. Labra, J.J., and K.K. Mak, "Development of Reconstruction Procedure for Pole Accidents," Final Report, Contract No. DTNH22-80-C-07014, National Highway Traffic Safety Administration, Washington, D.C., November 1980.

An examination of existing simulation and analytical models was performed. Software programs designed for reconstructing pole accidents, including DASF, LUMINAIRE, MODASF, and UTILITY POLE, were deemed unusable due to the significant amounts of information required to reconstruct the accident, e.g. the structural properties of individual poles and the physical properties of a luminaire transformer base. Therefore, a procedure to create a new subroutine for the well-validated CRASH was developed.

The examined analytical models made assumptions and simplifications in order to keep the mathematics and calculations at a manageable level. The key assumption was that the post failed in a shear mode and that shearing is instantaneous once the shear strength or base fracture energy is reached. While this assumption is valid for metal bases, timber poles cannot adequately be modeled this way, since wooden posts fail mostly in a bending mode with fiber striping.

Pole impacts were divided into three categories: (1) no noticeable pole damage, (2) partial fracture of the pole, and (3) complete separation of the post. In cases where there was no noticeable pole damage, the pole was treated as a rigid object. The pole was assumed to not absorb energy and that all energy dissipation occurred due to vehicle crush.

Equations were derived for the fracture of wooden utility poles. These are shown below in tabular and graphical format.

Table A-1. Pole Fracture Energy

Pole Circumference, C (in.)	Extent of Fracture	BFE (ft-lb)
≤26	Complete	20000
	Partial	$\frac{1}{2}(20{,}000 - (1.4 \times 10^{-5})\, C^{4.38})$
>26	Complete	$(1.4 \times 10^{-5})\, C^{4.38}$
	Partial	$\frac{1}{2}((1.4 \times 10^{-5})\, C^{4.38} - 20{,}000)$

Table A-2. Pole Curve Segments

Pole Circumference, C (in.)	Damage	Curve Segment
≤26	None	1
	Partial	3
	Complete	4
>26	None	5
	Partial	3
	Complete	2

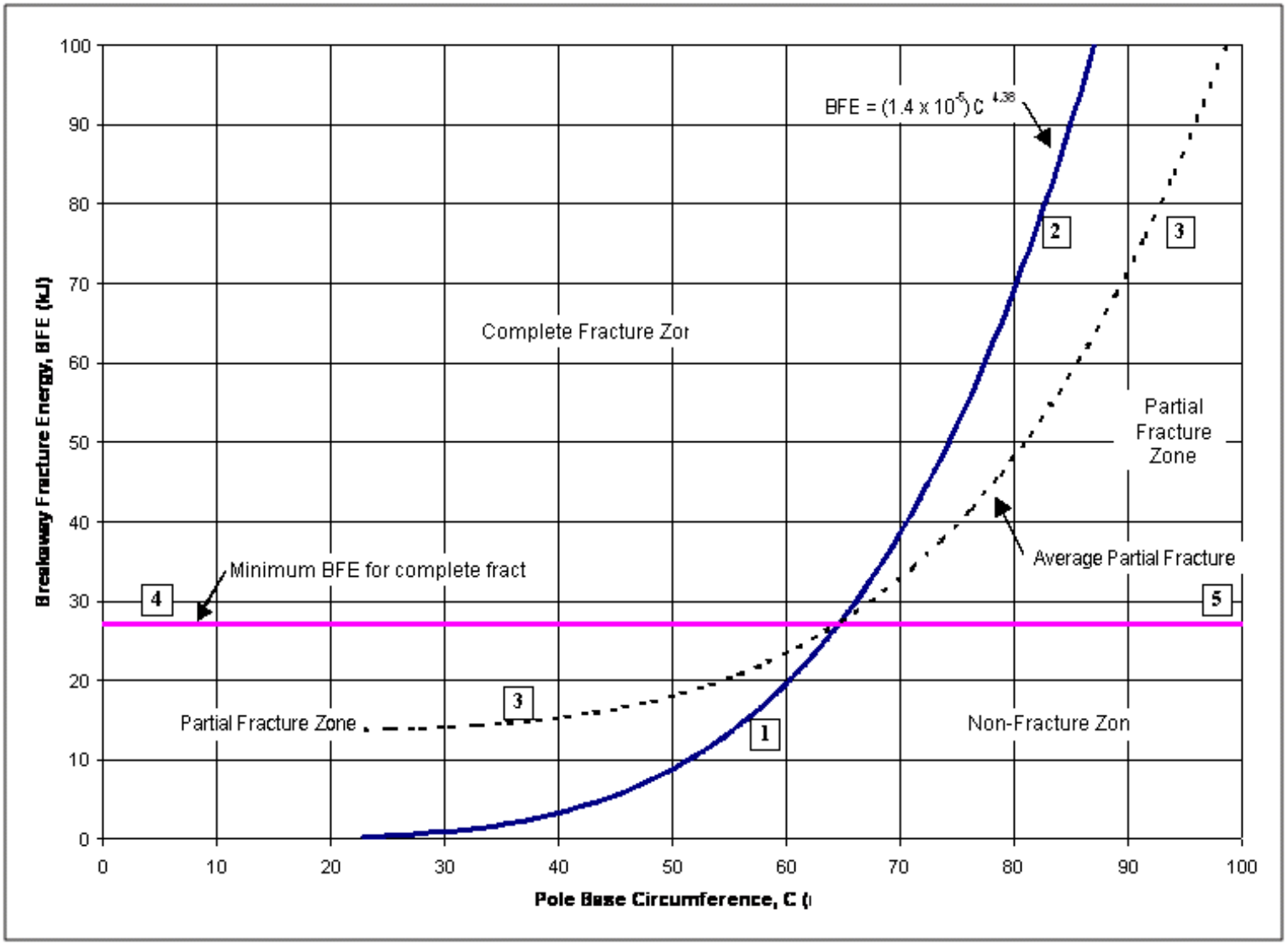


Figure A-2. Graphical Representation of Fracture of Wooden Utility poles

Averages found for breakaway luminaries were ~10 kip-ft.

The study determined that the minimum elements required for a complete reconstruction of a pole impact are: (1) type of pole, (2) material of pole or base, (3) length of pole, (4) cross-sectional dimensions at base of pole, (5) type of base / anchoring mechanism, (6) type of breakaway design, and (7) damage extent of the pole. It was found to be desirable to have the following information: (1) height of break / length of broken segment, (2) cross-sectional dimensions at the top and bottom of the broken segment, (3) final resting position of the pole, and (4) manufacturer of the breakaway device.

The analytical procedure for the five full-scale impacts varied between -5.5% and 45.9%. However, the procedure was never coded into subroutines for CRASH and is numerically intensive beyond the levels of accuracy obtained from the manual procedure.

Limitations and Use for NCHRP Project 17-22

The report gives good advisement on the energy absorption of fully- and partially-fractured posts during impact. The report also gives good suggestions on the data necessary to accurately reconstruct the crash and data that were considered desirable. While the procedure was never coded into subroutines for CRASH, this methodology provides a usable way to reconstruct pole impacts.

14. Mak, K.K. and R.L. Mason, "Accident Analysis - Breakaway and Nonbreakaway Poles Including Sign and Light Standards along Highway," Technical Report, Southwest Research Institute, San Antonio, Texas, August 1980.

The objectives of the study are to: (1) identify the extent of the pole accident problem; (2) determine the accident and injury severity rates associated with pole accidents; (3) assess the characteristics of pole accidents; and (4) evaluate the performance and cost-effectiveness of breakaway designs.

A probabilistic sample of 1,014 pole accidents and a non-random stratified sample of 533 metal pole accidents were investigated, in-dept,h in the study together with a census of all pole accidents and a sample inventory of poles. The data were collected in seven geographical locations over a period from January 1976 to October 1979.

The study results include:

- Extent of pole accident problem
- Characteristics of pole accident sites, vehicle damage, and occupant injuries
- Assessment of performance of various pole types
- Cost-effectiveness evaluation of breakaway modification as a safety countermeasure

The authors also established distributions of impact speeds and angles for pole accidents using the in-depth crash data as well as the relationships of impact conditions to injury severity.

Limitations and Use for NCHRP Project 17-22

This is one of the first major efforts to collect and analyze in-depth crash data on an ad hoc basis, i.e., not on a continuing basis like the NASS program. This effort was later continued with the NASS Longitudinal Barrier Special Study (LBSS). Also, the data from this study and the Narrow Bridge study (Mak 1983) were used to estimate impact speed and angle distributions (Mak 1986), similar to the objectives of NCHRP Project 17-22. This study provides a road map on the collection and analysis of in-depth crash data and the estimation of impact conditions.

15. Mak, K.K., and A. Magaro, "National Accident Sampling System (NASS) Longitudinal Barrier Special Study Coding/Editing and Field Procedures Manual," National Highway Traffic Safety Administration and Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1984.

16. Mak, K.K., and A. Magaro, "National Accident Sampling System (NASS) Luminaire and Sign Support Special Study Coding/Editing and Field Procedures Manual," National Highway Traffic Safety Administration and Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1982.

17. Mak, K.K., and A. Magaro, "National Accident Sampling System (NASS) Crash Cushion Special Study Coding/Editing and Field Procedures Manual," National Highway Traffic Safety Administration and the Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1982.

These reports deal with the coding and field procedures used to document the NASS special studies of Longitudinal Barriers, Luminaires and Sign Supports, and Crash Cushions. These manuals outline methods for collecting, recording, and verifying data for use in in-service evaluations. The manuals were intended for use by Primary Sampling Unit (PSU) investigators for data collection and Zone Center (ZC) personnel in their review process. The manual includes information identifying the name of each category, the references used in formulating the definitions, and the coding instructions for each of the variables. For each variable or group of variables, the variable number, name, format, beginning column, element value, source, remarks, field procedures, and related variables were included. The manual contains a section that identifies editing and consistency checks to aid PSU investigators and ZC personnel when reviewing the special study forms.

The NASS Longitudinal Barrier Special Study was designed to collect detailed information about accidents involving longitudinal barriers. The data was collected along with cases included in the NASS CDS program. Supplemental data collected during this study included the type of barrier struck, other objects or vehicles impacted, the type and slopes associated with the terrain traversed during the accident, and detailed information regarding vehicle trajectory throughout the accident. Due to the limited number of accidents included in the NASS CDS, all of these accidents involving longitudinal barriers were included in the LBSS study. Supplemental data collection included sufficient detail to reconstruct the barrier accidents in order to estimate impact speeds.

The other two special studies on luminaire and sign support and on crash cushion resulted in too few crashes to be of any significance.

<u>Limitations and Use for NCHRP 17-22</u>

This study provides a benchmark for data collection efforts sufficient to conduct accident reconstructions. Further, the data collection effort included much of the same information required

for the current project. This study will help provide templates for supplemental data collection under both the retrospective and prospective data collection efforts.

18. Mak, K.K., and L.R. Calcote, "Accident Analysis of Highway Narrow Bridge Sites," Final Report, FHWA Contract No. DOT-FH-11-9285, Federal Highway Administration, Washington, D.C., April 1983.

Data was compiled from the computerized bridge and roadway inventory data files from the States of Arizona, Michigan, Montana, Texas, and Washington. Accident data was assembled from State accident files for all the reported accidents occurring within 152.4 m (500 ft) of these bridges for a three-year period using a mile-point matching process. A total of 24,809 accidents occurred on these bridges or within their approach areas.

In order to be included in the study, bridges had to be on the state highway system, have no traffic control signals, and have all key physical data about the bridge known. For this study, a "narrow bridge" was a bridge with: (1) a total width of 5.5 m (18 ft) or less for one-lane bridges, (2) a combined width of 7.3 m (24 ft) or less for two-lane bridges, or (3) the total approach roadway width is greater than the total bridge width and the bridge shoulder width is less than or equal to 50 percent of the approach roadway shoulder width.

It was found that significant shoulder reductions (greater than or equal to 50%) tended to increase the accident rate for a bridge. However, widening bridges more than the minimum widths required for bridges to remain in place given in the AASHTO "Green Book" and realigning approach roadways may not be cost-effective on the sole bases of safety benefits, given the lack of strong relationships found in this study.

Limitations and Use for NCHRP Project 17-22

The statistical analyses performed by Mak *et al* to determine the relationships of accident frequency, rate, and severity at bridge sites to bridge and approach characteristics used variance analysis, correlation analysis, factor analysis, simple and multiple linear regressions, and discriminant analysis. The experiences with these, particularly the identification of the applicability of discriminant analysis, could show correlation, if not causality, with specific roadway or roadside features.

Mak noted that a surprisingly high percentage of impacts resulted in improper barrier performance, which must be examined carefully. Additionally, subsequent impacts were prevalent for barrier collisions at bridge sites and the trajectory of vehicles should be studied closely.

19. Mak, K.K., D.L. Sicking, and H.E. Ross, Jr., "Real-World Impact Conditions for Run-off-the-Road Accidents," Transportation Research Record 1065, Transportation Research Board, Washington, D.C., 1986, pp 45-55.

This paper provides information on real-world impact conditions for run-off-the-road accidents and develops distributions for impact speed and angle for various functional classes of highways. Data are from two sources: a representative sample of pole accidents collected over a 20-month period in Texas and Kentucky and a census of accidents involving bridge rails collected over a 21-month period in Texas. After screening, a total of 596 cases were available for analysis. The gamma function provided best fits for univariate impact speed and impact angle distributions. Since there is no known means of mathematically expressing a joint gamma distribution, the authors tested various known joint (bivariate) distributions, with little success. They then assumed that the impact speed and impact angle are independent of each other and estimated combined probability distributions for impact speed and angle stratified by functional class and based on the gamma distribution. The authors provide two examples of potential use.

The paper is accompanied by a discussion from J. D. Michie, who argues that the representation of the data set (i.e., police-reported pole and bridge related accidents) significantly effects the resulting distributions. He suggests a more representative data set would have yielded an exponential distribution. Michie also indicates that the data suffer from: a) lack of exposure information such as traffic volume, operating speed distribution, vehicle types, and distribution and density of roadside features, and b) measurement or estimate of unreported accidents. Michie suggests that the approach suggested by Cirillo "*Limitations of the Current NASS System as Related to FHWA Accident Research"* (TRR Circular 256, 1983) may be appropriate as it appears to address these limitations.

<u>Limitations and Use for NCHRP 17-22</u>

The authors were cognizant of the limitations of the study and acknowledge them in the paper and their closure statement. The paper is an important milestone in providing distribution of impact conditions. The paper is closely related to NCHRP 17-22 research. Some of the limitations (e.g., reliance on police reported accidents, consideration of only two types of accidents, and limited geographic representation) must be taken into account during NCHRP 17-22. Some of the assumptions in the study must also be verified, e.g., the gamma distribution is appropriate for both individual functional classes and combining data. Also, NCHRP 17-22 research must check for the correlation between impact speed and angle. The paper found weak correlation between these two parameters (-0.153 between impact speed and angle, i.e., higher speeds result in smaller impact angles). If there is evidence that the two variables are more closely related, then NCHRP 17-22 must explore various joint (bivariate) distributions. The research effort reported in the paper did not have enough data on rural freeways and assumed that urban freeways and expressways would approximate rural freeways. Efforts should be made to collect more data on rural freeways to avoid the same problems.

Cirillo's suggested approach on data collection must be reviewed. Efforts should be made, to the extent possible, to incorporate the two databases investigated in the research reported in this paper. Information must also be collected on post-impact vehicle trajectory in NCHRP 17-22, since it is important for accidents with longitudinal barriers (multiple impacts may be involved and injury severity increases with the number of impacts). Finally, care must be exercised to minimize the representation problems cited by Michie.

20. Mak, K.K., and D.L. Sicking, "Rollover Caused by Concrete Safety Shaped Barrier," FHWA Report No. DTFH61-85-C-00129, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., January 1989.

An extensive and comprehensive effort was performed to determine: (1) the extent of the rollover problem with concrete safety-shaped barriers, (2) the causative or contributory factors associated with these rollovers, and (3) the potential counter-measures available to reduce rollover in these cases. These goals were achieved through analysis of the NASS Longitudinal Barrier Special Study (LBSS) data file and computer simulation.

The LBSS data was examined to identify cases involving impacts with concrete safety-shaped barriers. A total of 130 NASS LBSS cases were identified and the hard copies provided by FHWA to the project staff for analysis. If possible reconstructions were performed to estimate the vehicle impact speed with the barrier. All cases resulting in vehicle rollovers (a total of 31) were clinically analyzed in depth in an effort to identify factors that may have contributed to rollover.

It was determined that a constant-slope surface barrier may provide the best compromise between the F-shape barrier, which offers little improvement over the safety-shaped barrier, and a vertical wall, which offers the greatest reduction in rollover potential but also has the greatest increase in lateral accelerations.

Limitations and Use for NCHRP Project 17-22

The implementation of HVOSM to determine roll distances from initial velocities and vehicle shapes will prove extremely useful in reconstructing run-off-road crashes where rollover occurred. Also of considerable use are the subroutines adapted for impacts with concrete barriers for CRASH3. These original programs have been obtained and recompiled for operating on Windows 2000 based machines.

Extensive examination of the quality of NASS LBSS accident cases was performed. This examination is extremely beneficial since the PSU investigators are responsible for the data used in NCHRP 17-22. The anticipation of problems with data and how to address these problems is also identified in this research.

21. Mak, K.K. and D.L. Sicking, "Rollover Caused by Concrete Safety Shaped Barrier," Transportation Research Record 1258, Transportation Research Board, Washington, D.C., 1992.

The Longitudinal Barrier Special Study (NASS-LBSS) was a special study incorporated into the NASS CDS program. Under this special study, additional data was collected on approximately 125 accidents involving concrete safety shaped barriers. The data collection was conducted in a prospective mode such that additional elements could be identified during the initial accident investigation. These data elements included detailed information about the barrier that was struck and terrain traversed during the accident. Barrier information included type of system and measurements of the contact region between the vehicle and the barrier.

The concrete safety shaped barrier accidents contained in the NASS LBSS data file were reconstructed to determine the speed, angle, and vehicle orientation at impact. The reconstruction procedure involved identifying energy losses during each stage of the accident, ranging from pre-impact skidding to secondary impacts with vehicles or other objects. Energy dissipated during an impact was estimated based on vehicle damage and length of contact with the barrier. Vehicle crush energy was estimated from measured damage profiles using vehicle stiffness parameters derived from the New Car Assessment Program (NCAP) crash tests. A computer program was developed that balanced the vehicle energy with the energy from the skidding and barrier friction. Damage associated with other types of impacts, including secondary vehicular impacts and other fixed object crashes were estimated based largely on vehicle crush measurements.

Although this study developed a great deal of information on accidents involving concrete safety shaped barriers, it does have some representativeness problems. The authors were not able to utilize the data to obtain distributions of impact conditions for ran-off-road accidents. Further, because the study was limited to longitudinal barriers, it was not possible to generalize any of the information to accidents involving other roadside objects.

Limitations and Use for NCHRP 17-22

This paper provides useful information on a study that generated impact conditions for longitudinal barriers. The same general approach is proposed for Project 17-22 with the exception that it will not be limited to longitudinal barriers. Procedures utilized to reconstruct the longitudinal barrier accidents will be very similar to what will be needed in Project 17-22. Further, problems associated with representativeness of the accident data should be avoided if possible.

22. Mak, K.K. and D.L. Sicking, "Development of Roadside Safety Data Collection Plan," Report No. FHWA-RD-92-113, Federal Highway Administration, McLean, VA, 1994

The primary objective of this research was to identify issues and gaps in the state-of-the-knowledge needed to improve the cost-effectiveness analysis procedure and to develop data collection plans for those issues and gaps that could be addressed with accident data. The research proposed five studies and developed data collection plans for those studies. These included:

- Validation of encroachment frequency/rate
- Determination of encroachment frequency/rate
- Effect of roadside conditions on impact probability and severity
- Distributions of impact conditions, and
- Relationships of impact conditions, performance limits, and injury probability and severity

The study plans were reviewed by a panel of experts and their comments taken into consideration. The recommended study on the distributions of impact conditions focuses on impact speed, angle, and vehicle orientation besides vehicle size, weight, and the nature of roadside object/feature. The plan for this study includes:

- Select sample roadway segments for each of the six highway types
- Setup data collection protocol (including sampling plan, accident notification scheme, data collection forms, etc.) and familiarize and train investigators with the protocol through a small pilot study
- Investigate in-depth a representative sample of single-vehicle, ran-off-road type accidents on these selected roadway segments
- Reconstruct the sampled accidents to determine impact conditions
- Compile descriptive statistics on vehicle trajectory and impact conditions
- Develop mathematical models for the distributions of impact speeds and angles

<u>Limitations and Use for NCHRP 17-22</u>

The report is most useful to NCHRP 17-22 and perhaps to some other on-going research projects (e.g., NCHRP 17-11). The data collection plan for identifying impact conditions should be closely reviewed under Tasks 3 and 4 of Project 17-22. Note that the study recommends interviewing the driver involved in the accident via telephone. The telephone interview could be used to collect driver socioeconomic data, which according to Mak are often causal in run-off-the-road accidents but unavailable. Although not practical for the retrospective data collection effort, contacting drivers may be helpful in the prospective data collection procedures and should be carefully considered. The study also recommends collecting information on drinking establishment locations and economic vitality of the local economy. Such information could be used to improve benefit/cost analysis procedures.

23. Mak, K.K., "Methods for Analyzing the Cost-Effectiveness of Roadside Safety Features," Transportation Research Circular Issue 435, Transportation Research Board, Washington, D.C., 1995, pp 42-62.

The author has discussed methods of cost-effectiveness evaluation of roadside safety features and appurtenances and provides information of the different cost-effectiveness analysis procedures. Most of the information in this document is based on "Development of Roadside Safety Data Collection Plan" by Mak and Sicking (1994).

The author provides an overview of the cost-effectiveness analysis methodology. Future research needs for the encroachment probability based cost-effectiveness analysis procedure are enumerated. According to the author, the most important area requiring improvement is the accident severity estimation procedures, which have the most effect on the outcomes of the cost-effectiveness analysis.

Several data sources are summarized (e.g., NASS Longitudinal Barrier Special Study (LBSS), NASS Continuous Sampling System (CSS), etc.) and their limitations discussed. Various previous research efforts are also presented. The data gaps suggested for improvement to the probability based cost-effectiveness procedure include (in order of relative importance to the procedure):

- Performance limits of roadside safety features and associated severity
- Relationships of injury probability and severity to impact conditions
- Distributions of impact conditions
- Effects of sideslopes on extent of lateral encroachment
- Severity associated with sideslopes
- Validation of encroachment frequency/rate and adjustment factors
- Evaluation of the extent of unreported accidents
- Trajectory of vehicles after encroaching into the roadside
- Relationships of surrogate severity measures to injury probability and severity

<u>Limitations and Use for NCHRP 17-22</u>

The paper provides a good review of efforts directed at cost-effectiveness analyses and lists the shortcomings of several cost-effectiveness tools such as, *AASHTO Guide for Designing, Selecting, and Locating Traffic Barriers*, the TTI's ABC, FHWA's BCAP, ROADSIDE, etc. The paper raises several important issues for future research including the ones under investigation in NCHRP 17-22 (identification of real-world impact conditions). It is useful in exposing the shortcomings of several databases for use in cost-effectiveness analysis. The use for NCHRP 17-22 is to avoid utilizing databases that have been identified in this paper as having limitations. These are NASS LBSS (non-representative) and NASS CSS (small sample of fixed object impacts).

24. Mak, K.K., R.P. Bligh, and L.I. Griffin, III, "Improvement of the Procedures for the Safety Performance Evaluation of Roadside Features," Final Report, NCHRP Project 22-14, Transportation Research Board, Washington, D.C., November 2000.

The objectives of this study are to: (1) evaluate the relevance and efficacy of procedures for the safety performance evaluation of highway features, and (2) assess the needs for updates to NCHRP Report 350.

The study identified a list of updating needs for crash testing and evaluation guidelines set forth in NCHRP Report 350 and the NCHRP project panel selected seven specific updating issues for further study:

- Test vehicles and specifications
- Impact conditions
- Critical impact point
- Efficacy of flail space model
- Soil type/condition
- Test documentation
- Working width measurement

White papers were prepared for each of these seven topics. In addition, a prototype methodology to assess the relevance issue was developed. However, there was little consensus among the roadside safety community on how relevance is even to be defined, not to mention an evaluation procedure.

Limitations and Use for NCHRP Project 17-22

One of the impetuses for Project 17-22 is to provide better data on the impact conditions of severe single-vehicle, ran-off-road crashes so that the impact conditions for the crash testing guidelines can be properly established. The discussions on impact conditions from this report provide an indication on one of the potential applications of data on impact condition and would be helpful in determining the data needs for Project 17-22.

25. Mak, K.K., and D.L. Sicking, "Continuous Evaluation of In-Service Highway Safety Feature Performance," Final Report 482, Arizona Department of Transportation, Phoenix, Arizona, September 2002.

This paper is the result of research sponsored by the Arizona DOT and it is focused on the conceptual framework for a national center on in-service performance evaluation of roadside safety appurtenances. The authors first make the case for in-service evaluation by indicating that real-world conditions significantly vary from crash test conditions (i.e., frozen or saturated soil, unforeseen problems with installation and maintenance of devices, etc.). As such, in-service performance evaluation is needed to assure that safety appurtenances are indeed performing as intended.

Because in-service performance evaluations tend to be labor-intensive and not within easy reach of any one or two DOTs, a national center that promotes better data compilation and dissemination of available information is needed. The paper provides information on the center's mission and objectives, scope, organization and funding sources, and potential benefits.

Limitations and Use for NCHRP 17-22

The need for a national center on in-service performance evaluation of roadside features appears justified and the proposed conceptual framework is sound. There is little direct application of the material to NCHRP 17-22 research.

26. McGinnis, R.G., "Reexamination of Roadside Encroachment Data," Transportation Research Record 1690, Transportation Research Board, Washington, D.C., 1999, pp 42-58.

This somewhat controversial paper is broadly focused on the issue of revision to guardrail runout lengths in the AASHTO Roadside Design Guide (RDG) and particularly on two encroachment data sets and their properties. The RDG procedures for guardrail runout lengths are based on encroachment data collected by Hutchinson and Kennedy (H&K) during the early 1960's. Revisions to the guardrail runout lengths were recommended by Wolford and Sicking based on more recent encroachment data collected in Canada in 1978 (the so called Cooper's data). McGinnis compares the two datasets (H&K and Cooper's) and reports several inconsistencies in the Cooper's dataset. Based on his analysis and findings, McGinnis suggests that reducing guardrail runout lengths from current RDG guidelines for highways with high speed limits may not be prudent. This suggestion is based on:

- Highways surveyed in the Canadian study were not similar to US high-speed freeways
- Highways surveyed by H&K were similar to many US high-speed freeways
- Statistically significant differences in encroachment lengths and encroachment departure angles existed between the Canadian survey teams for highways with similar speed limits

The paper is accompanied by discussions from three discussers: Peter Cooper and R. Sanderson, both involved with the Canadian study, and Dean Sicking, one of the two authors of a study that recommended changes to the RDG guidelines based on the Canadian data. While Cooper and Sanderson defend the Canadian study and indicate shortcomings in McGinnis's research, Sicking's effort is based on provision of a more complete and balanced picture. Sicking points to two earlier versions of this paper where McGinnis' finding was the opposite of what has been reported in this paper. In the earlier versions, McGinnis made the case that the two data sets were essentially the same and recommended that the two data sets be combined for use in developing guardrail length guidelines.

<u>Limitations and Use for NCHRP 17-22</u>

It appears that there are several limitations to this paper as pointed out in detail by the discussers. Primarily, the paper is useful in raising awareness of the differences over a subject of considerable significance to the highway safety community. The usefulness for NCHRP 17-22 lies in that the research effort should not fall prey to such controversy. To avoid criticism such as that received by Cooper's research, NCHRP 17-22 must document each and every detail of data collection, utilize expert data collectors, and run quality checks during and after data collection. The fact that Cooper's research has received such heavy scrutiny after two decades points to the need to document even minute research details and maintain excellent documentation after completion of the project.

27. Mendoza, A., A. Uribe, C.Z. Gil, and E. Mayoral, "Development of a Relational Accident Database Management System for Mexican Federal Roads," Transportation Research Record 1717, Transportation Research Board, Washington, D.C., 2000, pp 84-93.

The paper describes the Mexican Transportation Institute's development of a computerized accident data management system that combines data collected by various organizations in Mexico. The organizations whose data are combined include: the Federal Highway Patrol, toll road operators, insurance companies, medical services (hospitals and emergency medical services), other emergency services (fire departments, towing services, etc.), and the public prosecutor departments. Other organizations considered for data were research institutions, weather agencies, state traffic departments, the National Institute for Geography, Statistics, and Data Management, and the General Directorate of Protection and Preventive Medicine in Transportation.

The management system primarily utilizes accident data collected by the Federal Highway Patrol (called PFC in Spanish) since it is deemed the most complete. An overall linking scheme has been developed that links the PFC data to data from other agencies. Various variables (e.g., time & date of accident, location, vehicle and driver data, and judicial information) available in the different databases are utilized for the linking process.

The system can present the data at the national, state, and local levels and in various formats (e.g., GIS). An application to 1997 data is described in the paper.

Limitations and Use for NCHRP 17-22

The paper provides useful information on accident data integration from a variety of sources in Mexico. However, direct application of the methodologies and the system developed in this research to NCRHP 17-22 research effort is minimal. This is because of procedural, organizational, and jurisdictional differences between USA and Mexico

28. Miaou, Shaw-Pin, "Estimating Roadside Encroachment Rates With The Combined Strengths Of Accident-And Encroachment-Based Approaches," Publication No. FHWA-RD-01-124, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., September 2001.

Miaou proposed a method to estimate vehicle roadside encroachment rates using accident-based models. Miaou concluded that the results of his study indicated that the proposed method could be a viable approach to estimating roadside encroachment rates without actually collecting the encroachment data in the field, which can be expensive and technically difficult.

Miaou tested the consistency of his approach using two data sets from FHWA's Highway Safety Information System (HSIS). The model allows the rates to be estimated by average annual daily traffic volume, lane width, horizontal curvature, and vertical grade for rural two-lane undivided roads.

Limitations and Use for NCHRP Project 17-22

While the encroachment data was statistically examined and the effects of multiple variables were examined, there was no collection of information regarding the actual characteristics of individual accidents. This study will be most helpful in the processing and analysis of data after reconstructions have been performed. Miaou examined the functional forms to best match the data and these may be applicable to the finalized database evolving from NCHRP Project 17-22. Particularly, Miaou used the Poisson assumption for the randomness of accident frequency together with the assumption that the exponential function of the unobserved variables is gamma distributed.

29. Michie, J.D., "Evaluation of Severity of Collisions with Roadside Features: Data Needs. Summary, Part 2," Transportation Research Circular 256, Transportation Research Board, Washington, D.C., 1983, p 13.

This write up appears in the Transportation Research Circular 256, which contains the proceedings of a 1981 workshop sponsored by the TRB Committee on Safety Appurtenances. It summarizes the information presented in support of B-C analysis procedures for roadside safety programs. The work of seven presenters is summarized as follows.

There is need to have baseline data of the untreated roadside for reference in safety improvement comparisons and development of warrants for appurtenances. Full-scale crash tests are not practical for investigation of all possible collision conditions and the importance of evaluating appurtenances under field conditions was emphasized. However, as a complement to vehicle crash testing methods during appurtenance development, computer simulations have been shown to be cost effective under certain conditions. Investigators are cautioned about the importance in assessing the compatibility of specific hardware with the traffic and site characteristics in field evaluations. There is also a need to acquire detailed clinical data from selected accident cases. With regard to establishing a link between vehicle crash test severity and potential injury of vehicle occupants, the use of anthropometric dummies has certain limitations in that dummy responses are insufficient for use in the B-C analysis procedures. Further, extensive in-service evaluation, including numerous collision cases, is necessary to develop sufficient input to the B-C equation.

<u>Limitations and Use for NCHRP 17-22</u>

This write up summarizes points raised by several presenters at the TRB sponsored workshop. Almost all of these are still pertinent and useful for NCHRP 17-22 research.

30. Michie, J.D., and M.E. Bronstad, "Highway Guardrails: Safety Feature or Roadside Hazard?" Transportation Research Record 1468, Transportation Research Board, Washington, D.C., 1994, pp 1-9.

The objective of the study was to examine and assess the conventional wisdom of guardrail performance on highways. The authors review past literature on highway guardrail usage and mention several documents published from 1964 to 1989 that focus on the hazardous nature of guardrails. From the statements quoted by the authors, a reader might conclude that guardrails are not only a roadside hazard but that the perceived safety benefit, if any, is decreasing with time. The authors argue that perceptions on the hazardous nature of guardrail are based on incomplete and misleading accident data and that the conclusions reached on the analyses of those data are invalid. The following reasoning is presented:

- Only severe impacts that include injuries or a disabled vehicle are generally reported; relatively little is known about the number and extent of drive-away accidents.
- The police officer investigating the accident rarely indicated the type of guardrail because most officers are not trained in this technology; moreover, information on guardrail condition prior to the accident is almost always unavailable.
- Accidents involving guardrails are generally grouped according to the first harmful event even though hitting the guardrail may not have been the most harmful event; as such, injuries and damage may be incorrectly attributed to guardrails.
- Guardrails may be attributed the blame for events that are beyond guardrail design envelope; combinations of vehicle mass, speed, and impact angle may exceed crash test values resulting in barrier failure. However, it is arguable whether the occurrence of such accidents should, in any way, suggest that the installation is a hazard.

The authors examined previous research in four key areas: unreported accidents, the effects of recording first harmful event (instead of most harmful event), length of need and terminals, and condition and design of barriers. Based on their examination, they concluded that the success rate of longitudinal barriers is 94%, the severity indexes for barrier impacts used in the benefit-cost models may be excessively severe (resulting in understating benefits of installing guardrails), and severity indexes for barrier ends should distinguish whether the end is one of the newer crashworthy ends meeting the criteria outlined in NCHRP Report 230 or one of the older designs that does not meet these criteria.

<u>Limitations and Use for NCHRP 17-22</u>

The paper presents a good review of pertinent studies regarding highway guardrails and the case for re-assessment of guardrail performance, in light of the shortcomings of previous research, is convincing. Two issues are pertinent to NCHRP 17-22 research: unreported accidents and the standard and condition of roadside objects before accident. Since NCHRP 17-22 effort is focused on serious accidents, subsequent use of the results in any cost-effectiveness model may

underestimate benefits. Further, efforts should be made to collect information on standard and condition of roadside installations prior to the accident since some may not be properly installed or may not conform to newer standards.

31. Morgan, J.R., and D.L. Ivey, "Analysis of Utility Pole Impacts," Paper No. 870307, Society of Automotive Engineers, 1987.

A parametric study was conducted using a computer program that incorporated a fourth-order Runge-Kutta numerical integration scheme to create a two-dimensional model of the utility pole and vehicle. The model assumed that the energy required for pole facture is not velocity dependent over the range of interest. A linear relationship between load and crush distance was assumed for the vehicle, with the spring constant dependent only upon the vehicle mass.

Correlations between residual frontal deformation and the impact velocity were developed for various vehicle masses. Further testing was suggested on a wider range and combination of pole sizes, vehicle masses, and impact velocities to strengthen the database and the applicability of the reconstruction.

Limitations and Use for NCHRP Project 17-22

Focus of the study was on probabilities for injury levels as much as reconstruction of the crash itself. The simulation performed by Morgan *et al* can be used to verify velocity changes when compared with other methods for verification of results. However, stiffnesses for this study varied only upon weight, which is significantly less sophisticated than modern simulation methods.

32. Ray, M.H., and J.A. Hopp, "Performance of Breakaway Cable and Modified Eccentric Loader Terminals in Iowa and North Carolina: In-Service Evaluation," Transportation Research Record 1720, Transportation Research Board, Washington, D.C., 2000, pp 44-51.

This research, sponsored by the NCHRP (project 22-13), examined the in-service performance of the breakaway cable terminal (BCT) and the modified eccentric loader terminal (MELT) in Iowa and North Carolina. Data were collected in a two-year period (1997-1999) on 600 BCTs and 50 MELTs each in the two states. Data collection teams were notified about collisions from police and highway maintenance agencies, which then visited the collision site to collect guardrail terminal damage information. Data collected by the police and maintenance agency was also utilized in this study. Overall, data from 102 BCT and 42 MELT collisions were collected during the two years. Impact scenarios were determined on the basis of physical evidence at the scene (e.g., skid marks, ruts in the soil, scraps on the guardrail, etc.)

The authors compared their data to the NCHRP Report 350 crash tests and concluded that the tests in the report apparently relate to the way vehicles strike guardrail terminals in the field. However, some tested scenarios, such as the reverse-direction collisions, were rarely observed in the field, while important real-world scenarios such as side impacts are not included in NCHRP Report 350.

Characteristics of the collected data included: 60% of impacts striking the end of a 1.22 m offset guardrail terminal and the remaining 40% striking at or downstream of Post 2. Passenger cars dominated the in-service collision data. Over 60% of the police-reported MELT and BCT collisions resulting in property damage only. About 90% of collisions with guardrail terminals in Iowa were not reported to the police or the DOT. These collisions represent guardrail and guardrail terminal successes. Some potential problems with steel-tube foundations and the 12-gauge guardrail splice were observed. Only one of the concrete foundations used in a BCT in Iowa moved during an end-on collision while 12 end-on collisions involving the steel foundation tube moved.

No statistically significant differences were found between the performance of BCTs and MELTs or between the performances of the two devices across the two states.

Limitations and Use for NCHRP 17-22

The study appears sound and if BCTs and MELTs are focused during 17-22, then one could use the data collected during this study and investigate how it compares with newly collected 17-22 data. Since the authors of this study followed data collection methodology somewhat similar to what has initially been proposed in 17-22 (i.e., investigation of police reported accidents and collection of additional data during site visits), it would be useful to contact the authors for discussion on some of the pitfalls they faced during their data collection effort.

33. Ross, H.E., Jr., "Baseline Data Needs," Transportation Research Circular 256, Transportation Research Board, Washington, D.C., 1983, pp 6-7.

This write up appears in the Transportation Research Circular 256, which contains the proceedings of a 1981 workshop sponsored by the TRB Committee on Safety Appurtenances. It is focused on data needs for formulation of probabilistic models based on vehicle encroachment data that are used in benefit-cost (B-C) analysis. According to the author, the nature and frequency of inadvertent encroachments by a motorist are functions of numerous factors, including the motorist and the roadway. Data are needed to determine the relationship between encroachments and these various factors. With regard to roadway variables, encroachments are believed to be a function of roadway type, roadway and roadside geometry, traffic control devices, traffic conditions, and vehicle size. The author recommends collection of data that will enable predictions of: 1) the number of times an object will be struck in a given time period, 2) the type of vehicles expected to strike an object in a given time, 3) speeds and angles at which vehicles will strike objects, and 4) attitude at which vehicles will strike objects.

Once the number and type of vehicle involvements with a given roadside object have been estimated, the probability and level of injuries associated with each involvement must also be estimated. Impact severity may be estimated from physical test data, accident data, computer simulation, accident reconstruction, or engineering judgment.

Limitations and Use for NCHRP 17-22

This write up presents a critical view of the various data needed for conducting B-C analysis. There are no limitations to the write up and the data indicated in it are still sparsely available. NCHRP 17-22 is focused on collecting some of the data that has been alluded to in this write up. It is useful in providing background information.

34. Sicking, D.L., and H.E. Ross, Jr., "Benefit-Cost Analysis of Roadside Safety Alternatives," Transportation Research Record 1065, Transportation Research Board, Washington, D.C., 1986, pp 98-105.

This paper is focused on the improvement of benefit-cost (B-C) analysis of roadside safety alternatives. Although existing B-C analysis procedures do a good job of accounting for the different costs involved with a safety improvement, they generally overstate the severity of most accidents that are predicted to occur and are difficult to use. The procedure reported in this paper improves the versatility of the B-C analysis, the determination of severity associated with predicted accidents, and has been coded for use with microcomputers for easy implementation.

Development of the new procedure is based on an encroachment probability model that predicts accident occurrence and severity. The goal is to relate roadway and traffic characteristics to the expected accident frequency at a site. The model is based on the assumption that the number of run-off-the-road accidents that occur at a given site can be related to the number of vehicles that inadvertently leave the roadway at that site. Further, it is assumed that the frequency and nature of uncontrolled encroachments can be related to roadway and traffic characteristics. The general approach in calculating accident frequency is to determine the region along the roadway or hazard envelope, within which a vehicle leaving the travel way at a prescribed angle will strike the hazard. When two or more hazards are present, the hazard envelopes can overlap creating a complex geometric problem. Hazard envelopes in such cases can be described if the relative locations and the geometry of all hazards are known.

The encroachment probability model developed in this research uses hazard locations and geometry to determine the limits of all encroachment ranges and the lateral distances to each hazard within the range. The model then calculates the probability of a collision within each encroachment range. It utilizes encroachment characteristics from a database collected on Canadian four-lane divided highways and two-lane, two-way highways by Cooper in 1979. These data were adjusted to account for controlled encroachments and lateral extent of movement to eliminate the effect of paved shoulders. The model utilized combined impact speed and angle distributions developed from accident studies by Mak and Calcote and Mak, et al. Further, the model utilized accident costs based on societal costs of accidents linked to the severity index scale developed by Bronstad and Michie. Although crash tests provide a link between impact severities in terms of vehicle accelerations and damage, the fact that most crash tests are conducted at speeds near 60 mph creates a gap in severity indices data for roadside features at speeds of less than 60 mph. The authors assume a linear relationship between the severity index and impact speed in this model. Also, since most crash tests involve angles of 15-25 degrees, severity indices from other impact angles must be interpolated and extrapolated.

Overall, the B-C model described in the paper incorporates most of the improvements found in all previous models and has improved accuracy besides analysis of multiple hazards. The paper describes an application of the model to develop general barrier use guidelines.

Limitations and Use for NCHRP 17-22

Some of the limitations, acknowledged by the authors, include non-application to accidents other than run-off-the-road, the weak link between impact conditions and accident severity, and the difficulty in quantifying accident severities of some hazards such as drop-offs and roadside slopes. The data collected in NCHRP 17-22 can enhance some aspects of the model developed in this study; this paper can be used as a base for those improvements.

35. Troxel, L.A., "Severity Models for Roadside Objects," Transportation Research Circular Issue 416, Transportation Research Board, Washington, D.C., 1993, pp 58-68.

This paper provides useful information on historical development of methods used for determining which roadway designs are most likely to have accidents that result in serious or fatal injuries. After reviewing existing severity models, it then goes on to suggest some new models and likely data sources.

Within existing models, the paper discusses cost-based severity models, accident data probability severity models, relative severity index, and crash test severity models. These models have been based on expert opinion, accident data, crash test results, and computer simulations. Models based on engineering judgment are subjective and generally designed to relate to injury costs that are also subjective. The accident data models established that vehicle and accident characteristics can be used to predict injury severity, but problems of unreported accidents and low level of detail make most of these models unreliable. Crash test results used alone or with computer simulation show promise but a weak link is between vehicle or impact measurements with probability of occupant injury.

The paper suggests a model based on probability of injury rather than benefit/cost ratio:

$$P(I|C) = P(I|S)P(S|C) + P(I|F)\,P(F|C)$$

Where $P(I|C)$ = probability of injury given a crash
$P(I|S)$ = probability of injury given side impact
$P(S|C)$ = probability of side impact given a crash
$P(I|F)$ = probability of injury given frontal impact
$P(F|C)$ = probability of frontal impact given a crash

To determine $P(S|C)$ and $P(F|C)$, the use of crash test results and accident data are suggested. Crash test results on most roadside appurtenances can be obtained from the FHWA while the NASS accident databases including special studies (LBSS, Pole Special Studies, and the Crash Cushion Special Study) can be used for accident data.

Four models are suggested to determine $P(I|F)$ and $P(I|S)$. These are: Accident Data Regression Model, Modified Accident Data Regression Model, Crash Tests and Special Studies Model, and Crash Test Regression Model. The first two models use accident data alone (NASS, appropriate special studies, and state accident databases). The third proposed model is based on crash test data combined with LBSS data while the last model is based purely on crash test data. According to the author, whether the models suggested in this paper can be developed successfully or not, the process of developing them will be valuable in itself.

Limitations and Use for NCHRP 17-22

This paper provides a useful review of existing injury models and their limitations and suggests a new probability based model. Several data sources are suggested. Unfortunately, the suggested data sources have known limitations and it is doubtful if they can provide all of the information needed to develop the suggested probability model. The utility of this paper to NCHRP 17-22 is that data collected in NCHRP 17-22 can probably be used in conjunction with the databases cited in this paper to develop some of the regression-based models.

36. Viner, J.G., F.M. Council, and J.R. Stewart, "Frequency and Severity of Crashes Involving Roadside Safety Hardware by Vehicle Type," Transportation Research Record 1468, Transportation Research Board, Washington, D.C., 1994, pp 10-18.

In 1993, FHWA published a ruling that listed NCHRP Report 350 for guidance in determining the acceptability of roadside barriers and other safety appurtenances for use on National Highway System projects. Previously, most roadside hardware acceptance test programs had used the minimum crash test matrix of NCHRP Report 230, published in 1981. One of the differences between the two reports was the use of a 4,400-lb truck in NCHRP Report 350 compared to the 4,500 lb passenger car used in NCHRP Report 230.

This paper examines the relative safety experiences in crashes with roadside safety hardware by different vehicle body types. Data from North Carolina and Michigan were used to compare the relative severities of roadside safety hardware crashes involving two vehicle body types: the 4,400-lb pickup truck and the 4,500 lb passenger car. Additionally, FARS data were used both to define the size of the problem by vehicle type and to identify the vehicle types that appear to be over represented in hardware-related fatal crashes when compared with the estimated numbers of nationwide crashes into hardware from the GES files and with national numbers of registered vehicles from the R. L. Polk vehicle registration files.

Analysis indicated that the practical worst-case test philosophy of current roadside safety device evaluation procedures has provided about the same level of protection to drivers of vans, utility vehicles, and pickups as to passenger car drivers, provided the measure of safety is the likelihood of serious (fatal + incapacitating) injuries. However, if the measure of safety is the likelihood of fatalities, this does not appear to be the case. That is, drivers of pickups were found to be at greater risk. The likely reason for this greater risk of fatalities found for pickup drivers was ejection in rollover crashes. The authors recommend programs to increase seatbelt usage and other measures that may prevent ejection in a crash.

<u>Limitations and Use for NCHRP 17-22</u>

There are several limitations of the study that have been acknowledged by the authors. These include problems with the data such as: crash under-reporting in the two state databases and GES data and the inability of the Polk data to differentiate between urban and rural driving patterns. The study utilized data that are usually available for analyses and, as such, does not represent a unique source. Therefore, use for NCHRP 17-22 is limited, if any.

37. Zegeer, C.V., and M.R. Parker, "Effect of Traffic and Roadway Features on Utility Pole Accidents," Transportation Research Record 970, Transportation Research Board, Washington, D.C., 1984, pp 65-76.

The authors collected utility pole related data on 2,520 miles of highways utilizing different sources, e.g., highway and police files and photologs. Specifically, photologs were utilized to collect data on utility poles (diameter, material type, spacing, etc.), their lateral offsets, and obstructions in the encroachment envelope. About 65% of the data collected were in rural areas, 13% in urban areas, while the remaining were in urban fringe areas. The authors addressed the following questions:

- What are the dimensions of the utility pole accident problem (how many reported and how severe)?
- What factors affect the frequency of these accidents and can the relationships of accidents with these factors be utilized to estimate the effectiveness of utility pole countermeasures?
- What factors affect the severity of these accidents and what are the relationships between accident severity and utility pole accident countermeasures?

Using a variety of statistical analyses (correlation analysis, analysis of variance and covariance, and regression analysis) the authors reached the following conclusions:

- The overall accident rate was 16.61 utility pole accidents per hundred million vehicle miles and was 4.11 per hundred billion vehicle-pole interactions.
- Traffic volume, pole offset, and pole density are important in explaining accident frequency. Others include roadway class, shoulder width, horizontal curvature, lighting, and speed limit.
- Wooden poles and those with offsets of 1-10 ft resulted in greater injury severity. Severity also increased with roadway curvature for some speed limit categories. Speed limit was not found to be important.

A predictive regression model employing ADT, pole offset, and pole density as independent variables was formulated to explain accidents per mile per year.

Limitations and Use for NCHRP 17-22

Although the severity of utility pole accidents was identified and the effects of various highway variables on impact severity were examined, there was no attempt to collect any information regarding the nature of the impacts. No detailed information was collected that could help identify vehicular impact conditions. Other limitations of the study include the fact that all the independent variables used in the regression model, pole density, traffic volume, and pole offset, are all exposure related parameters. Other variables that may be important (e.g. driver characteristics, accident location, etc.) could not be included in the study.

APPENDIX B. 1997-2001 NASS-CDS Cases

Table B-1. Eligible Cases by Primary Sampling Unit (PSU)

Area Type	PSU	Unweighted		Weighted	
		No.	Percent	No.	Percent
Rural	2	59	4.93%	22953	3.33%
	4	35	2.93%	4930	0.71%
	11	145	12.12%	51212	7.42%
	13	130	10.87%	57320	8.31%
	43	100	8.36%	97323	14.11%
	48	114	9.53%	139620	20.24%
	76	109	9.11%	49884	7.23%
	78	85	7.11%	33025	4.79%
	Subtotal	777	64.97%	456267	66.14%
Suburban	5	16	1.34%	22955	3.33%
	8	28	2.34%	10016	1.45%
	9	64	5.35%	19683	2.85%
	12	94	7.86%	40154	5.82%
	45	60	5.02%	42112	6.10%
	73	48	4.01%	11084	1.61%
	75	57	4.77%	40993	5.94%
	81	52	4.35%	46627	6.76%
	Subtotal	419	35.03%	233624	33.86%
Total		1196	100.00%	689891	100.00%

Table B-2. List of Sampled Cases

Sampled Cases for 2000											
PSU 02	**PSU 11**		**PSU 12**	**PSU 13**		**PSU 45**		**PSU 48**	**PSU 75**	**PSU 76**	**PSU 78**
25	3	79	40	2	122	5	164	16	29	19	20
26	5	90	45	7	123	14	166	20	30	72	21
31	10	103	46	15	129	43	170	27	38	81	22
42	19	104	47	28	130	52	172	30	39	83	30
44	28	105	53	32	131	57	173	35	40	95	31
46	32	109	64	44	132	82	182	36	43	99	40
53	36	110	65	50	140	83	199	62	44	105	43
61	39	147	89	55	142	85	211	70		129	57
63	44	150	109	60	147	104		73		132	67
74	45	160	119	64	160	109		97		137	71
86	47	162	145	78	161	112		120		142	77
89	48		158	82	165	123		143		145	78
130	52		167	86	170	124		161		151	85
140	53		172	88	173	131		162			87
142	63		202	91	178	139		167			88
148	65			92		141		170			97
	71			99		145		181			98
	73			104		147		182			111
	74			112		159					
	76			116		160					
Number of Cases by PSU											
16	31		15	35		28		18	7	13	18
Total Cases in Zone 1 = 125								Total Cases in Zone 2 = 56			
Number of Cases for 2000				181							

Table B-2. List of Sampled Cases (Cont'd)

Sampled Cases for 2001														
PSU 02	**PSU 11**		**PSU 12**		**PSU 13**			**PSU 45**	**PSU 48**	**PSU 75**	**PSU 76**		**PSU 78**	
5	13	166	6	99	5	79	180	11	6	5	6	106	8	130
9	15	169	7	104	6	80	185	23	14	12	11	112	14	136
17	32	191	11	105	7	81	188	75	21	13	17	117	17	138
23	42	194	16	125	13	86	190	82	27	17	21	121	23	
42	45	212	19	128	26	89	206	93	34	47	22	142	24	
45	48	217	24	133	30	90	207	99	36	54	41	144	35	
68	52		25	137	31	92	208	136	52	85	43		45	
77	57		26	157	32	93		158	59	111	48		46	
79	61		29	160	33	94		171	75	118	50		48	
83	66		30	168	34	105		217	87	119	54		49	
84	84		35		40	126			90	139	55		50	
92	88		45		44	130			100	160	60		59	
97	100		54		47	134			140		65		65	
110	110		56		49	142			151		77		69	
112	119		57		52	148			152		82		71	
	120		58		54	149			160		84		81	
	121		62		59	150			171		89		84	
	126		67		64	151			174		95		85	
	130		82		68	153			183		101		92	
	133		90		69	161			186		103		93	
	138		91		72	169			196		104		124	
	149		94		76	175			200		105		125	
Number of Cases by PSU														
15	28		32		51			10	22	12	28		25	
Total Cases in Zone 1 = 136									Total Cases in Zone 2 = 87					
Number of Cases for 2001								223						

Table B-3. Breakdown of 1997 and 1998 NASS CDS Cases by Screening Criteria

Year	All Crashes for the 16 Rural and Suburban PSUs	Single-vehicle, Ran-Off-Road Crashes		Speed Limit ≥ 45 Mph		Complete Vehicle Inspections		Trajectory Data Available	
		No.	%	No.	%	No.	%	No.	%
1997	2979	979	32.9%	548	56.0%	343	62.6%	163	47.5%
1998	2951	932	31.6%	558	59.9%	397	71.1%	220	55.4%
Total	5930	1911	32.2%	1106	57.9%	740	66.9%	383	51.8%

Table B-4. Breakdown of Eligible 1997-1998 NASS CDS Cases by PSU

PSU	Area Type	Single Vehicle Ran-Off-Road Crashes			Eligible Crashes	
		1997	1998	Total	No.	%
2	Rural	62	65	127	29	22.8%
4	Rural	46	41	87	2	2.3%
11	Rural	64	88	152	68	44.7%
13	Rural	50	79	129	40	31.0%
43	Rural	72	70	142	20	14.1%
48	Rural	83	56	139	38	27.3%
76	Rural	30	52	82	6	7.3%
78	Rural	62	58	120	52	43.3%
Rural Subtotal		469	509	978	255	26.1%
5	Suburban	60	38	98	7	7.1%
8	Suburban	70	56	126	9	7.1%
12	Suburban	64	65	129	21	23.3%
73	Suburban	50	38	88	10	11.4%
9	Suburban	41	53	94	21	22.3%
45	Suburban	93	71	164	30	12.8%
75	Suburban	67	61	128	27	21.1%
81	Suburban	65	41	106	3	2.8%
Suburban Subtotal		510	423	933	128	13.7%
TOTAL		979	932	1911	383	20.0

Table B-5. Breakdown of Eligible 1997-1998 NASS CDS Cases by PSU and Vehicle Type

PSU	Area Type	Passenger Car		Light Truck		Total
		No.	%	No.	%	
2	Rural	20	69.0%	9	31.0%	29
4	Rural	2	100.0%	0	0.0%	2
11	Rural	39	57.4%	29	42.6%	68
13	Rural	24	60.0%	16	40.0%	40
43	Rural	16	80.0%	4	20.0%	20
48	Rural	29	76.3%	9	23.7%	38
76	Rural	2	33.3%	4	66.7%	6
78	Rural	27	51.9%	25	48.1%	52
Rural Subtotal		159	62.4%	96	37.6%	255
5	Suburban	6	85.7%	1	14.3%	7
8	Suburban	5	55.6%	4	44.4%	9
12	Suburban	14	66.7%	7	33.3%	21
73	Suburban	7	70.0%	3	30.0%	10
9	Suburban	15	71.4%	6	28.6%	21
45	Suburban	19	63.3%	11	36.7%	30
75	Suburban	12	44.4%	15	55.6%	27
81	Suburban	2	66.7%	1	33.3%	3
Suburban Subtotal		80	62.5%	48	37.5%	128
Total		239	62.4%	144	37.6%	383

Table B-6. Breakdown of Eligible 1997-1998 NASS CDS Cases by Speed Limit and Vehicle Type

Speed Limit (mph)	Passenger Car		Light Truck		Total
	No.	%	No.	%	
45	71	70.3%	30	29.7%	101
50	28	73.7%	10	26.3%	38
55	96	61.9%	59	38.1%	155
65	14	45.2%	17	54.8%	31
70	17	58.6%	12	41.4%	29
75	13	44.8%	16	55.2%	29
Total	239	62.4%	144	37.6%	383

Table B-7. List of Sampled 1997 NASS CDS Cases

Sampled Cases for 1997										
PSU 02	**PSU 09**	**PSU 11**		**PSU 12**	**PSU 13**	**PSU 43**	**PSU 48**	**PSU 73**	**PSU 75**	**PSU 78**
1	16	6	135	14	10	132	23	15	16	5
21	27	7	136	45	32		39	37	32	23
29	28	11	146	107	39		46	94	52	24
41	39	20	148	125	62		63	99	56	28
51	51	24	150	150	92		64	166	68	31
54	53	25	152	173	135		88		70	37
55	57	27	161	203	155		111		71	54
59	59	28	167	232	165		124		72	58
64	62	31	168	248	173		132		74	62
65	63	40	171		206		135		90	74
66	76	44	178		207		137		111	76
130	79	47	179		209		147		121	83
132		69	184				160		126	87
133		70	193				161		175	108
		71	194				163			120
		75					171			122
		85					198			124
		86					200			133
		128								137
Number of Cases by PSU										
14	12	34		9	12	1	18	5	14	19
Total Cases in Zone 1							Total Cases in Zone 2			
82							56			
Number of Cases for 1997				138						

Table B-8. List of Sampled 1998 NASS CDS Cases

Sampled Cases for 1998														
PSU 02	**PSU 09**	**PSU 11**		**PSU 12**		**PSU 13**		**PSU 43**	**PSU 48**		**PSU 73**	**PSU 75**	**PSU 78**	
2	12	6	134	18	214	7	145	25	4	145	7	2	20	94
22	28	11	135	28	224	14	155	50	10		12	23	24	95
37	52	15	136	33		15	156	99	13		85	46	27	107
70	59	30	142	36		17	159	101	22		143	54	29	108
74	63	39	143	46		18	165	105	25		149	56	31	110
79	80	55	144	52		38	167	111	26			62	36	113
80	87	56	153	65		46	182	129	30			100	47	114
84	89	88	155	76		52		138	31			115	48	115
88	91	92	170	87		54		170	44			140	53	119
91	123	94	178	88		55		177	45			184	60	124
102		95	185	115		76		185	47			218	63	131
112		102	189	133		102		188	61			229	68	138
122		104	199	143		103		204	62			234	70	142
148		106	207	147		105		217	95				71	
155		109	209	161		106		225	97				72	
		118		179		113		226	116				78	
		121		181		120		257	123				82	
		125		188		130		275	127				85	
		130		195		133		291	137				86	
		131		203		143			143				92	
Number of Cases by PSU														
15	10	35		22		27		19	21		5	13	33	
Total Cases in Zone 1									Total Cases in Zone 2					
128									72					
Number of Cases for 1998				128										

APPENDIX C. Supplemental Data Collection Protocol

SUPPLEMENTAL DATA COLLECTION PROTOCOL

The field data collection forms and the accompanying coding and instruction manuals for the supplemental field data collection effort undertaken in this study are presented in this Appendix.

Field Data Collection Form

There are two sets of field data collection forms:

- Supplemental highway data collection form, and
- Object struck data collection form.

In addition, there are two sets of coding forms for reconstruction of the crashes:

- First impact coding form, and
- Subsequent impact coding form.

Each of these forms are presented on the following pages. Pages C-3 through C-7 contain the supplemental highway data collection form while the object struck data collection form is shown on page C-8. The first and subsequent impact coding forms are shown on pages C-9 though C-12.

Coding and Field Procedures Manual

There are two coding and field procedures manuals, one for the supplemental data collection field forms and the other for the reconstruction coding forms. The coding and field procedures manual for supplemental data collection is presented on pages C-13 through C-34. The manual for reconstruction coding forms is shown on pages C-35 through C-60.

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

GENERAL HIGHWAY DATA

4. Land Use ___

___(1) Urban
___(2) Rural
___(9) Unknown

5. Class Trafficway ___

___(1) Interstate
___(2) U. S. route
___(3) State route
___(4) County road
___(5) City street
___(8) Other: _____

6. Access Control ___

___(1) Full
___(2) Partial
___(3) Uncontrolled

7. Average Lane Width ___ . ___ m

___(3.0) 3 m or narrower
___(3.1-4.9) Code actual lane width to nearest 0.1 m
___(5.0) 5 m or wider

8. Roadway Alignment at Point of Departure___

___(1) Straight
___(2) Curve right
___(3) Curve left

9. Radius of Curve

Measure the radius of curve using the middle ordinate method. See Coding Manual for field procedures.

At point of departure: R = ___ ___ ___ ___ m

Length of chord, C = _____ m

Middle ordinate, M = _____ mm

At point of maximum curvature within 100 m upstream of point of departure: R = ___ ___ ___ ___ m

Length of chord, C = _____ m

Middle ordinate, M = _____ mm

10. Roadway Profile at Point of Departure ___

___(0) Level (< 2%)
___(1) Upgrade
___(2) Downgrade
___(3) Crest
___(4) Sag

11. Vertical Grade

Measure the vertical grade using a digital inclinometer. See Coding Manual for field procedures.

At point of departure: +/- ___ ___ . ___ %

At point of maximum vertical grade within 100 m upstream of point of departure: +/- ___ ___ . ___ %

ROADSIDE DATA

12. Curb Presence ___

___(0) No curb
___(1) Barrier curb
___(2) Mountable curb

13. Curb Height ___ ___ ___ mm

___(000) No curb
___(001-998) Code actual curb height to nearest mm.

14. Shoulder Type ___

___(0) No shoulder
___(1) Paved shoulder
___(2) Gravel/Dirt shoulder
___(3) Grassy shoulder

15. Shoulder Width ___ . ___ m

___(0.0) No shoulder
___(0.1-9.8) Code actual shoulder width to nearest 0.1 m.

SLOPE DATA

16. Roadside Cross Section at Point of Departure ___

___ Choose the diagram that best describes the roadside cross section.
___(8) Other (Sketch)

17. Number of Slopes ___

___ (1-6) Code actual number of slopes
___ (7) 7 or more slopes.

Code for each slope the following data:

18. Lateral Offset to Beginning of Slope

Code actual lateral offset from edge of travelway to beginning of slope to nearest 0.1 m.

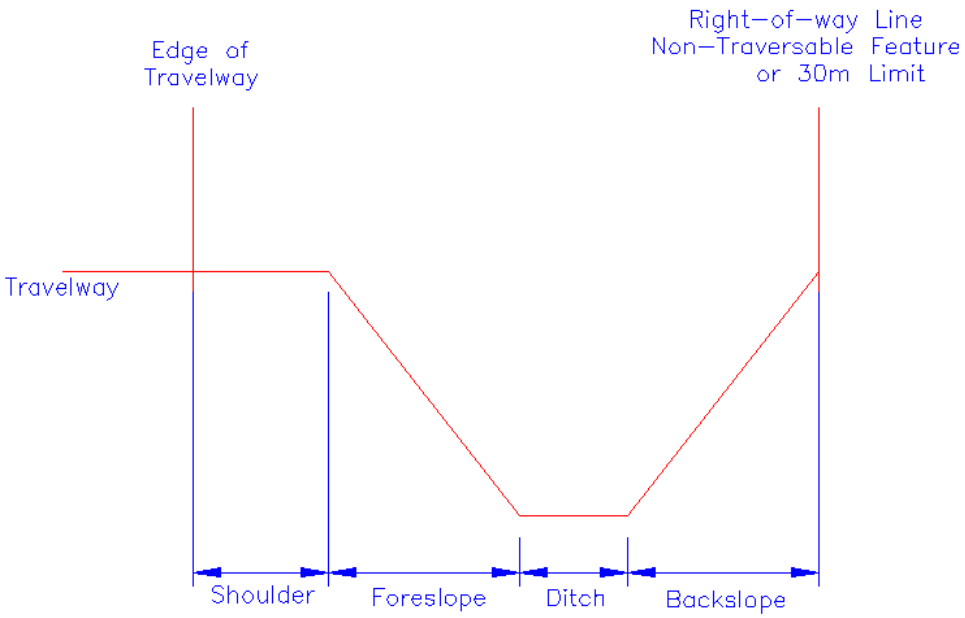
19. Rate of Slope

Measure the rate of slope using a smart level. See Coding Manual for field procedures.

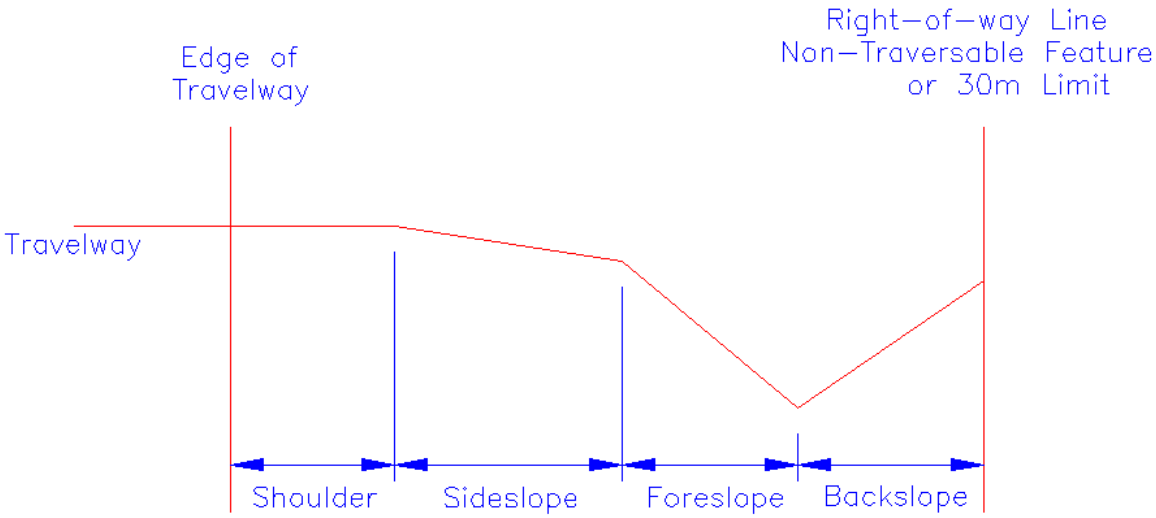
20. Width of Slope

Code actual width of slope to nearest 0.1 m.

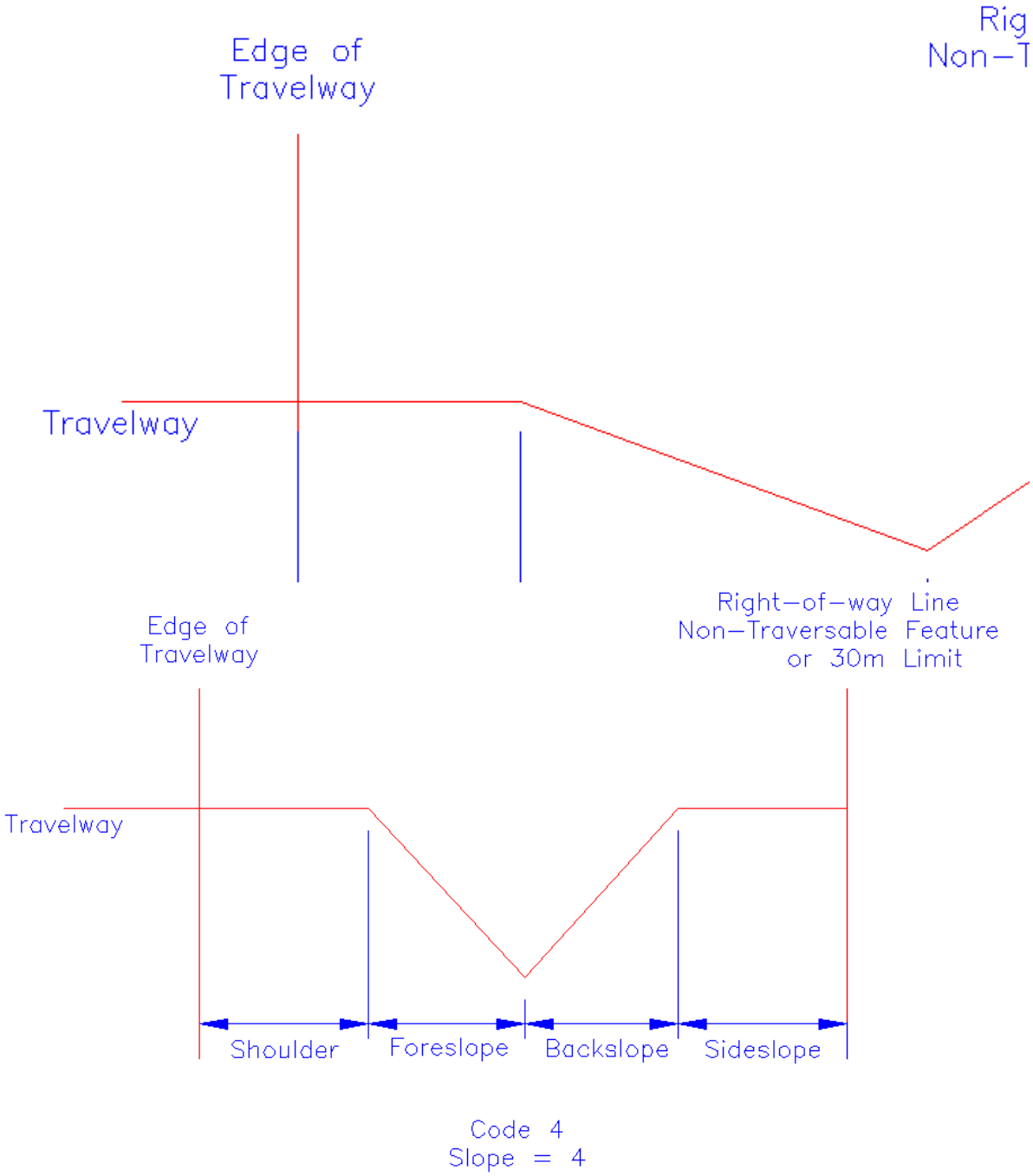
Slope	(18) Lateral Offset to Beginning of Slope	(19) Rate of Slope	(20) Width of Slope
1	0 0 . 0 m	+/- ___ ___ . ___ %	___ ___ . ___ m
2	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
3	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
4	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
5	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
6	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m



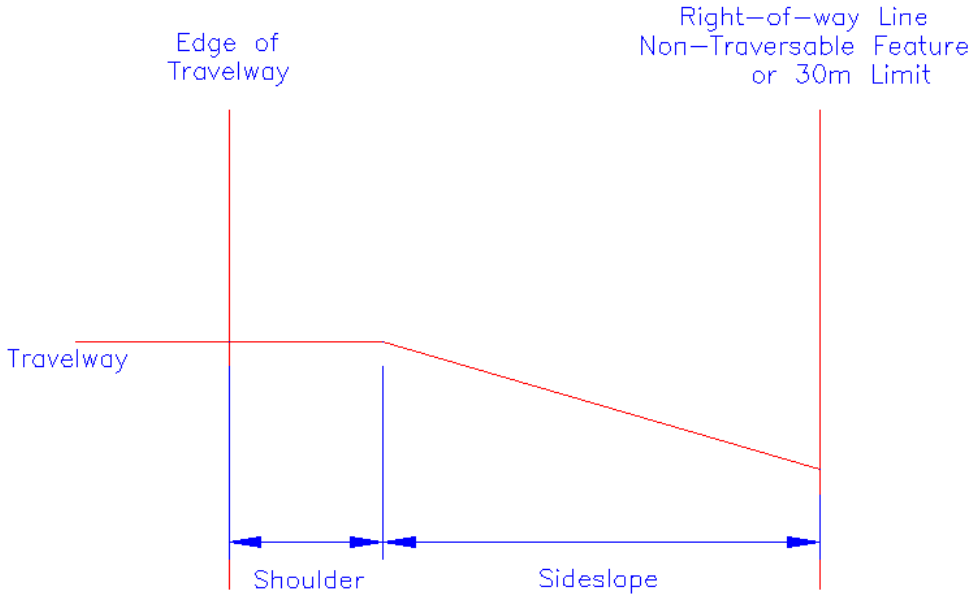
Code 1
Slope = 4



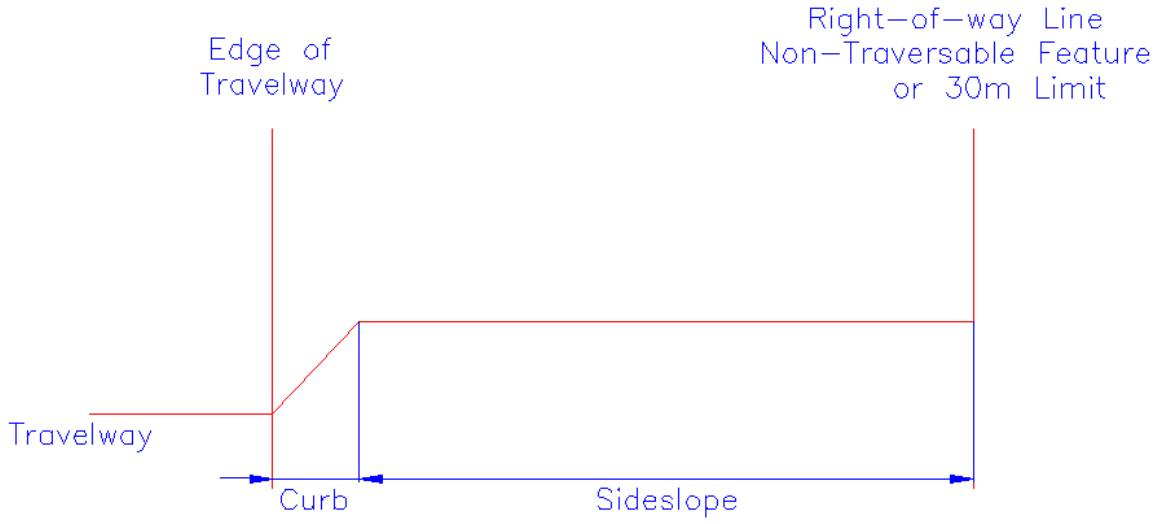
Code 2
Slope = 4



Code 4
Slope = 4



Code 5



Code 6
Slope = 2

OBJECT STRUCK DATA COLLECTION FORM

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

GENERAL STRUCK OBJECT DATA

4. Impact No. ___

5. Object Type ___

___(1) Rigid Object
___(2) Barrier
___(3) Utility Pole
___(4) Light Support
___(5) Sign Support
___(6) Crash Cushion
___(7) Other
___(9) Unknown or N/A

Description:

_____

_____

_____

_____

6. Material ___

___(1) Concrete
___(2) Steel
___(3) Wood
___(4) Combination
___(7) Other
___(9) Unknown or N/A

Description:

_____

_____

_____

DIMENSIONS OF STRUCK OBJECT

Enter dimensions of struck object. Note that required data vary depending on object type

Rigid Object: Length
Width
Height

Barrier: Mounting Height
Post Size
Post Spacing

Utility Pole: Height
Dimension at Base

Light Support: Height
Dimension at Base

Sign Support: Height
Dimension at Base

Crash Cushion: Length of Cushion

Dimensions:

_____

_____

_____

PHOTOGRAPHY

Please take photographs of the struck object from at least two different angles. For light and sign supports, take an additional photograph of the base. When appropriate, include a measuring tape in the photograph for reference purposes.

7. Photographs taken? ___

___(1) Yes
___(2) No

Photograph Identification Numbers:

_____

_____

_____

RECONSTRUCTION CODING FORM – FIRST EVENT

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

ENCROACHMENT DATA

4. Departure Angle ___ ___ ___ ^{o}

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of departure.

5. Vehicle Heading Angle ___ ___ ___ ^{o}

Enter vehicle heading angle in relation to edge of travelway at point of departure.

VEHICLE TRAJECTORY DATA

6. Driver Action ___

___(1) None
___(2) Braking Only
___(3) Steering Only
___(4) Braking and Steering
___(9) Unknown

Supporting Data:_____

_____

_____

7. Longitudinal Distance of Travel ___ ___ ___ m

Measure longitudinal distance of travel from point of departure to point of impact for first event and sketch the vehicle path in the space below:

8. No. of Trajectory Profile Points ___ ___

Enter number of points used for the trajectory profile. General guidelines:

Longitudinal Distance of Travel	No. of Trajectory Profile Points
<= 30 m	6
30 – 100 m	12
> 100 m	18

9. Lateral Offset of Trajectory Profile Points

Enter lateral offset, D(i), of each applicable trajectory project point to the nearest 0.1 meter (m).

D1 = ___ ___ . ___ m D2 = ___ ___ . ___ m

D3 = ___ ___ . ___ m D4 = ___ ___ . ___ m

D5 = ___ ___ . ___ m D6 = ___ ___ . ___ m

D7 = ___ ___ . ___ m D8 = ___ ___ . ___ m

D9 = ___ ___ . ___ m D10 = ___ ___ . ___ m

D11 = ___ ___ . ___ m D12 = ___ ___ . ___ m

D13 = ___ ___ . ___ m D14 = ___ ___ . ___ m

D15 = ___ ___ . ___ m D16 = ___ ___ . ___ m

D17 = ___ ___ . ___ m D18 = ___ ___ . ___ m

Comments: _____

_____

_____

10. Maximum Lateral Offset

Enter longitudinal distance, L(max), from point of departure to point of maximum lateral offset and extent of lateral offset , D(max).

L(max) ___ ___ ___ m

D(max) ___ ___ . ___ m

IMPACT CONDITIONS – FIRST EVENT

11. Location of Impact

Enter location of point of impact for first event in relation to point of departure for longitudinal location and to edge of travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

12. NASS CDS Data

Copy the following data items from the NASS CDS forms for first event:

Object Struck ___ ___

Collision Deformation Classification (CDC):

___ ___ ___ ___ ___ ___ ___

Point of Impact on Vehicle: _____

_____

_____

Vehicle Damage Profile:

Length of Damage (L): ___ ___ ___ ___ cm

Damage Profile (D1-D6):

D1 = ___ ___ . ___ cm D2 = ___ ___ . ___ cm

D3 = ___ ___ . ___ cm D4 = ___ ___ . ___ cm

D5 = ___ ___ . ___ cm D6 = ___ ___ . ___ cm

13. Impact Angle ___ ___ ___ °

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of impact for first event.

14. Vehicle Heading Angle at Impact ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of impact for first event.

SEPARATION CONDITIONS - FIRST EVENT

15. Location of Separation

Enter location of point of separation for first event in relation to point of departure for longitudinal location and edge of the travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

16. Separation angle ___ ___ ___ °

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of separation for first event.

17. Vehicle Heading Angle at Separation ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of separation for first event.

SUBSEQUENT EVENT/FINAL REST

18. Subsequent Event ___

___(1) Yes
___(2) No - Final Rest

If yes, code variables 19 and 20 as "Not Applicable" and proceed with coding of the subsequent event form for the second event. If no, continue with variables 19 and 20.

19. Location of Final Rest

Enter location of point of final rest.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

20. Vehicle Heading Angle at Final Rest ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of final rest.

RECONSTRUCTION CODING FORM – SUBSEQUENT EVENT

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

CURRENT EVENT IDENTIFICATION

4. Current Event No. ___ ___

5. Current Event Location

Enter location of point of impact for current event in relation to point of departure for longitudinal location and edge of travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

VEHICLE TRAJECTORY DATA

6. Driver Action ___

___(1) None
___(2) Braking Only
___(3) Steering Only
___(4) Braking and Steering
___(9) Unknown

Supporting Data: _____

_____

_____

7. Longitudinal Distance of Travel ___ ___ ___ m

Measure longitudinal distance of travel from point of separation for prior event to point of impact for current event and sketch the vehicle path in the space provided below:

8. No. of Trajectory Profile Points ___ ___

Enter number of points used for the trajectory profile. General guidelines:

Longitudinal Distance of Travel	No. of Trajectory Profile Points
<= 30 m	6
30 – 100 m	12
> 100 m	18

9. Lateral Offset of Trajectory Profile Points

Enter lateral offset, D(i), of each applicable trajectory project point to the nearest 0.1 meter (m).

D1 = ___ ___ . ___ m D2 = ___ ___ . ___ m

D3 = ___ ___ . ___ m D4 = ___ ___ . ___ m

D5 = ___ ___ . ___ m D6 = ___ ___ . ___ m

D7 = ___ ___ . ___ m D8 = ___ ___ . ___ m

D9 = ___ ___ . ___ m D10 = ___ ___ . ___ m

D11 = ___ ___ . ___ m D12 = ___ ___ . ___ m

D13 = ___ ___ . ___ m D14 = ___ ___ . ___ m

D15 = ___ ___ . ___ m D16 = ___ ___ . ___ m

D17 = ___ ___ . ___ m D18 = ___ ___ . ___ m

Comments: _____

_____

_____

10. Maximum Lateral Offset

Enter longitudinal distance, L(max), from point of departure to point of maximum lateral offset and extent of lateral offset , D(max).

L(max) ___ ___ ___ m

D(max) ___ ___ . ___ m

IMPACT CONDITIONS – CURRENT EVENT

11. Location of Impact

Enter location of point of impact for current event in relation to point of departure for longitudinal location and edge of travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

12. NASS CDS Data

Copy the following data items from the NASS CDS form for current event:

Object Struck ___ ___

Collision Deformation Classification (CDC):

___ ___ ___ ___ ___ ___ ___

Point of Impact on Vehicle: _____

_____

_____

Vehicle Damage Profile:

Length of Damage (L): ___ ___ ___ ___ cm

Damage Profile (D1-D6):

D1 = ___ ___ . ___ cm D2 = ___ ___ . ___ cm

D3 = ___ ___ . ___ cm D4 = ___ ___ . ___ cm

D5 = ___ ___ . ___ cm D6 = ___ ___ . ___ cm

13. Impact Angle ___ ___

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of impact for current event.

14. Vehicle Heading Angle at impact ___ ___ ___

Enter vehicle heading angle in relation to edge of travelway at point of impact for current event.

SEPARATION CONDITIONS - CURRENT EVENT

15. Location of Separation

Enter location of point of separation for current event in relation to point of departure for longitudinal location and edge of travelway for lateral offset

Longitudinal ___ ___ ___ . ___ m

Lateral ___ ___ . ___ m

16. Separation angle ___ ___ ___ °

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of separation.

17. Vehicle Heading Angle ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of separation.

SUBSEQUENT EVENT/FINAL REST

18. Subsequent Event ___

___(1) Yes
___(2) No - Final Rest

If yes, skip variables 19 and 20 and proceed with coding of the subsequent event form for the next event. If no, continue with variables 19 and 20.

19. Location of Final Rest

Enter location of point of final rest.

Longitudinal ___ ___ ___ . ___ m

Lateral ___ ___ . ___ m

20. Vehicle Heading Angle at Final Rest ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of final rest.

NATIONAL ACCIDENT SAMPLING SYSTEM (NASS)

SUPPLEMENTAL FIELD DATA COLLECTION

CODING INSTRUCTIONS AND FIELD PROCEDURES MANUAL

NCHRP Project 17-22
"Identification of Vehicular Impact Conditions
Associated with Serious Ran-Off-Road Crashes"

Prepared for

National Cooperative Highway Research Program
Transportation Research Board
Washington, D. C.

INTRODUCTION

Sample cases from the National Accident Sampling System (NASS) Crashworthiness Data System (CDS) are selected for use in clinical analysis under National Cooperative Highway Research Program (NCHRP) Project 17-22, "Identification of Vehicular Impact Conditions Associated with Serious Ran-Off-Road Crashes." The objectives of the study are: (1) to identify the vehicle types, impact conditions, and site characteristics associated with serious injury and fatal crashes involving roadside features and safety devices, and (2) to create a robust relational database for future research.

The NASS CDS data are very comprehensive for their intended purpose. However, they lack details pertaining to the roadway and roadside which are critical for the purpose of NCHRP Project 17-22. Some of the data elements can be estimated from manual review of the hard copies and photographs of the cases. However, there are some data elements that are not attainable through this manual review process. It is, therefore, necessary to collect additional field data to supplement the case materials.

Two data collection forms were developed for this supplemental data collection effort:

1. Supplemental data form – for data elements pertaining to roadway and roadside characteristics.

2. Struck object data form – for data elements pertaining to the struck objects.

This manual provides the instructions for the coding of the data elements and applicable field data collection procedures for these two data forms. Note that the two data forms are found under separate cover. Further, note that additional photographic coverage of the crash sites is necessary.

CODING INSTRUCTIONS AND FIELD PROCEDURES FOR SUPPLEMENTAL DATA FORM

Coding instructions and field procedures are provided for each of the 20 data elements or variables on this supplemental data form. The data elements are grouped under four general headings:

1. Case Identification,
2. General Highway Data,
3. Roadside Data, and
4. Slope Data.

For each group of data elements, there is a brief introduction followed by information on the individual data elements within the group. The following information is provided for each of the data elements:

Variable Number(s)
Variable Name(s)
Format
Codes
    Range
    Individual codes or responses
Coding Instructions
    Descriptions and definitions for individual codes or responses
    Illustrations (if applicable)
Field Procedures (if applicable)

CASE IDENTIFICATION VARIABLES

Data elements 1 through 3 are case identification variables, including: year, Primary Sampling Unit, and case number-stratum. These variables should be identical to those for the NASS CDS case so that the supplemental field data can be properly merged with the NASS CDS data.

1. Variable Name: Year

   Format: 2 column numeric

   Codes: 00 or 01

   Coding Instructions: Code the last two digits of the year of the accident.

2. Variable Name: Primary Sampling Unit

   Format: 2 column numeric

   Codes: 02, 11, 12, 13, 45, 48, 73, 75, 76 or 78

   Coding Instructions: Code the Primary Sampling Unit in which the accident occurred.

3. Variable Name: Case Number-Stratum

   Format: 4 column alphanumeric

   Coding Instructions: Code the case number and stratum, which should be the same as those for the NASS CDS case.

GENERAL HIGHWAY DATA VARIABLES

Variables 4 through 11 pertain to general highway data, including: land use, class trafficway, access control, average lane width, roadway alignment at point of departure, radius of curve, roadway profile at point of departure, and vertical grade. The data elements Land Use, Class Trafficway, and Access Control pertain to the highway in general. The data elements Average Lane Width, Roadway Alignment, and Roadway Profile pertain to the point of departure. For the data elements Radius of Curve and Vertical Grade, the measurements are to be taken both at the point of departure and the maximum point within 100 meters upstream of the point of departure.

The point of departure is the point where the vehicle departed from the travelway (or encroaches beyond the edge of the travelway). The edge of travelway is defined as the center of the edge line if it is present, or the edge of the pavement if there is no edge line.

4. Variable Name: Land Use

Format: 1 column numeric

Codes:
(1) Urban
(2) Rural
(9) Unknown

Coding Instructions: Select the code that best describes the land use around the crash site. An urban area (code 1) is defined as within the limits of a city or an incorporated area and the land use is typically residential or commercial in nature. A rural area (code 2) is defined as outside the limits of a city or an incorporated area and the land use is typically agricultural in nature. Code 9 if the land use is unknown or cannot be determined.

. Variable Name: Class Trafficway

Format: 1 column numeric

Codes:
(1) Interstate
(2) U. S. route
(3) State route
(4) County road
(5) City street
(8) Other: _____

Coding Instructions: Select the code that best describes the type of highway on which the accident occurred. The codes are arranged in descending order of preference. If the highway has multiple designations, e.g., U. S. 87 and State Route 38, code the highest

preference, which would be U. S. Highway (code 2) for this example. Code 8 if the class trafficway does not fit into any of the classes, e.g., private drive, and enter the information in the space provided.

6. Variable Name: Access Control

Format: 1 column numeric

Codes: (1) Full
(2) Partial
(3) Uncontrolled

Coding Instructions: Select the code that best describes the type of access control for the highway on which the accident occurred. Full access control (code 1) pertains to interstate highways and freeways in which access to the highway, i.e., entrance and exit, is limited to designated interchanges. Partial access control (code 2) pertains to expressways and divided highways where access to the highway is limited to intersections and designated crossovers. Uncontrolled access (code 3) pertains to highways where access to the highway from adjoining properties is not limited or controlled.

7. Variable Name: Average Lane Width

Format: 3 column numeric with one decimal place

Codes: (3.0) 3 m or narrower
(3.1 - 4.9) Code actual lane width to nearest 0.1 m
(5.0) 5 m or wider

Coding Instructions: Measure and record the lane width to the nearest 0.1 meter for the main travel lanes at the point of departure. Do not include the width of auxiliary lanes, such as entrance and exit lane, passing lane, two-way left-turn lane, etc. If the lane widths for the lanes are different, calculate and record the average lane width.

8. Variable Name: Roadway Alignment at Point of Departure

Format: 1 column numeric

Codes: (1) Straight
(2) Curve right
(3) Curve left

Coding Instructions: Select the code that best describes the roadway alignment at the point where the vehicle departed from the travelway. Curve right or left is in reference to the direction of vehicle travel prior to departing from the travelway.

9. Variable Name: Radius of Curve

Format: 4 column numeric

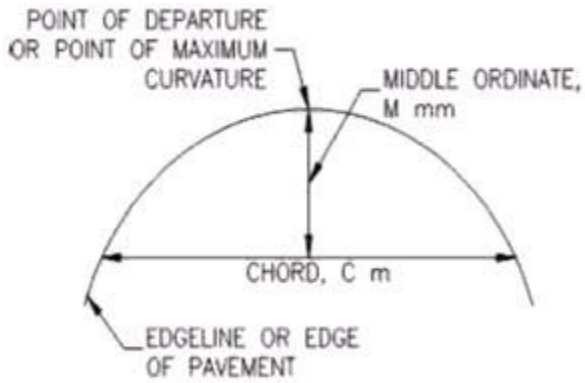
Codes: (0000) Straight
(0001 - 9999) Calculated radius of curve

Coding Instructions: Measure the radius of curve using the middle ordinate method as described below. The radius of curve should be measured at both the point where the vehicle departed the travelway and at the point of maximum curvature (determined visually) within 100 meters upstream of the point of departure in the direction of vehicle travel prior to departing from the travelway. Note that the radius of curve is rarely less than 50 or more than 2,000 meters.

Field Procedure:

Using the edge line or the edge of the pavement where the vehicle departed from the travelway as the reference line, stretch a chord (i.e., a straight line) of known length with a tape, as shown in the following diagram. The chord should be straight with the two ends at the reference line. For the radius of curve at the point of departure, the middle of the chord should correspond to the point of departure. Similarly, for the radius of curve at the point of maximum curvature, the middle of the chord should correspond to the point of maximum curvature. Note that a chord length of 30 meters or longer is preferred. However, a shorter chord length is acceptable if a longer chord length is not feasible or practical, e.g., at sharp curves where a longer chord length would intrude too much into the travelway. Record the length of the chord in meters in the space provided.

Use another tape to measure the middle ordinate, i.e., the distance from the center of the chord to the reference line, as shown in the following diagram. Record the length of the middle ordinate in millimeters in the space provided.



Calculate the radius of curve using the following formula and enter the radius in the space provided:

where R = Radius of curve in meters
C = Length of chord in meters
M = Middle ordinate in millimeters

10. Variable Name: Roadway Profile at Point of Departure

Format: 1 column numeric

Codes:
(1) Level (< 2%)
(2) Upgrade
(3) Downgrade
(4) Crest
(5) Sag

Coding Instructions: Select the code that best describes the roadway profile at the point where the vehicle departed from the travelway. Code 1 (level) if level or the vertical grade is less than 2 percent. Upgrade (code 2) or downgrade (code 3) is in reference to the direction of vehicle travel prior to departing from the travelway. Crest (code 4) is at the top of a hill and sag (code 5) is at the bottom of a hill.

11. Variable Name: Vertical Grade

Format: 5 column numeric, first column +/- sign, and one decimal place.

Codes: (+ 00.0) Level (vertical grade < 2%)
(+/- 00.1 - 99.9) Calculated vertical grade

Coding Instructions: Measure the vertical grade using the digital inclinometer method as described below. The vertical grade should be measured at both the point where the vehicle departed the travelway and at the point of maximum vertical grade (determined visually)

within 100 meters upstream of the point of departure in the direction of vehicle travel prior to departing from the travelway. Upgrade is coded as (+) and downgrade is coded as (-). Note that vertical grades, either upgrade or downgrade, are rarely steeper than 15 percent.

Coding for this variable should correspond to the coding of Variable 10, "Roadway Profile at Point of Departure," as shown in the following table:

Code for	Code for Variable 11, "Vertical Grade"	
Variable 10	Point of Departure	Maximum Vertical Grade
1 - Level	Code +00.0	Code +00.0
2 - Upgrade	Code actual upgrade	Code maximum upgrade
3 - Downgrade	Code actual downgrade	Code maximum downgrade
4 - Crest	Code actual grade	Code maximum grade
5 - Sag	Code actual grade	Code maximum grade

If Variable 10 is coded as "1 - Level", no measurement of vertical grade is necessary. Code the vertical grades at both the point of departure and the point of maximum vertical grade as +00.0.

If Variable 10 is coded as "2 - Upgrade" or "3 - Downgrade", code the actual upgrade or downgrade at the point of departure and the maximum upgrade or downgrade within 100 m upstream of the point of departure for the maximum vertical grade, respectively.

If Variable 10 is coded as "4 - Crest", code the actual grade at the point of departure, which may be level, upgrade or downgrade. Code the maximum grade within 100 m upstream of the point of departure for the maximum vertical grade. Note that the maximum vertical grade for a crest is typically an upgrade.

If Variable 10 is coded as "5 - Sag", code the actual grade at the point of departure, which may be level, upgrade or downgrade. Code the maximum grade within 100 m upstream of the point of departure for the maximum vertical grade. Note that the maximum vertical grade for a sag is typically a downgrade.

Field Procedure:

Place the digital inclinometer on the roadway surface parallel to the roadway at the point where vertical grade is to be measured and record the vertical grade. If the roadway surface is very uneven, it may be a good idea to place a 4-ft level on the roadway surface and then place the digital inclinometer on top of the 4-ft level for the grade measurement.

ROADSIDE DATA VARIABLES

Variables 12 through 15 pertain to general roadside data, including: Curb Presence, Curb Height, Shoulder Type, and Shoulder Width. These general roadside data are intended for identification of the degree of influence their presence or absence have on single-vehicle, ran-off-road accidents. All roadside data should be collected at the point of departure and on the same side of the roadway where the vehicle ran off the travelway.

12. Variable Name: Curb Presence

Format: 1 column numeric

Codes:
(0) No curb
(1) Barrier curb
(2) Mountable curb

Coding Instructions: Record the presence or absence of a curb and the curb type at the point where the vehicle departed from the travelway. Code 0 if there is no curb present. If a curb is present, identify the curb type and code as appropriate.

Barrier curbs (code 1) are relatively high (ranging from 150 to 250 mm or more in height) and steep faced (generally not exceeding a ratio of 3:1 vertical to horizontal), and designed to inhibit, or at least discourage, vehicles from leaving the roadway. The upper corner may be slightly rounded.

Mountable curbs (code 2) are 150 mm or less in height and have well rounded or plane sloping faces and are designed so that vehicles can cross over them with relative ease.

13. Variable Name: Curb Height

Format: 3 column numeric

Codes:
(000) No curb
(001-998) Code actual curb height to the nearest mm.

Coding Instructions: If there is no curb present, code 000. If a curb is present, code the actual curb height to the nearest mm.

To measure the curb height, place one end of a level on top of the curb and, while maintaining it in a level attitude, record the vertical distance from the bottom of the level to the toe of the curb or the gutter.

14. Variable Name: Shoulder Type

Format: 1 column numeric

Codes:
(0) No shoulder
(1) Paved shoulder
(2) Gravel/Dirt shoulder
(3) Grassy shoulder

Coding Instructions: Record the presence or absence of a shoulder and the shoulder type at the point where the vehicle departed from the travelway. Code 0 if there is no shoulder present. If a shoulder is present, code the type of material used for the shoulder: paved with concrete or asphalt (code 1), gravel or dirt (code 2), or sod (code 3).

15. Variable Name: Shoulder Width

Format: 3 column numeric with one decimal place

Codes:
(0.0) No shoulder
(0.1-9.8) Code actual shoulder width to the nearest 0.1 m.

Coding Instructions: If there is no shoulder present, code 0.0. If a shoulder is present, code the actual shoulder width to the nearest 0.1 meter.

SLOPE DATA VARIABLES

Variables 16 through 20 pertain to the roadside slope data, including: Roadside Cross Section, Number of Slopes, and for each slope, the Lateral Offset to Beginning of Slope, Rate of Slope, and Width of Slope. These roadside slope data are intended to describe the roadside cross section and terrain and to assess their influence on single-vehicle, ran-off-road accidents. All roadside slope data should be collected at the point of departure and on the same side of the roadway where the vehicle ran off the travelway.

The variables roadside cross section and number of slopes provide a qualitative description of the roadside cross section from the edge of the travelway, i.e., edge line or edge of pavement, to one of the following, whichever occurs first:

a. The first non-traversable feature, such as a longitudinal barrier, a vertical drop-off, a rock wall, or a line of closely spaced trees,

b. The right-of-way line, which is typically defined by a fence, or

c. If the right-of-way line is not clearly defined or more than 30 meters from the edge of the travelway and there is no non-traversable feature, use 30 meters as the limit.

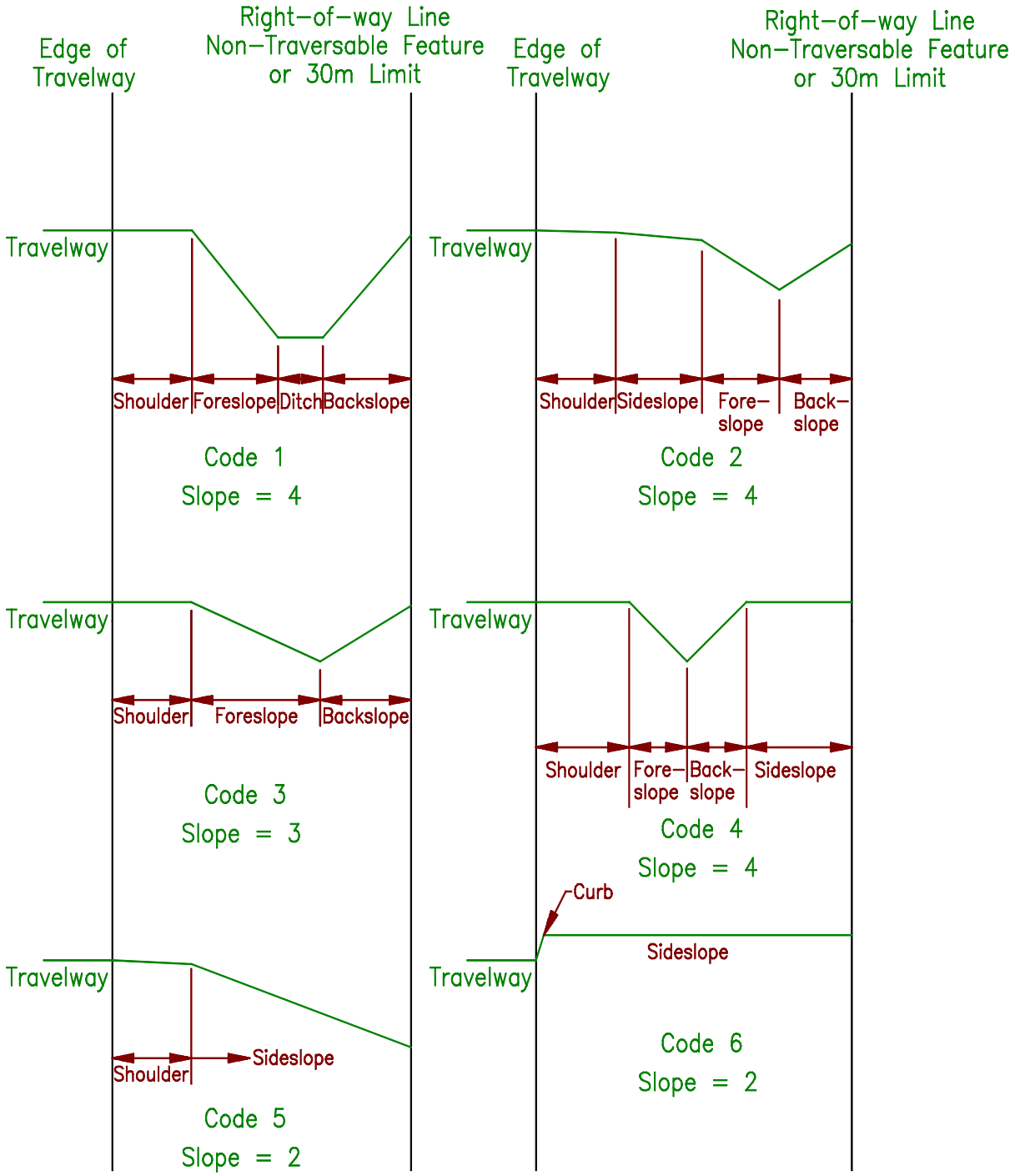
Spaces are provided for recording data on up to six slopes. If there are more than six slopes between the roadway edge and the first non-traversable feature, the right-of-way line, or 30 meters, then only data for the first six slopes will be coded. There is at least one slope between the roadway edge and the first non-traversable feature, the right-of-way line, or 30 meters. This first slope is usually a curb or a shoulder, followed by a foreslope, a ditch, and then a backslope. For each slope, record the following information: lateral offset to beginning of slope, rate of slope, and width of slope.

16. Variable Name: Roadside Cross Section at Point of Departure

Format: 1 column numeric

Codes: (1-6) Typical roadside cross sections
(8) Other (Sketch)

Coding Instructions: Select the cross section that best describes the actual roadside cross section at the point of departure from the list of typical roadside cross sections shown in the diagram on the following page. If the actual roadside cross section does not fit into any of the typical cross sections, code 8 and sketch in the cross section in the space below Variable 20 or on a separate sheet of paper.



TYPICAL ROADSIDE CROSS SECTIONS

17. Variable Name: Number of Slopes

Format: 1 column numeric

Codes: (1-6) Actual number of slopes
(7) 7 or more slopes

Coding Instructions: Code the actual number of roadside slopes. If there are more than six slopes, code 7 and enter data for Variables 18 through 20 for the first six slopes.

18. Variable Name: Lateral Offset to Beginning of Slope

Format: 4 column numeric with one decimal place

Codes: (00.0-30.0) Actual lateral offset of beginning of slope to the nearest 0.1 m.

Coding Instructions: Measure and record the actual lateral offset, i.e., the distance from the edge of the travelway (edge line or edge of pavement) to the beginning of the slope, to the nearest 0.1 meter. The measurement is to be made on the environmental surface. Note that the lateral offset for the first slope is necessarily 00.0 since it starts at the edge of the travelway. Also, note that the lateral offsets for subsequent slopes are cumulative, i.e., the lateral offset for the beginning of the second slope equals the width of the first slope, the lateral offset for the third slope equals the sum of the widths of the first and second slopes, etc.

Field Procedure: Stretch a 30-m tape from the edge of the travelway to the right-of-way line or the 30-m point perpendicular to the roadway. Identify the slopes and the transition points. Read and record the lateral offset for each slope.

19. Variable Name: Rate of Slope

Format: 5 column numeric, first column +/- sign, and one decimal place.

Codes: (+ 00.0) Level
(+/- 00.1 - 99.9) Calculated rate of slope

Coding Instructions: Measure the rate of slope for each slope using the digital inclinometer method as described for vertical grade. The rate of slope should be measured at the point where the vehicle departed the travelway. Upward slope is coded as (+) and downward slope is coded as (-).
Field Procedure:

Place a 4-ft level on the slope perpendicular to the roadway at the point where the rate of slope is to be measured. Place the digital inclinometer on top of the 4-ft level and record the rate the slope.

20. Variable Name: Width of Slope

Format: 4 column numeric with one decimal place

Codes: (00.0-30.0) Actual lateral offset of beginning of slope to the nearest 0.1 m.

Coding Instructions: Measure and record the actual width of the slope to the nearest 0.1 meter. The measurement is to be made on the environmental surface. Note that a curb is considered as a slope, but there is no physical width, so code the width for the curb as 00.0. Also, note that the width for a given slope is equal to the difference between the lateral offset of the beginning of the slope and the lateral offset of the beginning of the following slope. For example, if the lateral offsets of the beginning of slopes 3 and 4 are 7 and 15 meters, respectively, then the width of slope 3 is (15 - 7) or 8 meters.

CODING INSTRUCTIONS AND FIELD PROCEDURES
STRUCK OBJECT DATA FORM

Coding instructions and field procedures are provided for the data elements or variables on the struck object data form, which are grouped under four general headings:

1. Case Identification,
2. General Struck Object Data,
3. Dimensions of Struck Object, and
4. Photography. Data.

For each group of data elements, there is a brief introduction followed by information on the individual data elements within the group. The following information is provided for each of the data elements:

Variable Number(s)
Variable Name(s)
Format
Codes
    Range
    Individual codes or responses
Coding Instructions
    Descriptions and definitions for individual codes or responses
    Illustrations (if applicable)
Field Procedures (if applicable)

Due to the large number os potential roadside objects and features, the variables are very general without specific details. Instead, field investigators are asked to provide annotations or descriptions and photographs of the struck object. A form should be completed for each struck object.

It is recognized that some of the struck objects currently at the sites may be different from those at the time of the crash due to repairs or replacements for damages sustained in the impacts. However, given the retrospective nature of this supplemental data collection effort, data on the actual struck objects are no longer available. Thus, there is the implicit assumption that the struck objects were repaired to its original shape or replaced in kind. By comparing photographs taken during the initial investigation and this supplemental data collection effort, changes to the struck objects could be identified and assessed.

CASE IDENTIFICATION VARIABLES

Data elements 1 through 3 are case identification variables, including: year, Primary Sampling Unit, and case number-stratum. These variables should be identical to those for the NASS CDS case so that the supplemental field data can be properly merged with the NASS CDS data.

1. Variable Name: Year

   Format: 2 column numeric

   Codes: 00 or 01

   Coding Instructions: Code the last two digits of the year of the accident.

2. Variable Name: Primary Sampling Unit

   Format: 2 column numeric

   Codes: 02, 11, 12, 13, 45, 48, 73, 75, 76 or 78

   Coding Instructions: Code the Primary Sampling Unit in which the accident occurred.

3. Variable Name: Case Number-Stratum

   Format: 4 column alphanumeric

   Coding Instructions: Code the case number and stratum, which should be the same as those for the NASS CDS case.

GENERAL STRUCK OBJECT DATA VARIABLES

Variables 4 through 6 pertain to general struck object data, including: impact number, object type, and material.

4. Variable Name: Impact Number

Format: 1 column numeric

Codes: (1 - 8) Actual impact number
(9) Unknown

Coding Instructions: Code the impact number for the struck object, which should be the same as those for the NASS CDS case.

5. Variable Name: Object Type

Format: 1 column numeric

Codes:
(1) Rigid Object
(2) Barrier
(3) Utility Pole
(4) Light Support
(5) Sign Support
(6) Crash Cushion
(7) Other
(9) Unknown or N/A

Coding Instructions: Select the code that best describes the type of object struck in this particular impact. The codes are not meant to be all inclusive. Only objects of specific interest to this study are included on the list. Code 7 for all other objects not listed. Code 9 if unknown or not applicable, i.e., struck object not found. Also, provide a brief description of the struck object, e.g., W-beam guardrail with wood posts, guardrail terminal, etc., in the space provided.

6. Variable Name: Material

Format: 1 column numeric

Codes:
(1) Concrete
(2) Steel

(3) Wood
(4) Combination
(7) Other
(9) Unknown or N/A

Coding Instructions: Select the code that best describes the principal type of material for the struck object, i.e., concrete, steel and wood. Code 4 if a combination of materials are used, e.g., steel W-beam guardrail with wood posts, concrete barrier with steel rail on top, etc. Code 7 for all other materials not listed. Code 9 if unknown or not applicable, i.e., struck object not found. Also, provide a brief description of the materials for the struck object, e.g., W-beam guardrail with wood posts, guardrail terminal, etc., in the space provided.

DIMENSIONS OF STRUCK OBJECT

Enter dimensions of the struck object in the space provided. The required data vary depending on the object type, as listed below:

- Rigid Object
  - Enter the length, width and height of the object.

- Barrier
  - Enter height of barrier, measured from the ground to the top of the barrier. For barriers installed in soil, an average of several measurement may be necessary if the ground surface is uneven.
  - For barriers with posts, measure the cross section of the post, i.e., overall width and depth for rectangular wooden or steel I-beam posts and circumference or diameter of round wooden posts.
  - For barriers with posts, measure the spacing between the posts, center to center. Measurement should be taken in the standard section of the barrier areas where post spacing is uniform, and not in the area of the end terminal where post spacing may vary.

- Utility Pole
  - Enter the estimated height of the pole.
  - Measure the cross section of the base of the utility pole, i.e., overall width and depth for rectangular steel structures and circumference (or diameter) of round or polygonal poles.

- Light Support
  - Enter the estimated height of the support.
  - Measure the cross section of the base of the pole i.e., overall width and depth for rectangular poles and circumference (or diameter) of round or polygonal poles. For light supports that are designed to break away upon impact, the measurement should be taken just above the transformer base or the flange of the slip base.

- Sign Support
  - Enter the estimated height of the support.
  - Measure the cross section of the base of the pole i.e., overall width and depth for steel I-beam or channel posts or circumference (or diameter) of round or polygonal posts.. For sign supports with a slip base design, the measurement should be taken just above the flange of the slip base.

- Crash Cushion

- Enter length of crash cushion, measured from the nose to the end of the crash cushion or the backup structure. For sand barrel type of crash cushion, note the number of rows and the number of barrels each row.

Field Procedure:

All dimensions are measurable using a tape measure except for heights of pole structures and sign supports. An infrared distance measuring device will be used to estimate the height of pole structures and sign support. Stand at a distance equal to or greater than the estimated height of the object and measure the distances to the top (D_t) and bottom (D_b) of the object. Calculate the height of the pole structure or sign support using the following formula:

$$\text{Height (in meters)} = 1.7 + \sqrt{[(D_t)^2 - (D_b)^2]}$$

Round off to the nearest 0.5 meter and enter the values in the space provided.

PHOTOGRAPHY

For each struck object, take photographs of the object from at least two different angles. For light and sign supports, take an additional photograph of the base. When appropriate, include a measuring tape in the photograph for reference purposes. A reminder to take the photographs is provided on the data form itself plus space for entering the photograph identification numbers.

7. Variable Name: Photographs taken?

Format: 1 column numeric

Codes: (1) Yes
(2) No

Coding Instructions: Code 1 if photographs are taken. This variable is intended only as a reminder and does not serve any other purposes. Code 2 if photographs are not taken for whatever reason.

Assign identification numbers to the photographs and enter the numbers in the space provided. These identification numbers would help to correlate the photographs with the struck objects.

NATIONAL ACCIDENT SAMPLING SYSTEM (NASS)

SUPPLEMENTAL FIELD DATA COLLECTION

RECONSTRUCTION CODING MANUAL

NCHRP Project 17-22
"Identification of Vehicular Impact Conditions
Associated with Serious Ran-Off-Road Crashes"

Prepared for

National Cooperative Highway Research Program
Transportation Research Board
Washington, D. C.

INTRODUCTION

Sample cases from the National Accident Sampling System (NASS) Crashworthiness Data System (CDS) are selected for use in clinical analysis under National Cooperative Highway Research Program (NCHRP) Project 17-22, "Identification of Vehicular Impact Conditions Associated with Serious Ran-Off-Road Crashes." The objectives of the study are: (1) to identify the vehicle types, impact conditions, and site characteristics associated with serious injury and fatal crashes involving roadside features and safety devices, and (2) to create a robust relational database for future research.

The NASS CDS data are very comprehensive for their intended purpose. However, they lack details pertaining to the roadway and roadside which are critical for the purpose of NCHRP Project 17-22. Some of the data elements can be estimated from manual review of the hard copies and photographs of the cases. However, there are some data elements that are not attainable through this manual review process. It is, therefore, necessary to collect additional field data to supplement the case materials.

In addition to the supplemental field data collection effort, reconstruction of the sampled cases is needed to estimate their impact conditions. Note that the effort described herein does not cover impact speed and performance of struck object, which will be reconstructed separately. There are two coding forms associated with this portion of the reconstruction effort:

1. First event coding form – for coding of reconstruction data elements pertaining to the first event.

2. Subsequent event coding form – for coding of reconstruction data elements pertaining to subsequent events. One set of coding forms should be completed each subsequent event.

This manual provides the instructions for the coding of the data elements for these two coding forms. Sources for coding these reconstruction data elements include: completed NASS CDS data forms, scaled diagram, and photographic coverage.

CODING INSTRUCTIONS FOR FIRST EVENT CODING FORM

Coding instructions are provided for each of the 20 data elements or variables on this reconstruction coding form for the first harmful event (herein referred to as the first event). The data elements are grouped under six general headings:

1. Case Identification,
2. Encroachment Data,
3. Vehicle Trajectory Data,
4. Impact Conditions,
5. Separation Conditions, and
6. Subsequent Event/Final Rest.

For each group of data elements, there is a brief introduction followed by information on the individual data elements within the group. The following information is provided for each of the data elements:

Variable Number(s)
Variable Name(s)
Format
Codes
    Range
    Individual codes or responses
Coding Instructions
    Descriptions and definitions for individual codes or responses
    Illustrations (if applicable)

CASE IDENTIFICATION VARIABLES

Data elements 1 through 3 are case identification variables, including: year, Primary Sampling Unit, and case number-stratum. These variables should be identical to those for the NASS CDS case so that the supplemental field data can be properly merged with the NASS CDS data.

1. Variable Name: Year

   Format: 2 column numeric

   Codes: 00 or 01

   Coding Instructions: Code the last two digits of the year of the accident.

2. Variable Name: Primary Sampling Unit

   Format: 2 column numeric

   Codes: 02, 11, 12, 13, 45, 48, 73, 75, 76 or 78

   Coding Instructions: Code the Primary Sampling Unit in which the accident occurred.

3. Variable Name: Case Number-Stratum

   Format: 4 column alphanumeric

   Coding Instructions: Code the case number and stratum, which should be the same as those for the NASS CDS case.

ENCROACHMENT DATA VARIABLES

Variables 4 and 5 pertain to encroachment data at the point of departure from the travelway, including: departure angle and vehicle heading angle. The point of departure is defined as the point where the vehicle departed from the travelway (or encroaches beyond the edge of the travelway). The edge of travelway is defined as the center of the edge line if it is present, or the edge of the pavement if there is no edge line.

4. Variable Name: Departure Angle

Format: 3 column numeric

Codes: (001-359) Actual departure angle
(999) Unknown

Coding Instructions: Enter the angle of the vehicle C. G. direction of travel at the point of departure. The departure angle is measured in relation to the edge of the travelway in the general direction of travel. Note that the departure angle must be between 1 and 90 degrees for a right-sided departure and between 270 and 359 degrees for a left-sided departure. The departure angle is typically measured from the scaled diagram and based on available scene evidence.

5. Variable Name: Vehicle Heading Angle

Format: 3 column numeric

Codes: (000 -360) Actual vehicle heading angle
(999) Unknown

Coding Instructions: Enter the vehicle heading angle at the point of departure. The vehicle heading angle is measured in relation to the edge of the travelway in the general direction of travel. The vehicle heading angle at the point of departure is typically measured from the scaled diagram and based on available scene evidence.

VEHICLE TRAJECTORY DATA VARIABLES

Variables 6 through 10 pertain to the vehicle trajectory data between the point of departure from the travelway to the point of the first event, including: driver action, longitudinal distance of travel, number of trajectory profile points, lateral offset of trajectory profile points and maximum lateral offset. The point of departure is defined as the point where the vehicle first departed from the travelway (or encroaches beyond the edge of the travelway). The edge of travelway is defined as the center of the edge line if it is present, or the edge of the pavement if there is no edge line.

Note that the vehicle trajectory is defined using the point of the vehicle that first left the travelway as the reference point. For example, the reference point for a tracking vehicle running off the right side of the roadway is typically the right front corner of the vehicle.

6. Variable Name: Driver Action

Format: 1 column numeric

Codes:
(1) None
(2) Braking Only
(3) Steering Only
(4) Braking and Steering
(9) Unknown

Coding Instructions: Select the code that best describes the action of the driver between the point of departure from the travelway to the point of impact for the first event. Information for coding this variable include: CDS coded variable, scene evidence, driver interview, and annotated data. Document the supporting data in the space provided as well as any additional information of interest, e.g., braking initially followed by steering and braking.

7. Variable Name: Longitudinal Distance of Travel

Format: 3 column numeric

Codes:
(000-997) Actual longitudinal distance of travel in meters
(999) Unknown

Coding Instructions: Record the longitudinal distance of travel, to the nearest meter, from the point of departure from the travelway to the point of impact for the first event. Note that this is the longitudinal distance as measured along the edge of the travelway and not the distance along the path of the vehicle. The longitudinal distance of travel is typically obtained from available scene measurements or measured from the scaled diagram .

8. Variable Name: Number of Trajectory Profile Points

Format: 2 column numeric

Codes: 06, 12 or 18

Coding Instructions: Enter the number of trajectory profile points used to define the vehicle trajectory from the point of departure to the point of impact for the first event. The number of trajectory profile points is a function of the longitudinal distance of travel. The general guidelines are as follows:

Longitudinal Distance of Travel	No. of Trajectory Profile Points
<= 30 m	6
30 – 100 m	12
> 100 m	18

To locate the trajectory profile points, the longitudinal distance of travel is divided into equal parts based on the number of trajectory profile points. For example, if the longitudinal distance of travel is 55 m, which corresponds to 12 trajectory profile point according to the general guidelines, is 12, the longitudinal distance is divided into 11 equal spaces of 5 m each (55/11 = 5 m). The first trajectory profile point is at the point of departure. The second trajectory profile point is 5 m downstream, 10 m for the third trajectory profile point, ... , and the last trajectory profile point is at the point of impact for the first event.

9. Variable Name: Lateral Offset of Trajectory Profile Points

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.9) Unknown

Coding Instructions: Enter lateral offset, D(i), of each applicable trajectory project point to the nearest 0.1 meter (m). At each of the trajectory profile point, measure the lateral distance from the edge of the travelway to the reference point on the vehicle that defines the vehicle path.

10. Variable Name: Maximum Lateral Offset

The maximum lateral offset along the vehicle path may or may or may not coincide with one of the trajectory profile points. Thus, a separate entry is provided for the maximum lateral offset. The point of maximum lateral offset is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway.

For the longitudinal measurement, L (max):

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(999) Unknown

For the lateral offset measurement, D(max):

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.9) Unknown

Coding Instructions: Enter the location of the point of maximum lateral extent of encroachment. The location is defined by two measurements: longitudinal distance, L(max), measured from the point of departure to the point of maximum lateral extent of encroachment, and the extent of the maximum lateral offset , D(max).

IMPACT CONDITIONS (FIRST EVENT) DATA VARIABLES

Variables 11 through 14 pertain to the impact conditions of the first event, including: location, NASS CDS coded data elements, impact angle and vehicle heading angle at impact. The point of impact for the first event is defined as the point where the vehicle first impacted a roadside object or feature, or rolled over.

11. Variable Name: Location of Impact

The location of point of impact for the first event is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway. Note that the location of the point of impact for the first event is defined by the struck object and not by the vehicle reference point. Thus, while the longitudinal distance is the same as the last trajectory profile point, the lateral offset may differ.

For the longitudinal measurement:

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(999) Unknown

For the lateral offset measurement:

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.9) Unknown

Coding Instructions: Enter the location of the point of impact for the first event in relation to the struck object. The location is defined by two measurements: longitudinal distance, measured from the point of departure to the point of impact for the first event and the lateral offset from the edge of the travelway.

12. NASS CDS Data

Copy the following data items from the applicable NASS CDS forms pertaining to the first event:

- Object Struck
- Collision Deformation Classification (CDC)
- Vehicle Damage Profile: Length of Damage (L) and Damage Profile (D1-D6)

Also, provide a narrative to describe the point of impact on the vehicle.

13. Variable Name: Impact Angle

Format: 3 column numeric

Codes: (001-359) Actual impact angle
(999) Unknown

Coding Instructions: Enter the angle of the vehicle C. G. direction of travel at the point of impact for the first event. The impact angle is measured in relation to the edge of the travelway in the general direction of travel. Note that the impact angle must be between 1 and 90 degrees for a right-sided departure and between 270 and 359 degrees for a left-sided departure. The impact angle is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object.

14. Variable Name: Vehicle Heading Angle at Impact

Format: 3 column numeric

Codes: (000 -360) Actual vehicle heading angle
(999) Unknown

Coding Instructions: Enter the vehicle heading angle at the point of impact for the first event. The vehicle heading angle is measured in relation to the edge of the travelway in the general direction of travel. The vehicle heading angle is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object.

SEPARATION CONDITIONS (FIRST EVENT) DATA VARIABLES

Variables 15 through 17 pertain to the separation conditions of the first event, including: location, separation angle and vehicle heading angle at separation. The point of separation is defined as the point where the vehicle first separated from the struck roadside object or feature. Point of separation is typically applicable to only objects or features with some length, e.g., a guardrail or a concrete wall. For a point object such as a pole structure, the point of separation will essentially be the same as the point of impact. Also, in instances where the vehicle essentially came to rest against the struck object, there is no point of separation and variables 15 through 17 should be coded as "Not Applicable".

15. Location of Separation

The location of separation for the first event is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway. Note that the location of separation for the first event is also defined by the struck object and not the vehicle reference point.

For the longitudinal measurement:

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(998) Not Applicable
(999) Unknown

For the lateral offset measurement:

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.8) Not Applicable
(99.9) Unknown

Coding Instructions: Enter the location of the point of separation for the first event in relation to the struck object. The location is defined by two measurements: longitudinal distance, measured from the point of departure to the point of separation for the first event and the lateral offset from the edge of the travelway. In instances where the vehicle essentially came to rest against the struck object, there is no point of separation and the variable should be coded as "Not Applicable".

16. Variable Name: Separation Angle

Format: 3 column numeric

Codes: (000-360) Actual separation angle
(998) Not Applicable
(999) Unknown

Coding Instructions: Enter the angle of the vehicle C. G. direction of travel at the point of separation for the first event. The separation angle is measured in relation to the edge of the travelway in the general direction of travel. The separation angle is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object. In instances where the vehicle essentially came to rest against the struck object, there is no point of separation and the variable should be coded as "Not Applicable".

17. Variable Name: Vehicle Heading Angle at Separation

Format: 3 column numeric

Codes: (000 -360) Actual vehicle heading angle
(998) Not Applicable
(999) Unknown

Coding Instructions: Enter the vehicle heading angle at the point of separation for the first event. The vehicle heading angle is measured in relation to the edge of the travelway in the general direction of travel. The vehicle heading angle at separation for the first event is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object. In instances where the vehicle essentially came to rest against the struck object, there is no point of separation and code the variable as "Not Applicable".

SUBSEQUENT EVENT/FINAL REST DATA VARIABLES

Variables 18 through 20 pertain to the subsequent event or final rest data, including: subsequent event, location of final rest, and vehicle heading angle at final rest. The point of final rest is defined as the point where the vehicle came to a complete stop. In instances where there was subsequent event(s), there is no point of final rest and variables 19 and 20 should be skipped and left blank.

18. Variable Name: Subsequent Event

Format: 1 column numeric

Codes: (1) Yes
(2) No - Final Rest

Code if there is any subsequent event (Code 1) or if the vehicle came to final rest after the first event (Code 2). If there is a subsequent event, code variables 19 and 20 as "Not Applicable" and proceed with coding of the subsequent event form for the second event. If the vehicle came to final rest after the first event, enter the applicable information for variables 19 and 20 on the point of final rest.

19. Variable Name: Location of Final Rest

The location of final rest is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway. Note that the location of final rest is defined by the vehicle center of gravity (C. G.).

For the longitudinal measurement:

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(998) Not Applicable
(999) Unknown

For the lateral offset measurement:

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.8) Not Applicable

(99.9) Unknown

Coding Instructions: Enter the location of the point of final rest in relation to the vehicle c. g. The location is defined by two measurements: longitudinal distance, measured from the point of departure to the point of final rest and the lateral offset from the edge of the travelway. In instances where there was subsequent event(s), code the variable as "Not Applicable".

20. Variable Name: Vehicle Heading Angle at Final Rest

Format: 3 column numeric

Codes: (000 -360) Actual vehicle heading angle
(998) Not Applicable
(999) Unknown

Coding Instructions: Enter the vehicle heading angle at the point of final rest. The vehicle heading angle is measured in relation to the edge of the travelway in the general direction of travel. The vehicle heading angle at final rest is typically measured from the scaled diagram and based on available scene evidence. In instances where there was subsequent event(s), code the variable as "Not Applicable".

CODING INSTRUCTIONS FOR SUBSEQUENT EVENT CODING FORM

Coding instructions are provided for each of the 20 data elements or variables on this reconstruction coding form for subsequent events. The data elements are grouped under six general headings:

1. Case Identification,
2. Current Event Identification,
3. Vehicle Trajectory Data,
4. Impact Conditions - Current Event
5. Separation Conditions - Current Event, and
6. Subsequent Event/Final Rest.

For each group of data elements, there is a brief introduction followed by information on the individual data elements within the group. The following information is provided for each of the data elements:

Variable Number(s)
Variable Name(s)
Format
Codes
    Range
    Individual codes or responses
Coding Instructions
    Descriptions and definitions for individual codes or responses
    Illustrations (if applicable)

CASE IDENTIFICATION VARIABLES

Data elements 1 through 3 are case identification variables, including: year, Primary Sampling Unit, and case number-stratum. These variables should be identical to those for the NASS CDS case so that the supplemental field data can be properly merged with the NASS CDS data.

1. Variable Name: Year

   Format: 2 column numeric

   Codes: 00 or 01

   Coding Instructions: Code the last two digits of the year of the accident.

2. Variable Name: Primary Sampling Unit

   Format: 2 column numeric

   Codes: 02, 11, 12, 13, 45, 48, 73, 75, 76 or 78

   Coding Instructions: Code the Primary Sampling Unit in which the accident occurred.

3. Variable Name: Case Number-Stratum

   Format: 4 column alphanumeric

   Coding Instructions: Code the case number and stratum, which should be the same as those for the NASS CDS case.

CURRENT EVENT IDENTIFICATION

Variables 4 and 5 pertain to identification of the current event being coded, including: event number and location.

4. Variable Name: Current Event Number

Format: 2 column numeric

Codes: (01-96) Actual event number

Coding Instructions: Enter the number of the current event as coded in the NASS CDS forms.

5. Variable Name: Current Event Location

The location of the current event is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway. Note that the location is defined in relation to the struck object.

For the longitudinal measurement:

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(999) Unknown

For the lateral offset measurement:

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.9) Unknown

Coding Instructions: Enter the location of the point of impact for the current event in relation to the struck object. The location is defined by two measurements: longitudinal distance, measured from the point of departure to the point of impact for the current event and the lateral offset from the edge of the travelway.

VEHICLE TRAJECTORY DATA VARIABLES

Variables 6 through 10 pertain to the vehicle trajectory data between the point of separation for the previous event to the point of impact for the current event, including: driver action, longitudinal distance of travel, number of trajectory profile points, lateral offset of trajectory profile points and maximum lateral offset.

Note that the vehicle trajectory is still defined using the point of the vehicle that first left the travelway as the reference point. For example, the reference point for a tracking vehicle running off the right side of the roadway is typically the right front corner of the vehicle.

6. Variable Name: Driver Action

Format: 1 column numeric

Codes:
(1) None
(2) Braking Only
(3) Steering Only
(4) Braking and Steering
(9) Unknown

Coding Instructions: Select the code that best describes the action of the driver between the point of separation from the previous event to the point of impact for the current event. Information for coding this variable include: CDS coded variable, scene evidence, driver interview, and annotated data. Document the supporting data in the space provided as well as any additional information of interest, e.g., braking initially followed by steering and braking.

7. Variable Name: Longitudinal Distance of Travel

Format: 3 column numeric

Codes:
(000-997) Actual longitudinal distance of travel in meters
(999) Unknown

Coding Instructions: Record the longitudinal distance of travel, to the nearest meter, from the point of separation for the previous event to the point of impact for the current event. Note that this is the longitudinal distance as measured along the edge of the travelway and not the distance along the path of the vehicle. The longitudinal distance of travel is typically obtained from available scene measurements or measured from the scaled diagram .

8. Variable Name: Number of Trajectory Profile Points

Format: 2 column numeric

Codes: 06, 12 or 18

Coding Instructions: Enter the number of trajectory profile points used to define the vehicle trajectory from the point of separation for the previous event to the point of impact for the current event. The number of trajectory profile points is a function of the longitudinal distance of travel. The general guidelines are as follows:

Longitudinal Distance of Travel	No. of Trajectory Profile Points
<= 30 m	6
30 – 100 m	12
> 100 m	18

To locate the trajectory profile points, the longitudinal distance of travel is divided into equal parts based on the number of trajectory profile points. For example, if the longitudinal distance of travel is 55 m, which corresponds to 12 trajectory profile point according to the general guidelines, is 12, the longitudinal distance is divided into 11 equal spaces of 5 m each (55/11 = 5 m). The first trajectory profile point is at the point of separation for the previous event. The second trajectory profile point is 5 m downstream, 10 m for the third trajectory profile point, ... , and the last trajectory profile point is at the point of impact for the current event.

9. Variable Name: Lateral Offset of Trajectory Profile Points

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.9) Unknown

Coding Instructions: Enter lateral offset, D(i), of each applicable trajectory project point to the nearest 0.1 meter (m). At each of the trajectory profile point, measure the lateral distance from the edge of the travelway to the reference point on the vehicle that defines the vehicle path.

10. Variable Name: Maximum Lateral Offset

The maximum lateral offset along the vehicle path may or may or may not coincide with one of the trajectory profile points. Thus, a separate entry is provided for the maximum lateral offset. The point of maximum lateral offset is defined by two measurements: the

longitudinal distance from the point of departure and the lateral offset from the edge of the travelway.

For the longitudinal measurement, L (max):

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(999) Unknown

For the lateral offset measurement, D(max):

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.9) Unknown

Coding Instructions: Enter the location of the point of maximum lateral extent of encroachment between the point of separation for the previous event to the point of impact for the current event. The location is defined by two measurements: longitudinal distance, L(max), measured from the point of departure to the point of maximum lateral extent of encroachment, and the extent of the maximum lateral offset , D(max).

IMPACT CONDITIONS (CURRENT EVENT) DATA VARIABLES

Variables 11 through 14 pertain to the impact conditions of the current event, including: location, NASS CDS coded data elements, impact angle and vehicle heading angle at impact. The point of impact for the current event is defined as the point where the vehicle first impacted a roadside object or feature, or rolled over, for the current event.

11. Variable Name: Location of Event

The location of point of impact for the current event is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway. Note that the location is defined by the struck object and not the vehicle reference point. Thus, while the longitudinal distance is the same as the last trajectory profile point, the lateral offset may differ.

For the longitudinal measurement:

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(999) Unknown

For the lateral offset measurement:

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.9) Unknown

Coding Instructions: Enter the location of the point of impact for the current event in relation to the struck object. The location is defined by two measurements: longitudinal distance, measured from the point of departure to the point of impact for the current event and the lateral offset from the edge of the travelway.

12. NASS CDS Data

Copy the following data items from the applicable NASS CDS forms pertaining to the current event:

- Object Struck
- Collision Deformation Classification (CDC)
- Vehicle Damage Profile: Length of Damage (L) and Damage Profile (D1-D6)

Also, provide a narrative to describe the point of impact on the vehicle for the current event.

13. Variable Name: Impact Angle

Format: 3 column numeric

Codes: (001-359) Actual departure angle
(999) Unknown

Coding Instructions: Enter the angle of the vehicle C. G. direction of travel at the point of impact for the current event. The impact angle is measured in relation to the edge of the travelway in the general direction of travel. Note that the impact angle must be between 1 and 90 degrees for a right-sided departure and between 270 and 359 degrees for a left-sided departure. The impact angle is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object.

14. Variable Name: Vehicle Heading Angle at Impact

Format: 3 column numeric

Codes: (000 -360) Actual vehicle heading angle
(999) Unknown

Coding Instructions: Enter the vehicle heading angle at the point of impact for the current event. The vehicle heading angle is measured in relation to the edge of the travelway in the general direction of travel. The vehicle heading angle is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object.

SEPARATION CONDITIONS (CURRENT EVENT) DATA VARIABLES

Variables 15 through 17 pertain to the separation conditions of the current event, including: location, separation angle and vehicle heading angle at separation. The point of separation is defined as the point where the vehicle first separated from the struck roadside object or feature. Point of separation is typically applicable to only objects or features with some length, e.g., a guardrail or a concrete wall. For a point object such as a pole structure, the point of separation will essentially be the same as the point of impact. Also, in instances where the vehicle essentially came to rest against the struck object, there is no point of separation and variables 15 through 17 should be coded as "Not Applicable".

15. Location of Separation

The location of separation for the current event is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway. Note that the location of separation is also defined by the struck object and not the vehicle reference point.

For the longitudinal measurement:

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(998) Not Applicable
(999) Unknown

For the lateral offset measurement:

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.8) Not Applicable
(99.9) Unknown

Coding Instructions: Enter the location of the point of separation for the current event in relation to the struck object. The location is defined by two measurements: longitudinal distance, measured from the point of departure to the point of separation for the current event and the lateral offset from the edge of the travelway. In instances where the vehicle essentially came to rest against the struck object, there is no point of separation and the variable should be coded as "Not Applicable".

16. Variable Name: Separation Angle

Format: 3 column numeric

Codes: (000-360) Actual separation angle
(998) Not Applicable
(999) Unknown

Coding Instructions: Enter the angle of the vehicle C. G. direction of travel at the point of separation for the current event. The separation angle is measured in relation to the edge of the travelway in the general direction of travel. The separation angle is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object. In instances where the vehicle essentially came to rest against the struck object, there is no point of separation and the variable should be coded as "Not Applicable".

17. Variable Name: Vehicle Heading Angle at Separation

Format: 3 column numeric

Codes: (000 -360) Actual vehicle heading angle
(998) Not Applicable
(999) Unknown

Coding Instructions: Enter the vehicle heading angle at the point of separation for the current event. The vehicle heading angle is measured in relation to the edge of the travelway in the general direction of travel. The vehicle heading angle at separation for the current event is typically measured from the scaled diagram and based on available scene evidence and damages to the vehicle and struck object. In instances where the vehicle essentially came to rest against the struck object, there is no point of separation and code the variable as "Not Applicable".

SUBSEQUENT EVENT/FINAL REST DATA VARIABLES

Variables 18 through 20 pertain to the subsequent event or final rest data, including: subsequent event, location of final rest, and vehicle heading angle at final rest. The point of final rest is defined as the point where the vehicle came to a complete stop. In instances where there was subsequent event(s), there is no point of final rest and variables 19 and 20 should be skipped and left blank.

18. Variable Name: Subsequent Event

Format: 1 column numeric

Codes: (1) Yes
(2) No - Final Rest

Code if there is any subsequent event (Code 1) or if the vehicle came to final rest after the current event (Code 2). If there is a subsequent event, code variables 19 and 20 as "Not Applicable" and proceed with coding of the subsequent event form for the next event. If the vehicle came to final rest after the current event, enter the applicable information for variables 19 and 20 on the point of final rest.

19. Variable Name: Location of Final Rest

The location of final rest is defined by two measurements: the longitudinal distance from the point of departure and the lateral offset from the edge of the travelway. Note that the location of final rest is defined by the vehicle center of gravity (C. G.).

For the longitudinal measurement:

Format: 3 column numeric

Codes: (001-997) Actual longitudinal distance to the nearest meter
(998) Not Applicable
(999) Unknown

For the lateral offset measurement:

Format: 3 column numeric with 1 decimal place

Codes: (00.0-99.6) Actual lateral offset to the nearest 0.1 meter
(99.7) 99.7 meters or greater
(99.8) Not Applicable

(99.9) Unknown

Coding Instructions: Enter the location of the point of final rest in relation to the vehicle C. G. The location is defined by two measurements: longitudinal distance, measured from the point of departure to the point of final rest and the lateral offset from the edge of the travelway. In instances where there was subsequent event(s), code the variable as "Not Applicable".

20. Variable Name: Vehicle Heading Angle at Final Rest

Format: 3 column numeric

Codes: (000 -360) Actual vehicle heading angle
(998) Not Applicable
(999) Unknown

Coding Instructions: Enter the vehicle heading angle at the point of final rest. The vehicle heading angle is measured in relation to the edge of the travelway in the general direction of travel. The vehicle heading angle at final rest is typically measured from the scaled diagram and based on available scene evidence. In instances where there was subsequent event(s), code the variable as "Not Applicable".

APPENDIX D. Database Content

Table D-1. Reconstruction Summary, Vehicle Data, and Event Statistics

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Reconstruction Summary	Case_Set	Reconstruction Set	17-22, 17-11, or FHWA	Descriptor identifying what case set the reconstructions were obtained from	No
	Case_Num	Case Number	Number	Identifier for case in NASS database	No
	Case_Year	Year	Number	Accident Year	No
	Case_PSU	PSU	Number	PSU Location Identifier	No
	Case ID	Case ID	Number	Case ID in indicated PSU	No
	Depart_Vel	Departure Velocity (km/h)	Number	Calculated velocity determined from accident reconstruction	No
	Depart_Vel_Eng	Departure Velocity (mph)	Number	Departure velocity in English units	No
	Depart_Angle	Departure Angle (deg)	Number	Angle between a tangent line to the road at the point of departure (POD) and vehicle CG trajectory	No
	Depart_Lat_Energy	Lateral Departure Energy (kJ)	Number	Vehicle's lateral energy with respect to roadway travel, $1/2*m*(v*\sin\theta)^2$	No
	Depart_Sideslip_Angle	Vehicle Sideslip Angle (deg)	Number	Difference between vehicle heading angle and CG trajectory; angles are positive when measured clockwise	No
	Rated_Wgt	Weighting Factor (RATWGT)	Number	Case weighted rating factor, used to determine how "normal" the impact was, as determined by NASS	No
Vehicle Data	Veh_Year	Year	Number	Vehicle year	No
	Veh_Make	Make	Name	Vehicle make (e.g. Chevrolet, Ford etc)	No
	Veh_Model	Model	Name	Vehicle model (e.g. Blazer, S-10 etc)	No
	Veh_VIN	VIN	Number	VIN Identifier	No
	Veh_Class	Class	See "NASS Naming Conventions"	Vehicle class defined based on wheelbase and width, as recorded on NASS website	No
	Veh_Wgt_Engl	Weight (lbs)	Number	Vehicle weight	No
	Veh_Mass	Mass (kg)	Number	Vehicle mass	No
	Veh_Drive	Drive Type	FWD / RWD / 4WD / Unk	Front, Rear, 4-Wheel Drive, or Unknown	No
Event Statistics	Into_Lanes_Opp	Encroach in Opposing Lanes	Y / N	Indicator for whether vehicle encroached into opposing travel lanes	No
	Struck_Veh_Opp	Struck Opposing Vehicle	Y / N	Indicator for whether vehicle struck opposing vehicle	No
	Most_Sev_Event	Most Severe Event	A / B / C / D / R	One of Impacts A through D or R (rollover, if not coded)	Yes / No

Table D-2. Road Characteristics (Part I)

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Road Characteristics	No_Lanes_POD	No. Travel Lanes at POD	Number	Number of travel lanes in direction of vehicle travel at POD	Yes
	No_Lanes_Opp_ POD	No. Travel Lanes in Opposite Direction	Number	Number of travel lanes in opposite direction of vehicle travel at POD	Yes
	Lane_Division	Lane Division	D / N / NLM / UNK / N/A	Lane division possibilities: Divided, Not Divided, No Lane Markings, Unknown, or Not Applicable	No
	Lane_Divider	Division Type	CB / GR / OM / CL / TH / N/A	Concrete barrier, guardrail, open median, center lane, other divider type, or not applicable	No
	Land_Use_1	Land Use	See "NASS Naming Conventions"	Regional area in which road is located, as determined by the NASS researchers	No
	Speed_Lim	Speed Limit (kph)	Number	Metric speed limit	No
	Speed_Lim_Eng	Speed Limit (mph)	Number	English speed limit	No
	Char_ADT	Characteristic Traffic Volume	Low / Med / High / Very High	This is based off of observations from photos, land use, travel lanes, and road wear pattern vs. age- Rural: Low- Urban low traffic, Med- Urban high traffic or interstate, High- 6+ lane roadway, Very High	Yes
	Road_Class_1	Class Trafficway	See "NASS Naming Conventions"	Roadway classification, as determined by NASS team	No
	Access_Cntl_1	Access Control	See "NASS Naming Conventions"	Type of access control on the roadway, as determined by NASS team	No
	Ave_LW_1	Average Lane Width (m)	Number	Average of lane widths on road, as determined by NASS team	No
	Road_Align_1	Alignment at POD	See "NASS Naming Conventions"	Roadway alignment, straight or curved	No
	ROC_POD_1	Radius of Curvature (ROC) at POD (m)	Number	Radius of roadway curvature at POD No. 1	No
	ROC_LOC_1	Length of Chord at POD (m)	Number	Length of choord of roadway curve at POD No. 1	No
	ROC_MO_1	Middle Ordinate at POD (mm)	Number	Length of middle ordinate of roadway curve at POD No. 1	No
	ROC_Max_1	ROC at Point of Max Curvature (m)	Number	Radius of roadway curvature at point of max curvature within 100 m of POD	No
	ROC_LOC_Max_1	Length of Chord at Max Curvature (m)	Number	Length of choord of roadway curve at point of max curvature within 100 m of POD	No
	ROC_MO_Max_1	Middle Ordinate at Max Curvature (mm)	Number	Length of middle ordinate of roadway curve at point of max curvature within 100 m of POD	No

Table D-3. Road Characteristics (Part II)

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Road Characteristics	Initial_Depart_Side	Departure Side	L / R	Side of the road that the vehicle departed, left or right	No
	Road_Profile_1	Roadway Profile	See "NASS Naming Conventions"	Qualitative description of vertical road slope, based on hills, crests, and valleys, determined by NASS team	No
	Grade_POD_1	Vertical Grade at POD (%)	Percentage	Percent vertical grade at POD No. 1	No
	Grade_Max_1	Max Grade (%)	Percentage	Maximum vertical grade near POD No. 1	No
	Vis_Block	Visibility Constraint	Name	Objects which may obscure view of road or other vehicles, based on photographic evidence	Yes
	Lighting	Lighting	Y / N / N/A	Yes, street lights; No, no road lighting; N/A, does not affect case	Yes
	Curb_1	Curb Presence	Y / N / U	Is curb present: Yes, No, or Unknown	No
	Curb_Height_1	Curb Height (mm)	Number	Height of curb from road	No
	Shoulder_Type_1	Shoulder Type	See "NASS Naming Conventions"	Material used to construct shoulder, as determined by NASS researchers	No
	Shoulder_Wid_1	Shoulder Width (m)	Number	Width from road to edge of defined shoulder	No
	CS_POD_1	Roadside Cross-Section at POD	See "NASS Naming Conventions"	Shape of the slope cross-section near roadside, as determined by NASS researchers	No
	No_Slopes_1	No. of Slopes	Number	Number of slopes measured with slope rates to be used in describing roadside cross-section	No

Table D-4. Road Characteristics (Part III)

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Road Characteristics	Slope_1_1	Slope 1 Start (m)	Number	Lateral location from edge of travel lane to SBP 1	No
	SR_1_1	Slope Rate (%)	Percentage	Slope rate of slope 1	No
	SW_1_1	Width (m)	Number	Total width of slope 1	No
	Slope_2_1	Slope 2 Start (m)	Number	Lateral location from edge of travel lane to SBP 2	No
	SR_2_1	Slope Rate (%)	Percentage	Slope rate of slope 2	No
	SW_2_1	Width (m)	Number	Total width of slope 2	No
	Slope_3_1	Slope 3 Start (m)	Number	Lateral location from edge of travel lane to SBP 3	No
	SR_3_1	Slope Rate (%)	Percentage	Slope rate of slope 3	No
	SW_3_1	Width (m)	Number	Total width of slope 3	No
	Slope_4_1	Slope 4 Start (m)	Number	Lateral location from edge of travel lane to SBP 4	No
	SR_4_1	Slope Rate (%)	Percentage	Slope rate of slope 4	No
	SW_4_1	Width (m)	Number	Total width of slope 4	No
	Slope_5_1	Slope 5 Start (m)	Number	Lateral location from edge of travel lane to SBP 5	No
	SR_5_1	Slope Rate (%)	Percentage	Slope rate of slope 5	No
	SW_5_1	Width (m)	Number	Total width of slope 5	No
	Slope_6_1	Slope 6 Start (m)	Number	Lateral location from edge of travel lane to SBP 6	No
	SR_6_1	Slope Rate (%)	Percentage	Slope rate of slope 6	No
	SW_6_1	Width (m)	Number	Total width of slope 6	No
	Slope_7_1	Slope 7 Start (m)	Number	Lateral location from edge of travel lane to SBP 7	No
	SR_7_1	Slope Rate (%)	Percentage	Slope rate of slope 7	No
	SW_7_1	Width (m)	Number	Total width of slope 7	No
	Slope_8_1	Slope 8 Start (m)	Number	Lateral location from edge of travel lane to SBP 8	No
	SR_8_1	Slope Rate (%)	Percentage	Slope rate of slope 8	No
	SW_8_1	Width (m)	Number	Total width of slope 8	No
	Road_Cond	Road Conditions	Wet / Snow / Slush / Dry / Unk	Roadway conditions at the time of departure	No
	Road_Surf	Road Surface	A / C / D / G / O	Roadway surface:A-asphalt, C-concrete, D-dirt, G-gravel, O-other	No

Table D-5. First Impact (Part I)

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
First Impact	Acc_Time	Time of Accident	NumberNumber: NumberNumber	Use military time (00:00 to 23:59)	No
	Acc_Month	Month	Name	Month in which accident occurred	No
	Acc_Weather	Weather Conditions	CL / SN / HA / SL / RN / UNK	Weather conditions based on accident reports at time of departure: clear, snow, hail, sleet, rain, unk	No
	Impact_No_A	Sequential Impact Number	Number	First impact recorded in impact sequence. If more than four impacts were recorded, this number indicates the first significant impact.	No
	Impact_Speed_A	Impact Speed A (km/h)	Number	Speed at impact for Impact A	No
	Impact_Speed_A_Eng	Impact Speed A (mph)	Number	Speed at impact for Impact A, English units	No
	Barrier_Angle_A	Impact Angle A wrt Barrier (deg)	Number	Vehicle trajectory angle with respect to barrier tangency (if applicable)	No
	Impact_Angle_A	Impact Angle A wrt Road (deg)	Number	Vehicle trajectory angle with respect to tangent line to road at POD	No
	IS_Barr_A	Impact Severity A wrt Barrier (kJ)	Number	Impact severity at impact A wrt barrier, $M/2(V\sin\theta_b)^2$ (if applicable)	No
	IS_Road_A	Impact Severity A wrt Road (kJ)	Number	Impact severity at impact A wrt roadway encroachment, $M/2(V\sin\theta_i)^2$	No
	Impact_Orient_A	Impact Orientation A (deg)	Number	Vehicle orientation angle with respect to road tangent line to road at POD	No
	Obj_Type_A	Object Type	See “NASS Naming Conventions”	Object classification as recorded in NASS file	No
	Obj_Mat_A	Material (if applicable)	See "NASS Naming Conventions"	Construction material for first object struck, as recorded by NASS	No
	Obj_Diam_A	Diameter (cm)	Number	Diameter of object in first coded impact	Yes / No
	Obj_Len_A	Length (cm)	Number	Length of object in first coded impact	Yes / No
	Obj_Wid_A	Width (cm)	Number	Width of object in first coded impact	Yes / No
	Obj_Hgt_A	Height (cm)	Number	Height of object in first coded impact	Yes / No
	Dim_Origin_A	Dimensions Obtained By	Measured/Estimated	Indicator for whether NASS team performed measurements or whether it was estimated from photographs	No
	Obj_Struck_A	Object Impacted	Name	Description of the first object impacted	Yes
	Rollover	Rollover	Y / N	Did a rollover occur at any point in the impact sequence, yes or no?Rollover did not have to occur at coded impact A.	No
	Rollover_Cause	Cause	Description	Brief description of what caused rollover, if applicable	Yes

Table D-6. First Impact (Part II), Lateral Offset from Roadway, and Impact Location from POD

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
First Impact	Photos_A	Photos	Y / N	Were photos taken of each object impacted	No
	Clarity_A	Clarity	Y / N	Measure of accuracy of dimensions, relative to use of measurement devices and number of photos used. Clarity is assumed to be present if the NASS researchers measured the object.	Yes
	Driver_Action_A	Driver Action	See "NASS Naming Conventions"	Evasive manuever performed by the driver prior to or during departure, as recorded by NASS	No
	Impact_Dist_Btwn_A	Impact Distance from POD (m)	Number	Distance from first coded impact to POD no. 1	No
Lateral Offset from Roadway	No_Traj_Pts_A	No. Trajectory Points	6 / 12 / 18	Number of equal increments used to determine the trajectory	No
	D1_A	D1	Number	Lateral distance to CG, trajectory point 1	No
	D2_A	D2	Number	Lateral distance to CG, trajectory point 2	No
	D3_A	D3	Number	Lateral distance to CG, trajectory point 3	No
	D4_A	D4	Number	Lateral distance to CG, trajectory point 4	No
	D5_A	D5	Number	Lateral distance to CG, trajectory point 5	No
	D6_A	D6	Number	Lateral distance to CG, trajectory point 6	No
	D7_A	D7	Number	Lateral distance to CG, trajectory point 7	No
	D8_A	D8	Number	Lateral distance to CG, trajectory point 8	No
	D9_A	D9	Number	Lateral distance to CG, trajectory point 9	No
	D10_A	D10	Number	Lateral distance to CG, trajectory point 10	No
	D11_A	D11	Number	Lateral distance to CG, trajectory point 11	No
	D12_A	D12	Number	Lateral distance to CG, trajectory point 12	No
	D13_A	D13	Number	Lateral distance to CG, trajectory point 13	No
	D14_A	D14	Number	Lateral distance to CG, trajectory point 14	No
	D15_A	D15	Number	Lateral distance to CG, trajectory point 15	No
	D16_A	D16	Number	Lateral distance to CG, trajectory point 16	No
	D17_A	D17	Number	Lateral distance to CG, trajectory point 17	No
	D18_A	D18	Number	Lateral distance to CG, trajectory point 18	No
Impact Location from POD (m)	Long_Impact_Loc_A	Longitudinal (m)	Number	Longitudinal distance from POD no. 1 to impact A	No
	Lat_Impact_Loc_A	Lateral (m)	Number	Lateral distance from POD no. 1 to impact A, measured from roadway tangency	No

Table D-7. Vehicle Damage and Vehicle Separation

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Vehicle Damage	CDC_A	CDC	Number String	CDC deformation classification from impact A	No
	Impact_Plane_A	Region of Impact	Name	Region of vehicle where impact was centralized at impact A:Roof/Top, Right or Left Side, Front, Bumper etc	No
	Damage_Len_A	Length of Damage (cm)	Number	Length of damage imparted to vehicle	No
	C1_A	C1 (cm)	Number	Crush depth along first measurement point	No
	C2_A	C2 (cm)	Number	Crush depth along second measurement point	No
	C3_A	C3 (cm)	Number	Crush depth along third measurement point	No
	C4_A	C4 (cm)	Number	Crush depth along fourth measurement point	No
	C5_A	C5 (cm)	Number	Crush depth along fifth measurement point	No
	C6_A	C6 (cm)	Number	Crush depth along sixth measurement point	No
Vehicle Separation	Sep_Long_Loc_A	Longitudinal Location (m)	Number	Longitudinal location where vehicle separated from object impacted in impact A	No
	Sep_Lat_Loc_A	Lateral Location (m)	Number	Lateral location where vehicle separated from object impacted in impact A	No
	Sep_Angle_A	Angle (deg)	Number	Angle between vehicle CG trajectory and a tangent line to the roadway at point of departure in impact A	No
	Sep_Veh_Head_Angle_A	Heading (deg)	Number	Direction of vehicle heading when vehicle separated from impact A wrt a tangent line to the roadway at the point of departure	No

Table D-8. Opposite Side Departure

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Opposite Side Departure (if Applicable)	Land_Use_2	Land Use	See "NASS Naming Conventions"	Regional area in which road is located, as determined by the NASS researchers, for second departure (if applicable)	No
	Road_Class_2	Class Trafficway	See "NASS Naming Conventions"	Roadway classification for second departure, as determined by NASS team (if applicable)	No
	Access_Cntl_2	Access Control	See "NASS Naming Conventions"	Type of access control on the roadway at departure 2, as determined by NASS team	No
	Ave_LW_2	Average Lane Width (m)	Number	Average lane width , second departure (if applicable)	No
	Road_Align_2	Alignment at POD	See "NASS Naming Conventions"	Roadway alignment, straight or curved, second departure (if applicable)	No
	ROC_POD_2	Radius of Curvature (ROC) at POD (m)	Number	Radius of roadway curvature at POD No. 2	No
	ROC_LOC_2	Length of Chord at POD (m)	Number	Length of choord of roadway curve at POD No. 2	No
	ROC_MO_2	Middle Ordinate at POD (mm)	Number	Length of middle ordinate of roadway curve at POD No. 2	No
	ROC_Max_2	ROC at Point of Max Curvature (m)	Number	Radius of roadway curvature at point of max curvature within 100 m of POD	No
	ROC_LOC_Max_2	Length of Chord at Max Curvature (m)	Number	Length of choord of roadway curve at point of max curvature within 100 m of POD	No
	ROC_MO_Max_2	Middle Ordinate at Max Curvature (mm)	Number	Length of middle ordinate of roadway curve at point of max curvature within 100 m of POD	No
	Road_Profile_2	Departure Side	L / R	Side of the road that the vehicle departed, left or right	No
	Grade_POD_2	Vertical Grade at POD (%)	Percentage	Percent grade at POD No. 1, second departure (if applicable)	No
	Grade_Max_2	Max Grade (%)	Percentage	Maximum grade near POD No. 1, second departure (if applicable)	No
	Curb_2	Curb Presence	Y / N / U	Yes, No, or Unknown, second departure (if applicable)	No
	Curb_Hgt_2	Curb Height (mm)	Number	Height of curb from road , second departure (if applicable)	No
	Shoulder_Type_2	Shoulder Type	See "NASS Naming Conventions"	Shoulder material, second departure (if applicable)	No
	Shoulder_Wid_2	Shoulder Width (m)	Number	Width from road to edge of defined shoulder, second departure (if applicable)	No
	CS_POD_2	Roadside Cross-Section at POD	See "NASS Naming Conventions"	Shape of the slope cross-section near roadside, second departure (if applicable)	No
	No_Slopes_2	No. of Slopes	Number	Number of slope rates described for roadside cross-section, second departure (if applicable)	No

Table D-9. Second Impact

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Second Impact	Impact_No_B	Sequential Impact Number	Number	Second impact recorded in impact sequence. If more than four impacts were recorded, this number indicates	No
	Impact_Speed_B	Impact Speed B	Number	Speed At impact for Impact B	No
	Impact_Speed_B_Eng	Impact Speed B (mph)	Number	Speed At impact for Impact B, English units	No
	Barrier_Angle_B	Impact Angle B wrt Barrier (deg)	Number	Vehicle trajectory angle with respect to barrier tangency (if applicable)	No
	Impact_Angle_B	Impact Angle B wrt Road (deg)	Number	Vehicle trajectory angle with respect to tangent line to road at POD	No
	IS_Barr_B	Impact Severity B wrt Barrier (kJ)	Number	Impact severity at impact B wrt barrier, $M/2(V\sin\theta_b)^2$ (if applicable)	No
	IS_Road_B	Impact Severity B wrt Road (kJ)	Number	Impact severity at impact B wrt roadway encroachment, $M/2(V\sin\theta_i)^2$	No
	Impact_Orient_B	Impact Orientation B (deg)	Number	Vehicle orientation angle with respect to tangent line to road at POD	No
	Obj_Diam_B	Diameter (cm)	Number	Diameter of object in second coded impact	Yes / No
	Obj_Len_B	Length (cm)	Number	Length of object in second coded impact	Yes / No
	Obj_Wid_B	Width (cm)	Number	Width of object in second coded impact	Yes / No
	Obj_Hgt_B	Height (cm)	Number	Height of object in second coded impact	Yes / No
	Obj_Struck_B	Object Impacted	Description	Description of object struck in impact B	No
	Photos_B	Photos	Y / N	Were photos taken of each object impacted	No
	Clarity_B	Clarity of Dimensions	Y / N	Measure of accuracy of dimensions, relative to use of measurement devices and number of photos used. Clarity is assumed to be present if the NASS researchers measured the object.	No
	Driver_Action_B	Driver Action	See "NASS Naming Conventions"	Evasive manuever performed by the driver prior to or during impact B, as recorded by NASS	No
	Impact_Dist_Btwn_B	Distance Traveled Between Impacts (m)	Number	Distance from impact B to POD no. 1	No

Table D-10. Lateral Offset from Roadway, Impact Location from POD, and Vehicle Damage

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Lateral Offset from Roadway	No_Traj_Pts_B	No. Trajectory Points	6 / 12 / 18	Number of equal increments used to determine the trajectory	No
	D1_B	D1	Number	Lateral distance to CG, trajectory point 1, between impacts A and B	No
	D2_B	D2	Number	Lateral distance to CG, trajectory point 2, between impacts A and B	No
	D3_B	D3	Number	Lateral distance to CG, trajectory point 3, between impacts A and B	No
	D4_B	D4	Number	Lateral distance to CG, trajectory point 4, between impacts A and B	No
	D5_B	D5	Number	Lateral distance to CG, trajectory point 5, between impacts A and B	No
	D6_B	D6	Number	Lateral distance to CG, trajectory point 6, between impacts A and B	No
	D7_B	D7	Number	Lateral distance to CG, trajectory point 7, between impacts A and B	No
	D8_B	D8	Number	Lateral distance to CG, trajectory point 8, between impacts A and B	No
	D9_B	D9	Number	Lateral distance to CG, trajectory point 9, between impacts A and B	No
	D10_B	D10	Number	Lateral distance to CG, trajectory point 10, between impacts A and B	No
	D11_B	D11	Number	Lateral distance to CG, trajectory point 11, between impacts A and B	No
	D12_B	D12	Number	Lateral distance to CG, trajectory point 12, between impacts A and B	No
	D13_B	D13	Number	Lateral distance to CG, trajectory point 13, between impacts A and B	No
	D14_B	D14	Number	Lateral distance to CG, trajectory point 14, between impacts A and B	No
	D15_B	D15	Number	Lateral distance to CG, trajectory point 15, between impacts A and B	No
	D16_B	D16	Number	Lateral distance to CG, trajectory point 16, between impacts A and B	No
	D17_B	D17	Number	Lateral distance to CG, trajectory point 17, between impacts A and B	No
	D18_B	D18	Number	Lateral distance to CG, trajectory point 18, between impacts A and B	No
Impact Location from POD (m)	Long_Impact_Loc_B	Longitudinal Location (m)	Number	Longitudinal distance from POD no. 1 to impact B	No
	Lat_Impact_Loc_B	Lateral Location (m)	Number	Lateral distance from POD no. 1 to impact B, measured from roadway tangency	No
Vehicle Damage	CDC_B	CDC	Number String	CDC deformation classification, impact B	No
	Impact_Plane_B	Region of Impact	Name	Region of vehicle where impact was centralized:Roof/Top, Right or Left Side, Front, Bumper etc, impact B	No
	Damage_Len_B	Length of Damage (cm)	Number	Length of damage imparted to vehicle, impact B	No
	C1_B	C1 (cm)	Number	Crush depth along first measurement point, impact B	No
	C2_B	C2 (cm)	Number	Crush depth along second measurement point, impact B	No
	C3_B	C3 (cm)	Number	Crush depth along third measurement point, impact B	No
	C4_B	C4 (cm)	Number	Crush depth along fourth measurement point, impact B	No
	C5_B	C5 (cm)	Number	Crush depth along fifth measurement point, impact B	No
	C6_B	C6 (cm)	Number	Crush depth along sixth measurement point, impact B	No

Table D-11. Vehicle Separation and Third Impact

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Vehicle Separation	Sep_Long_Loc_B	Longitudinal Location (m)	Number	Longitudinal location where vehicle separated from object impacted in impact B	No
	Sep_Lat_Loc_B	Lateral Location (m)	Number	Lateral location where vehicle separated from object impacted in impact B	No
	Sep_Angle_B	Angle (deg)	Number	Angle between vehicle CG trajectory and a tangent line to the roadway at point of departure in impact B	No
	Sep_ Head_Angle_B	Heading (deg)	Number	Direction of vehicle heading when vehicle separated from impact B wrt a tangent line to the roadway at the point of departure	No
Third Impact	Impact_No_C	Sequential Impact Number	Number	Third impact recorded in impact sequence. If more than four impacts were recorded, this number indicates the third significant impact.	No
	Impact_Speed_C	Impact Speed C (km/h)	Number	Speed At impact for Impact C	No
	Impact_Speed_C_Eng	Impact Speed C (mph)	Number	Speed At impact for Impact C, English units	No
	Barrier_Angle_C	Impact Angle C wrt Barrier (deg)	Number	Vehicle trajectory angle with respect to barrier tangency (if applicable)	No
	Impact_Angle_C	Impact Angle C wrt Road (deg)	Number	Vehicle trajectory angle with respect to tangent line to road at POD	No
	IS_Barr_C	Impact Severity C wrt Barrier (kJ)	Number	Impact severity at impact C wrt barrier, M/2(Vsinθb)2 (if applicable)	No
	IS_Road_C	Impact Severity C wrt Road (kJ)	Number	Impact severity at impact C wrt roadway encroachment, M/2(Vsinθi)2	No
	Impact_Orient_C	Impact Orientation C (deg)	Number	Vehicle orientation angle with respect to tangent line to road at POD	No
	Obj_Diam_C	Diameter (cm)	Number	Diameter of object in third coded impact	Yes / No
	Obj_Len_C	Length (cm)	Number	Length of object in third coded impact	Yes / No
	Obj_Wid_C	Width (cm)	Number	Width of object in third coded impact	Yes / No
	Obj_Hgt_C	Height (cm)	Number	Height of object in third coded impact	Yes / No
	Obj_Struck_C	Object Impacted	Description	Description of object struck in impact C	Yes / No
	Photos_C	Photos	Y / N	Were photos taken of each object impacted	No
	Clarity_C	Photo Clarity	Y / N	Measure of accuracy of dimensions, based on number of photos and obtained measurements. Clarity is assumed to be present if the NASS researchers measured the object.	No
	Driver_Action_C	Driver Action	See "NASS Naming Conventions"	Evasive manuever performed by the driver prior to or during impact C, as recorded by NASS	No
	Impact_Dist_Btwn_C	Distance Traveled Between Impacts (m)	Number	Distance from impact C to POD no. 1	No

Table D-12. Lateral Offset from Roadway, Impact Location from POD, and Vehicle Damage

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Lateral Offset from Roadway	No_Traj_Pts_C	No. Trajectory Points	6 / 12 / 18	Number of equal increments used to determine the trajectory	No
	D1_C	D1	Number	Lateral distance to CG, trajectory point 1, between impacts B and C	No
	D2_C	D2	Number	Lateral distance to CG, trajectory point 2, between impacts B and C	No
	D3_C	D3	Number	Lateral distance to CG, trajectory point 3, between impacts B and C	No
	D4_C	D4	Number	Lateral distance to CG, trajectory point 4, between impacts B and C	No
	D5_C	D5	Number	Lateral distance to CG, trajectory point 5, between impacts B and C	No
	D6_C	D6	Number	Lateral distance to CG, trajectory point 6, between impacts B and C	No
	D7_C	D7	Number	Lateral distance to CG, trajectory point 7, between impacts B and C	No
	D8_C	D8	Number	Lateral distance to CG, trajectory point 8, between impacts B and C	No
	D9_C	D9	Number	Lateral distance to CG, trajectory point 9, between impacts B and C	No
	D10_C	D10	Number	Lateral distance to CG, trajectory point 10, between impacts B and C	No
	D11_C	D11	Number	Lateral distance to CG, trajectory point 11, between impacts B and C	No
	D12_C	D12	Number	Lateral distance to CG, trajectory point 12, between impacts B and C	No
	D13_C	D13	Number	Lateral distance to CG, trajectory point 13, between impacts B and C	No
	D14_C	D14	Number	Lateral distance to CG, trajectory point 14, between impacts B and C	No
	D15_C	D15	Number	Lateral distance to CG, trajectory point 15, between impacts B and C	No
	D16_C	D16	Number	Lateral distance to CG, trajectory point 16, between impacts B and C	No
	D17_C	D17	Number	Lateral distance to CG, trajectory point 17, between impacts B and C	No
	D18_C	D18	Number	Lateral distance to CG, trajectory point 18, between impacts B and C	No
Impact Location from POD (m)	Long_Impact_Loc_C	Longitudinal Location (m)	Number	Longitudinal distance from POD no. 1 to impact C	No
	Lat_Impact_Loc_C	Lateral Location (m)	Number	Lateral distance from POD no. 1 to impact C, measured from roadway tangency	No
Vehicle Damage	CDC_C	CDC	Number String	CDC deformation classification, impact C	No
	Impact_Plane_C	Region of Impact	Name	Region of vehicle where impact was centralized in impact C:Roof/Top, Right or Left Side, Front, Bumper etc	No
	Damage_Len_C	Length of Damage (cm)	Number	Length of damage imparted to vehicle	No
	C1_C	C1 (cm)	Number	Crush depth along first measurement point	No
	C2_C	C2 (cm)	Number	Crush depth along second measurement point	No
	C3_C	C3 (cm)	Number	Crush depth along third measurement point	No
	C4_C	C4 (cm)	Number	Crush depth along fourth measurement point	No
	C5_C	C5 (cm)	Number	Crush depth along fifth measurement point	No
	C6_C	C6 (cm)	Number	Crush depth along sixth measurement point	No

Table D-13.Vehicle Separation and Fourth Impact

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Vehicle Separation	Sep_Long_Loc_C	Longitudinal Location (m)	Number	Longitudinal location where vehicle separated from object impacted in impact C	No
	Sep_Lat_Loc_C	Lateral Location (m)	Number	Lateral location where vehicle separated from object impacted in impact C	No
	Sep_Angle_C	Angle (deg)	Number	Angle between vehicle CG trajectory and a tangent line to the roadway at point of departure in impact C	No
	Sep_Head_Angle_C	Heading (deg)	Number	Direction of vehicle heading when vehicle separated from impact C wrt a tangent line to the roadway at the point of departure	No
Fourth Impact	Impact_No_D	Sequential Impact Number	Number	Fourth impact recorded in impact sequence. If more than four impacts were recorded, this number indicates the fourth significant impact.	No
	Impact_Speed_D	Impact Speed D (km/h)	Number	Speed At impact for Impact D	No
	Impact_Speed_D_Eng	Impact Speed D (mph)	Number	Speed At impact for Impact D, English units	No
	Barrier_Angle_D	Impact Angle D wrt Barrier (deg)	Number	Vehicle trajectory angle with respect to barrier tangency (if applicable)	No
	Impact_Angle_D	Impact Angle D wrt Road (deg)	Number	Vehicle trajectory angle with respect to tangent line to road at POD	No
	IS_Barr_D	Impact Severity D wrt Barrier (kJ)	Number	Impact severity at impact D wrt barrier, M/2(Vsinθb)2 (if applicable)	No
	IS_Road_D	Impact Severity D wrt Road (kJ)	Number	Impact severity at impact D wrt roadway encroachment, M/2(Vsinθi)2	No
	Impact_Orient_D	Impact Orientation D (deg)	Number	Vehicle orientation angle with respect to tangent line to road at POD	No
	Obj_Diam_D	Diameter (cm)	Number	Diameter of object in fourth coded impact	Yes / No
	Obj_Len_D	Length (cm)	Number	Length of object in fourth coded impact	Yes / No
	Obj_Wid_D	Width (cm)	Number	Width of object in fourth coded impact	Yes / No
	Obj_Hgt_D	Height (cm)	Number	Height of object in fourth coded impact	Yes / No
	Obj_Struck_D	Object Impacted	Description	Description of object struck in impact D	No
	Photos_D	Photos	Y / N	Were photos taken of each object impacted	No
	Clarity_D	Photo Clarity	Y / N	Measure of accuracy of dimensions, based on number of photos and obtained measurements. Clarity is assumed to be present if the NASS researchers measured the object.	No
	Driver_Action_D	Driver Action	See "NASS Naming Conventions"	Evasive manuever performed by the driver prior to or during impact D, as recorded by NASS	No
	Impact_Dist_Btwn_D	Distance Traveled Between Impacts (m)	Number	Distance from impact C to POD no. 1	No

Table D-14. Lateral Offset from Roadway, Impact Location from POD, Vehicle Damage, and Vehicle Separation

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Lateral Offset from Roadway	No_Traj_Pts_D	No. Trajectory Points	6 / 12 / 18	Number of equal increments used to determine the trajectory	No
	D1_D	D1	Number	Lateral distance to CG, trajectory point 1, between impacts C and D	No
	D2_D	D2	Number	Lateral distance to CG, trajectory point 2, between impacts C and D	No
	D3_D	D3	Number	Lateral distance to CG, trajectory point 3, between impacts C and D	No
	D4_D	D4	Number	Lateral distance to CG, trajectory point 4, between impacts C and D	No
	D5_D	D5	Number	Lateral distance to CG, trajectory point 5, between impacts C and D	No
	D6_D	D6	Number	Lateral distance to CG, trajectory point 6, between impacts C and D	No
Impact Location from POD (m)	Long_Impact_Loc_D	Longitudinal Location (m)	Number	Longitudinal distance from POD no. 1 to impact D	No
	Lat_Impact_Loc_D	Lateral Location (m)	Number	Lateral distance from POD no. 1 to impact D, measured from roadway tangency	No
Vehicle Damage	CDC_D	CDC	Number String	CDC deformation classification for impact D	No
	Impact_Plane_D	Region of Impact	Name	Region of vehicle where impact was centralized:Roof/Top, Right or Left Side, Front, Bumper etc	No
	Damage_Len_D	Length of Damage (cm)	Number	Length of damage imparted to vehicle from impact D	No
	C1_D	C1 (cm)	Number	Crush depth along first measurement point	No
	C2_D	C2 (cm)	Number	Crush depth along second measurement point	No
	C3_D	C3 (cm)	Number	Crush depth along third measurement point	No
	C4_D	C4 (cm)	Number	Crush depth along fourth measurement point	No
	C5_D	C5 (cm)	Number	Crush depth along fifth measurement point	No
	C6_D	C6 (cm)	Number	Crush depth along sixth measurement point	No
Vehicle Separation	Sep_Long_Loc_D	Longitudinal Location (m)	Number	Longitudinal location where vehicle separated from object impacted in impact D	No
	Sep_Lat_Loc_D	Lateral Location (m)	Number	Lateral location where vehicle separated from object impacted in impact D	No
	Sep_Angle_D	Angle (deg)	Number	Angle between vehicle CG trajectory and a tangent line to the roadway at point of departure in impact D	No
	Sep_Head_Angle_D	Heading (deg)	Number	Direction of vehicle heading when vehicle separated from impact D wrt a tangent line to the roadway at the point of departure	No

Table D-15. Occupants, Number of Injuries, Final Position from POD, Length of First Departure, and Length of Second Departure

Group Title	Cell Title	Description	Data Type	NOTES	Based on Photographic Evidence?
Occupants	Alcohol	Alcohol Presence	Y / N	Was alcohol a factor in the crash?	No
	BAC	BAC	Number	Blood Alcohol Content, if applicable (driver)	No
	Substances	Other Substances	Y / N	Any additional controlled substances used	No
	Distractions	Distractions	Description	Driver distractions causing inattention to the road	No
	No_Occupants	No. Occupants	Number	Number of occupants in the vehicle	No
	Fatality	Fatality	Y / N	Did a fatality occur in the crash?	No
	Belted_Driver	Belted Driver	Y / N	Was the driver belted?	No
	No_Belted_Pass	No. Belted Passengers	Number	Number of occupants wearing safety belts	No
	Eject	Ejection	Y / N	Were any occupants ejected from the vehicle?	No
Number of Injuries	Inj_Fatality	Number of Fatalieis	Number	Number of fatalities in crash	No
	Inj_A	Number of Incapacitating Injuries	Number	Number of occupants with incapacitating injuries	No
	Inj_B	Number of Non-Incapacitating Injuries	Number	Number of occupants with non-incapacitating injuires	No
	Inj_C	Number of Possible Injured	Number	Number of occupants with possible injuries	No
	Inj_Uninjured	Number Uninjured	Number	Number of occupants uninjured	No
	Inj_Unknown	Number Unknown	Number	Number of occupants with unknown injuires	No
	Inj_PDO	Number PDO	Number	Binary; indicates whether or not it was a property-damage-only crash	No
Final Position from POD	FP_Long	Longitudinal (m)	Number	Final resting place longitudinally from POD 1	No
	FP_Lat	Lateral (m)	Number	Final resting place laterally from POD 1	No
	FP_Heading_Angle	Heading Angle (deg)	Number	Final rest heading angle between vehicle and roadway tangency from POD 2 (1 if only one POD)	No
Length of First Departure	LOD_Lr1	Longitudinal (m)	Number	Maximum longitudinal offset from POD 1	No
	LOD_Ll1	Lateral (m)	Number	Maximum lateral offset from POD 1	No
Length of Second Departure	LOD_Lr2	Longitudinal (m)	Number	Maximum longitudinal offset from POD 2 (if applicable)	No
	LOD_Ll2	Lateral (m)	Number	Maximum lateral offset from POD 2 (if applicable)	No

Table D-16. NASS Naming Conventions (Part I)

Variable Title	Coded Parameter	NASS Researcher Description
Vehicle Class:	**C**	**Compact**
	S	**Subcompact**
	I	**Intermediate**
	D	**Sedan**
	F	**Full-Size Sedan**
	L	**Largest Size**
	CP	**Compact Pickup**
	LP	**Large Pikup**
	OP	**Other Pickup Type**
	UP	**Unknown Pickup Type**
	CU	**Compact Utility**
	SU	**Stationwagon Utility**
	LU	**Large Utility**
	MV	**Minivan**
	FV	**Full-Size Van**
	LV	**Large Van**
Land Use:	**1**	**Urban**
	2	**Rural**
	9	**Unknown**
Class Trafficway:	**1**	**Interstate**
	2	**US Route**
	3	**State Route**
	4	**County Road**
	5	**City Street**
	8	**Other (specify)**
Access Control:	**1**	**Full**
	2	**Partial**
	3	**Uncontrolled**
Roadway Alignment:	**1**	**Straight**
	2	**Curve Right**
	3	**Curve Left**
Roadway Profile:	**0**	**Level**
	1	**Upgrade**
	2	**Downgrade**
	3	**Crest**
	4	**Sag**
Curb Presence:	**0**	**No Curb**
	1	**Barrier Curb**
	2	**Mountable Curb**
Shoulder Type:	**0**	**No shoulder**
	1	**Paved Shoulder**
	2	**Gravel/Dirt Shoulder**
	3	**Grassy Shoulder**
	4	**Paved and Gravel/Dirt Shoulders side by side (Shoulder width is combined width of both)**

Table D-17. NASS Naming Conventions (Part II)

Variable Title	Coded Parameter	NASS Researcher Description
Roadside Cross-Section (see diagram):	1	V-ditch with flat transition between foreslope and backslope
	2	V-ditch with two foreslopes
	3	V-ditch with single foreslope and backslope
	4	V-ditch with two backslopes
	5	Single foreslope
	6	Curb and sidewalk
	8	Other

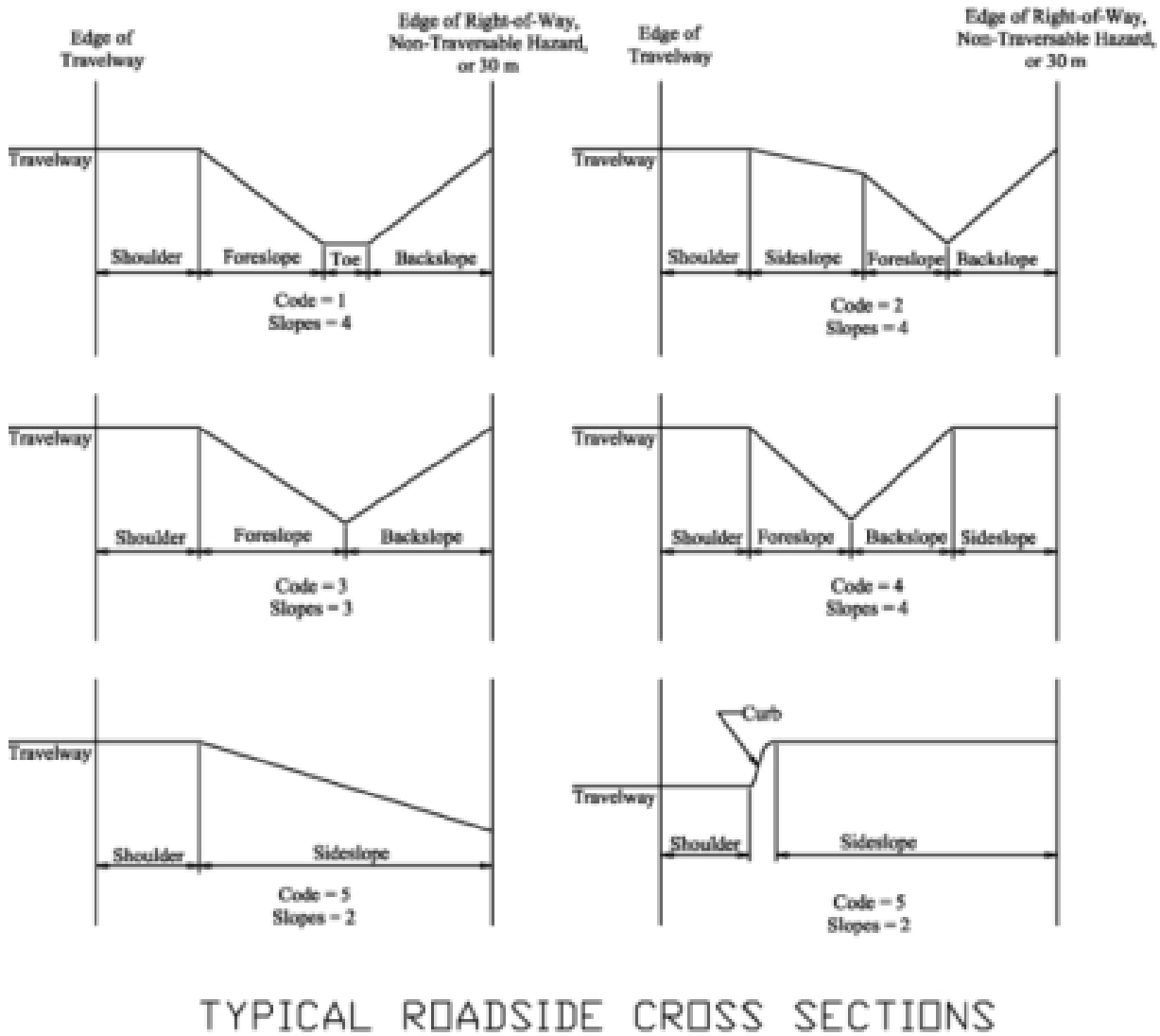


Table D-18. NASS Naming Conventions (Part III)

Variable Title	Coded Parameter	NASS Researcher Description
Object Type:	1	Rigid Object
	2	Barrier
	3	Utility Pole
	4	Light Support
	5	Sign Support
	6	Crash Cushion
	7	Other
	9	Unknown or N/A
Material	1	Concrete
	2	Steel
	3	Wood
	4	Combination
	7	Other
	9	Unknown or N/A
Driver Action:	1	None
	2	Braking Only
	3	Steering Only
	4	Braking and Steering
	9	Unknown
Ejections	Y	There were ejections
	N	No ejections
	P	Partial Ejections
	P/Y	Partial and Full ejections

APPENDIX E. Additional Tables, Plots, and Analysis Results

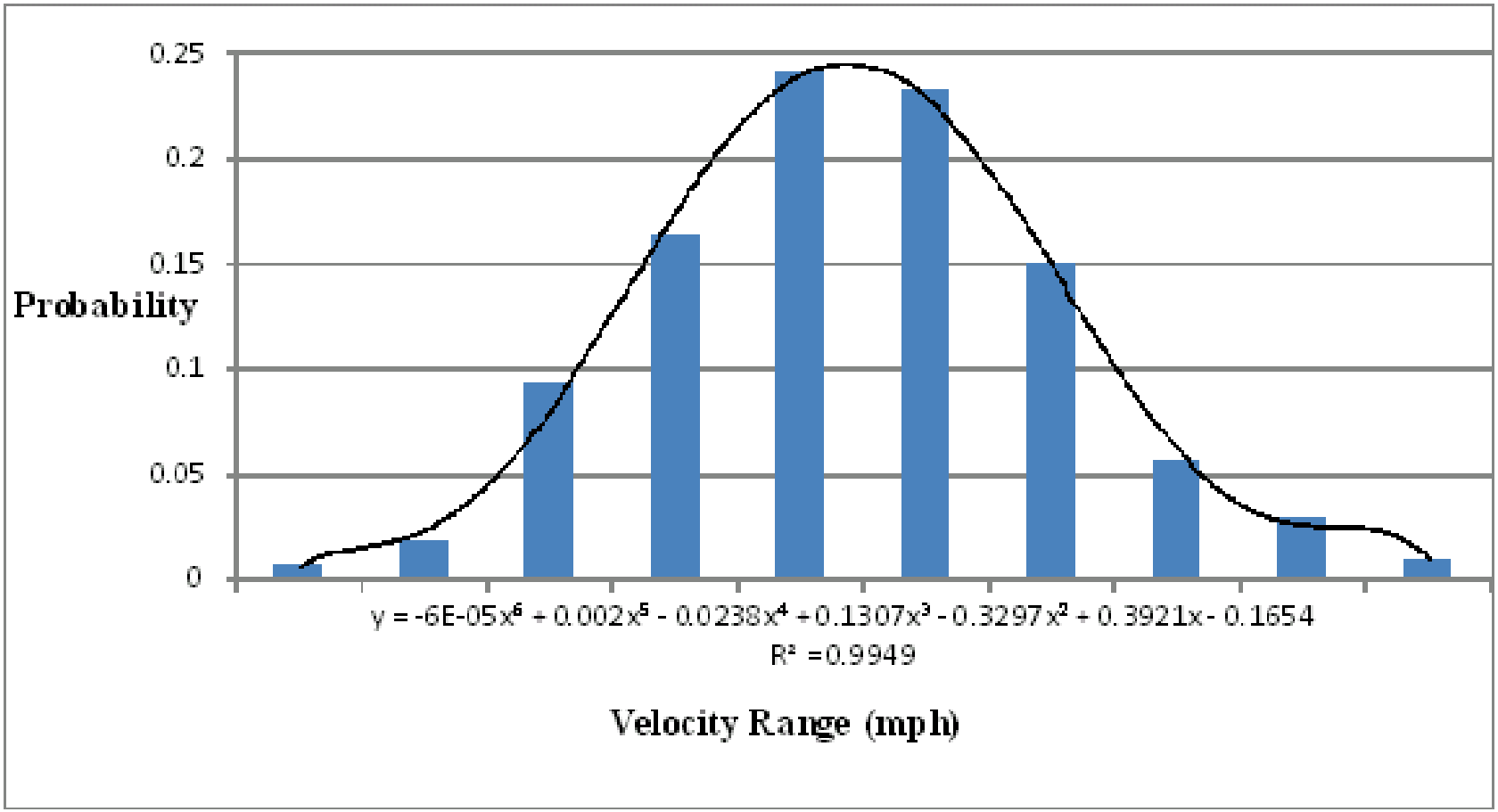


Figure E-1. Departure Velocity for All Data

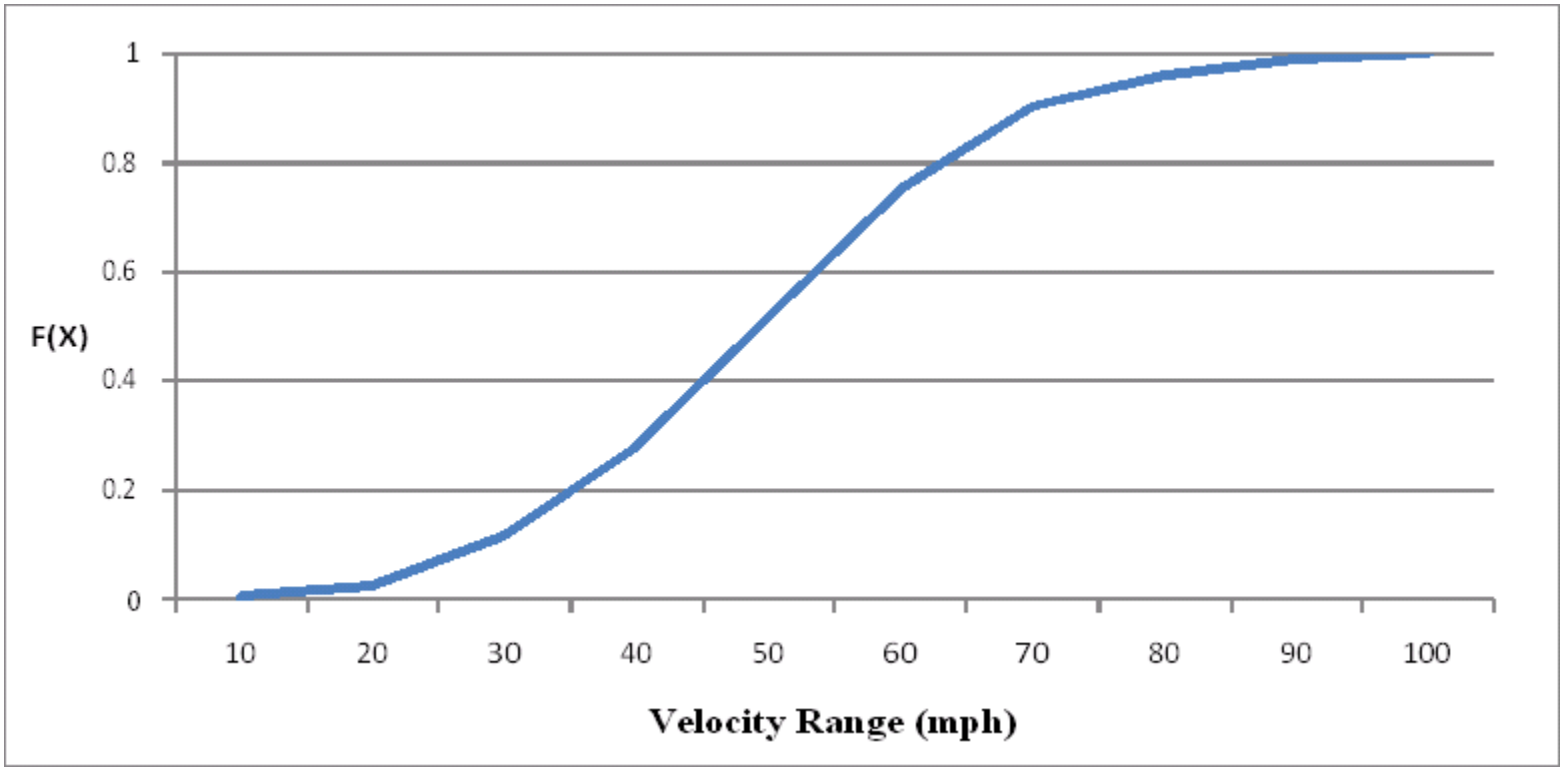


Figure E-2. Departure Velocity Cumulative Distribution for All Data

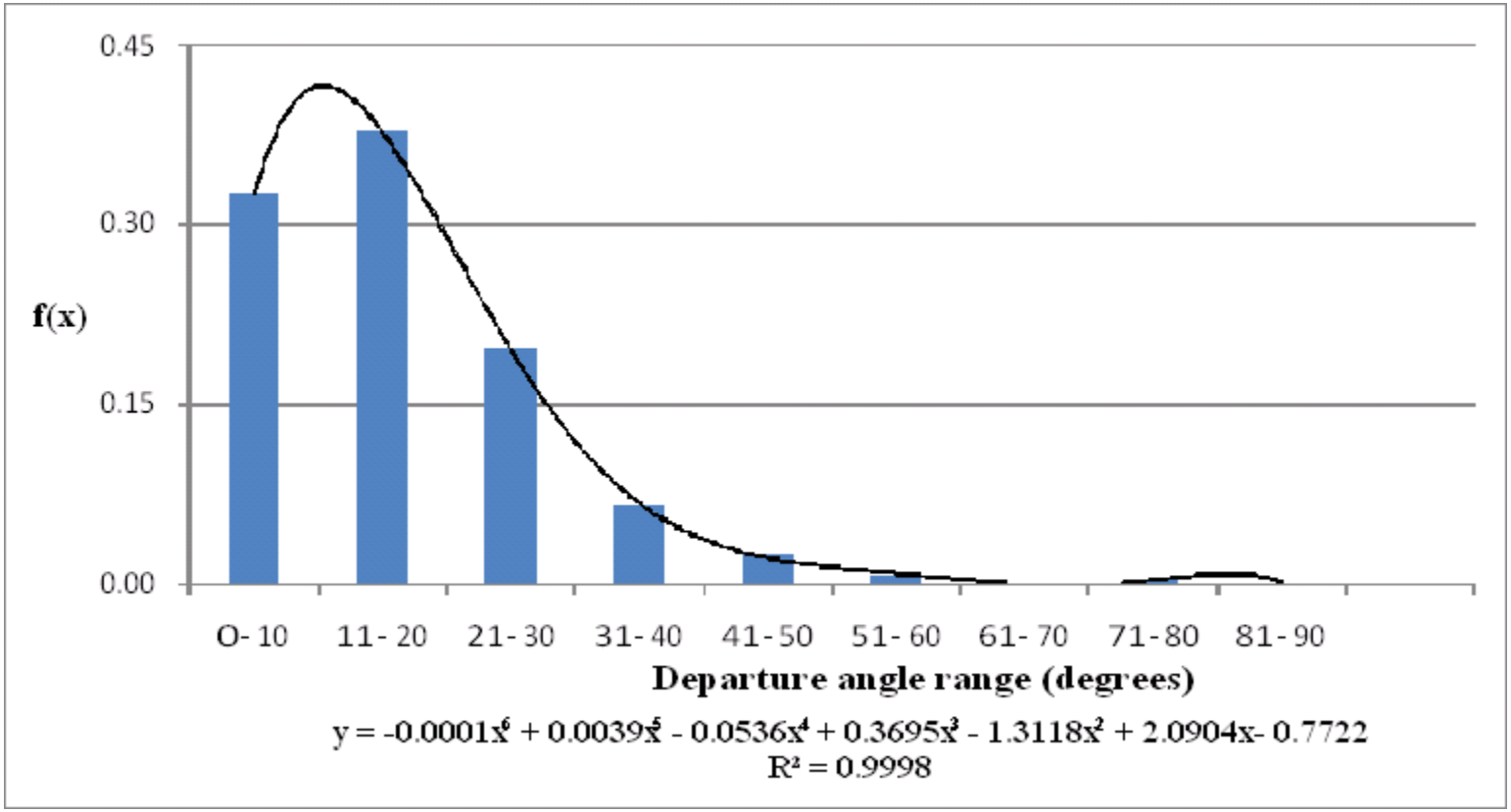


Figure E-3. Departure Angle Probability Distribution for All Data

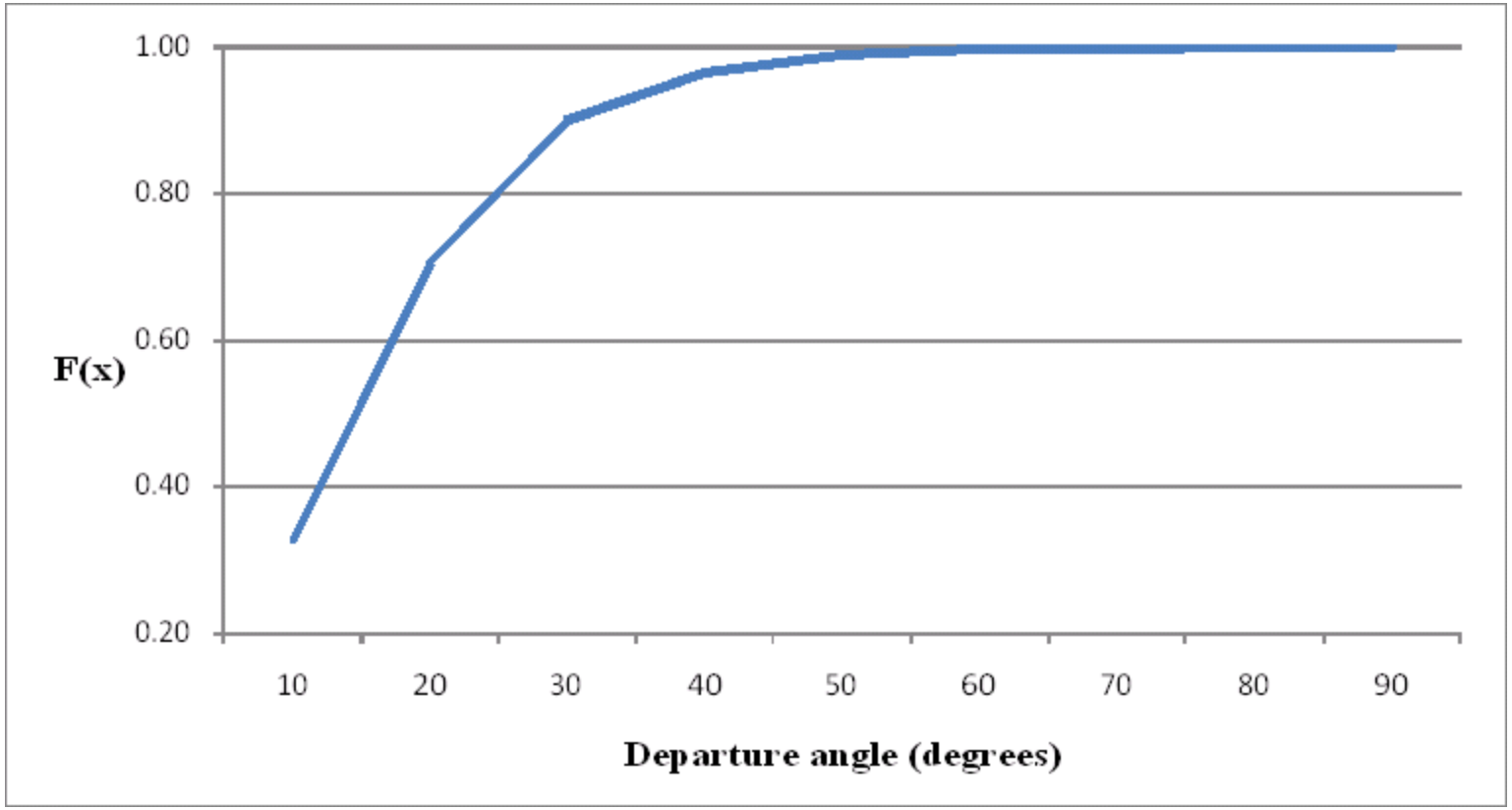


Figure E-4. Departure angle cumulative distribution for all data

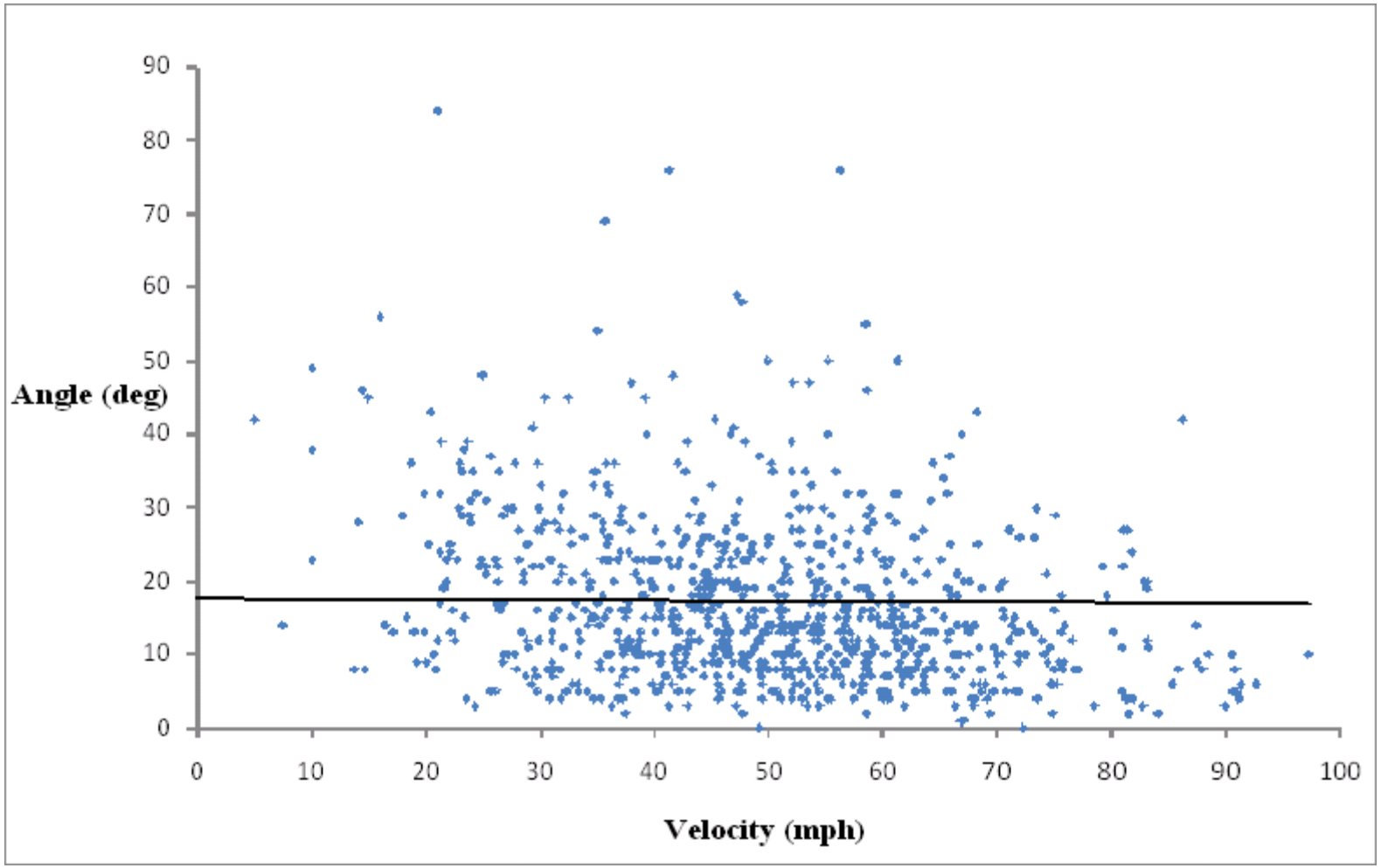


Figure E-5. Scatter plot of the departure velocity (x axis) and departure angle (y axis)

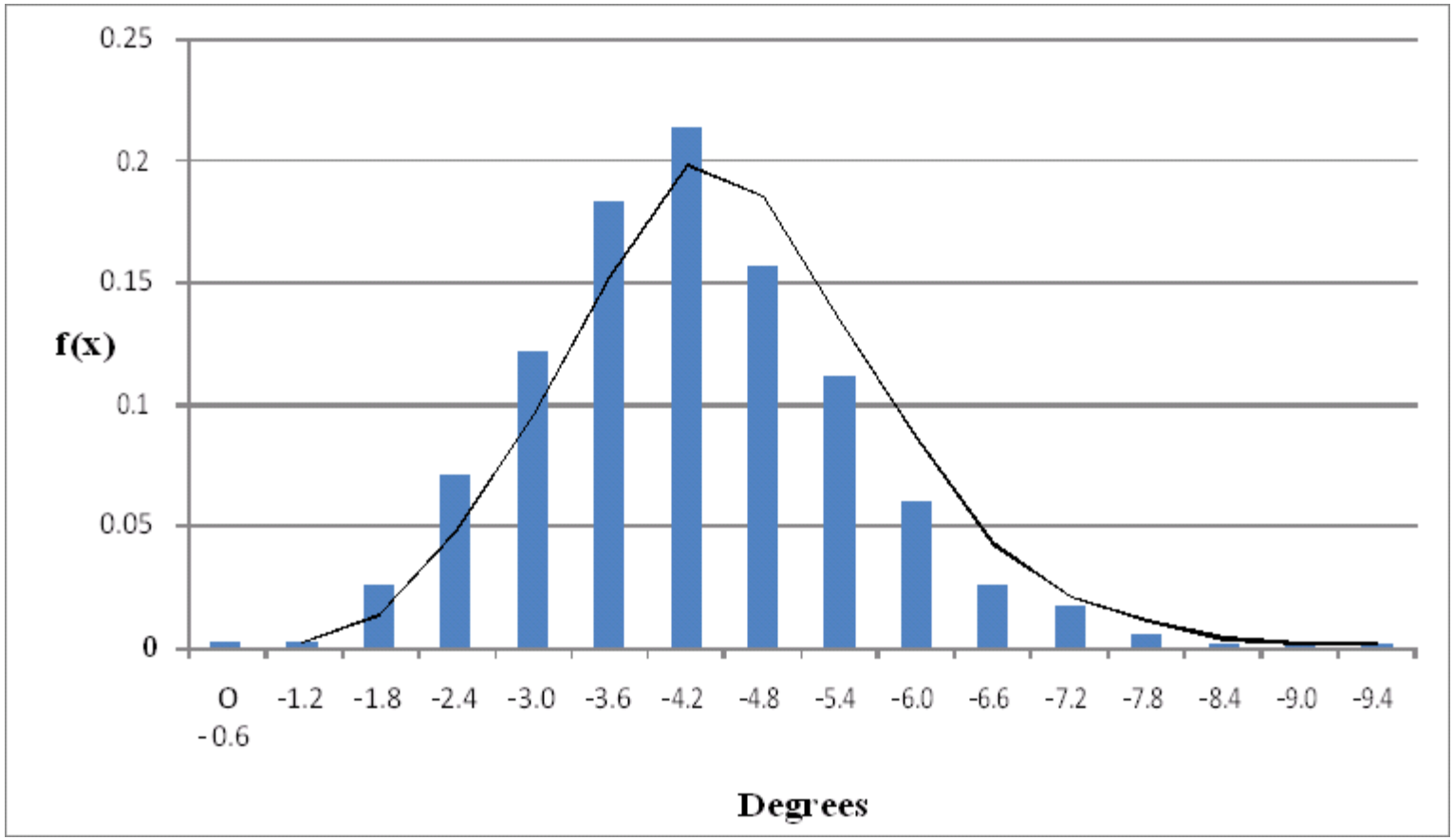


Figure E-6. Distribution of square root of angle

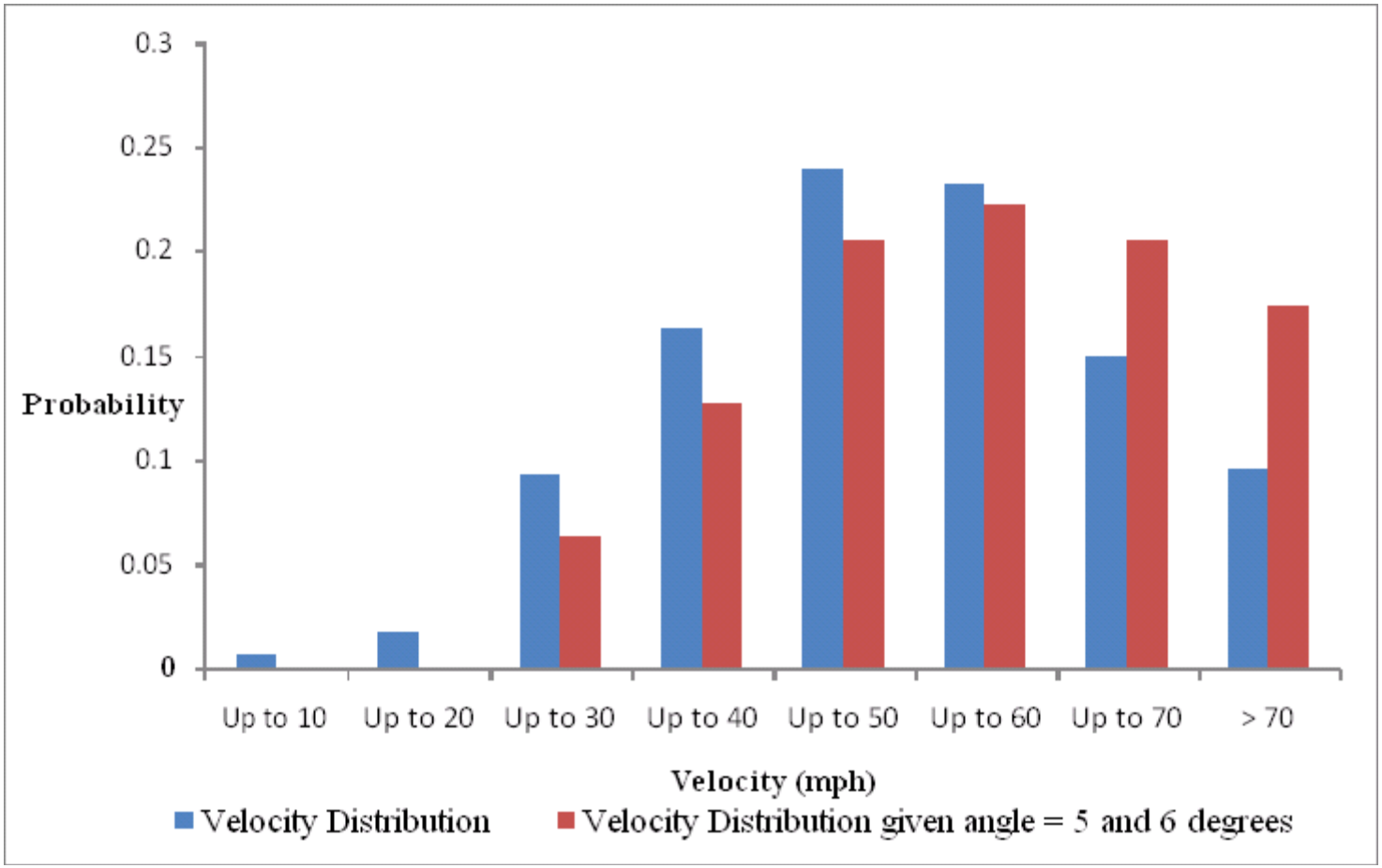


Figure E-7. Conditional probability from Bivariate Normal Distribution (5-6 degrees)

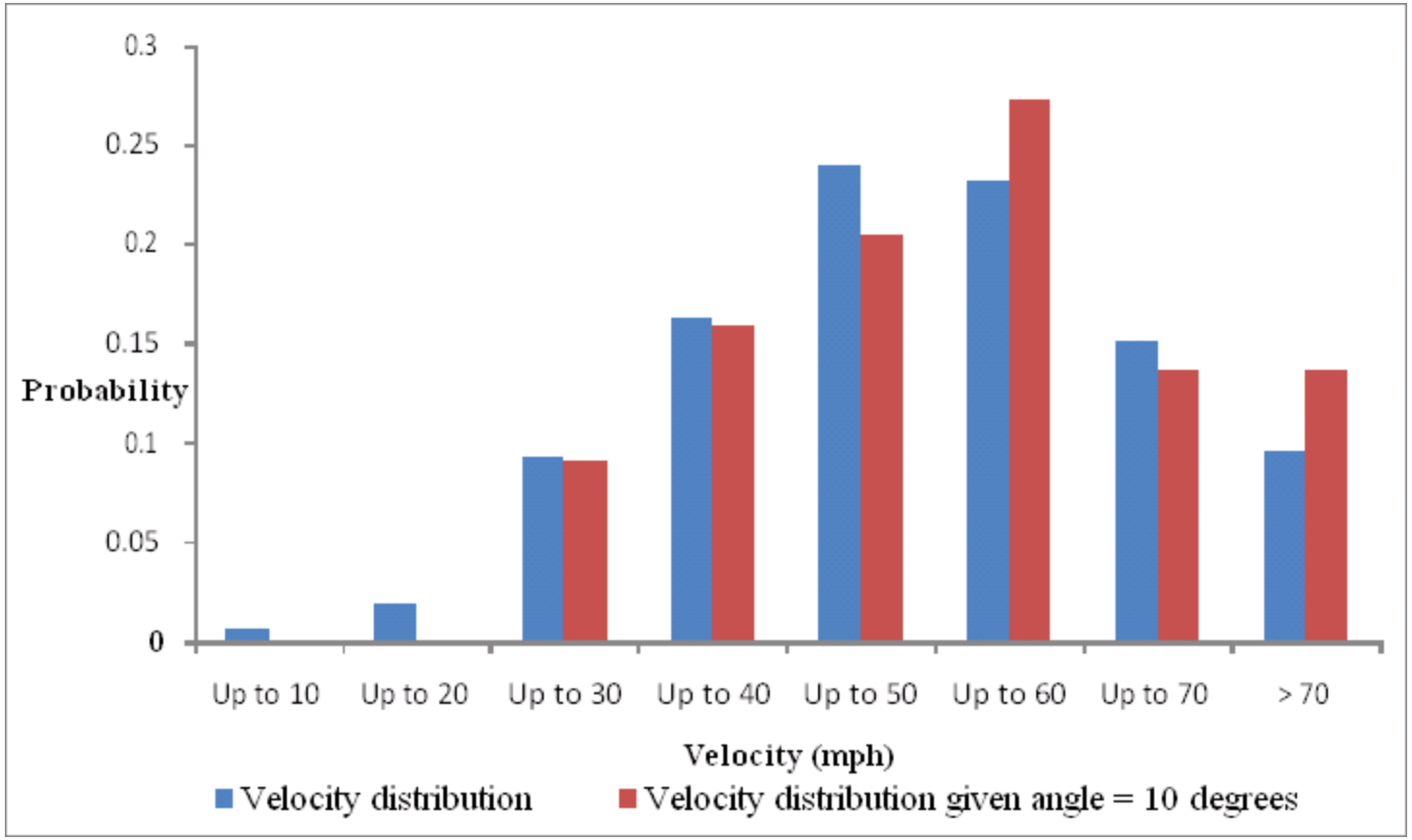


Figure E-8. Conditional probability from Bivariate Normal Distribution (10 degrees)

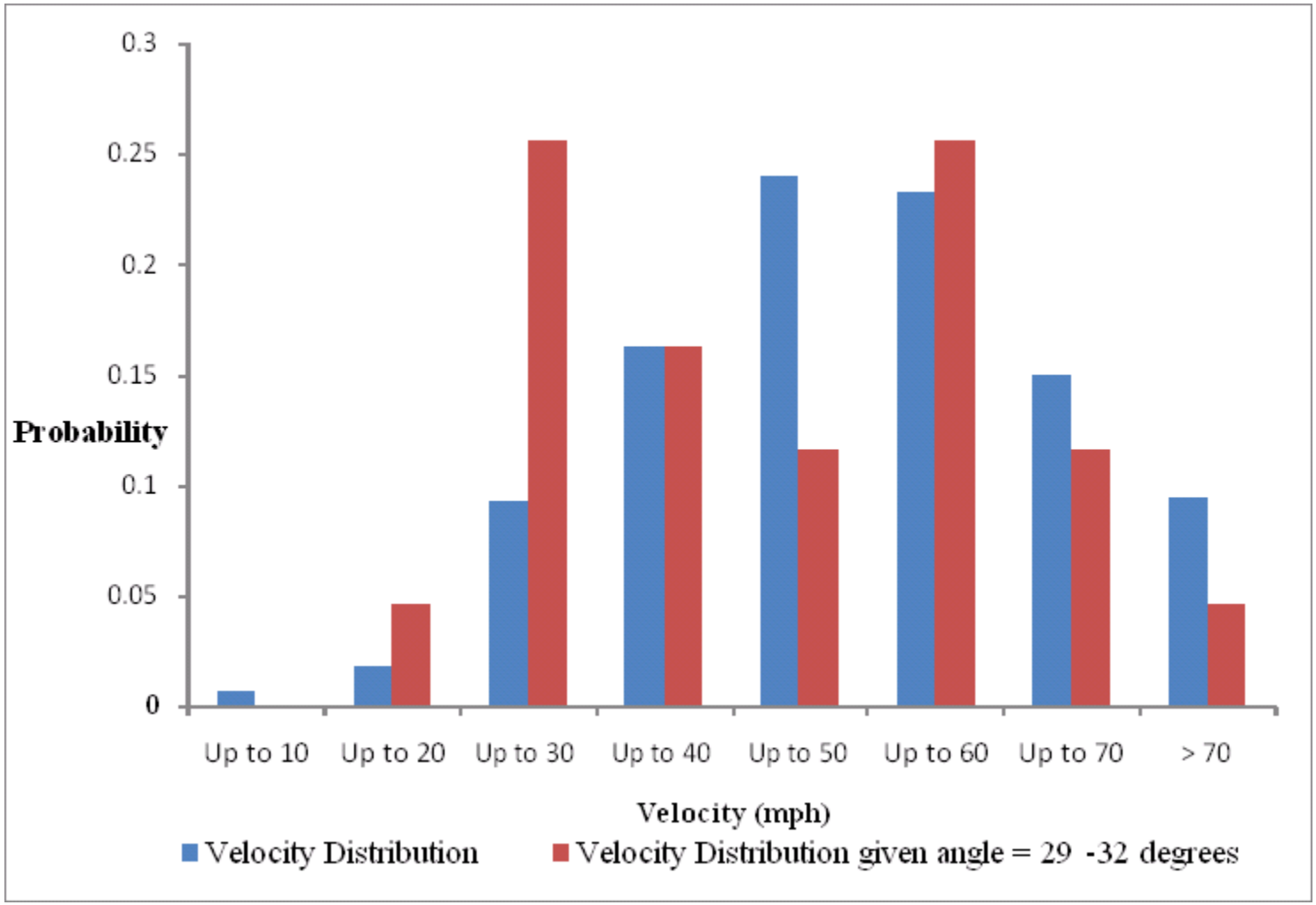


Figure E-9. Conditional probability from Bivariate Normal Distribution (29-32 degrees)

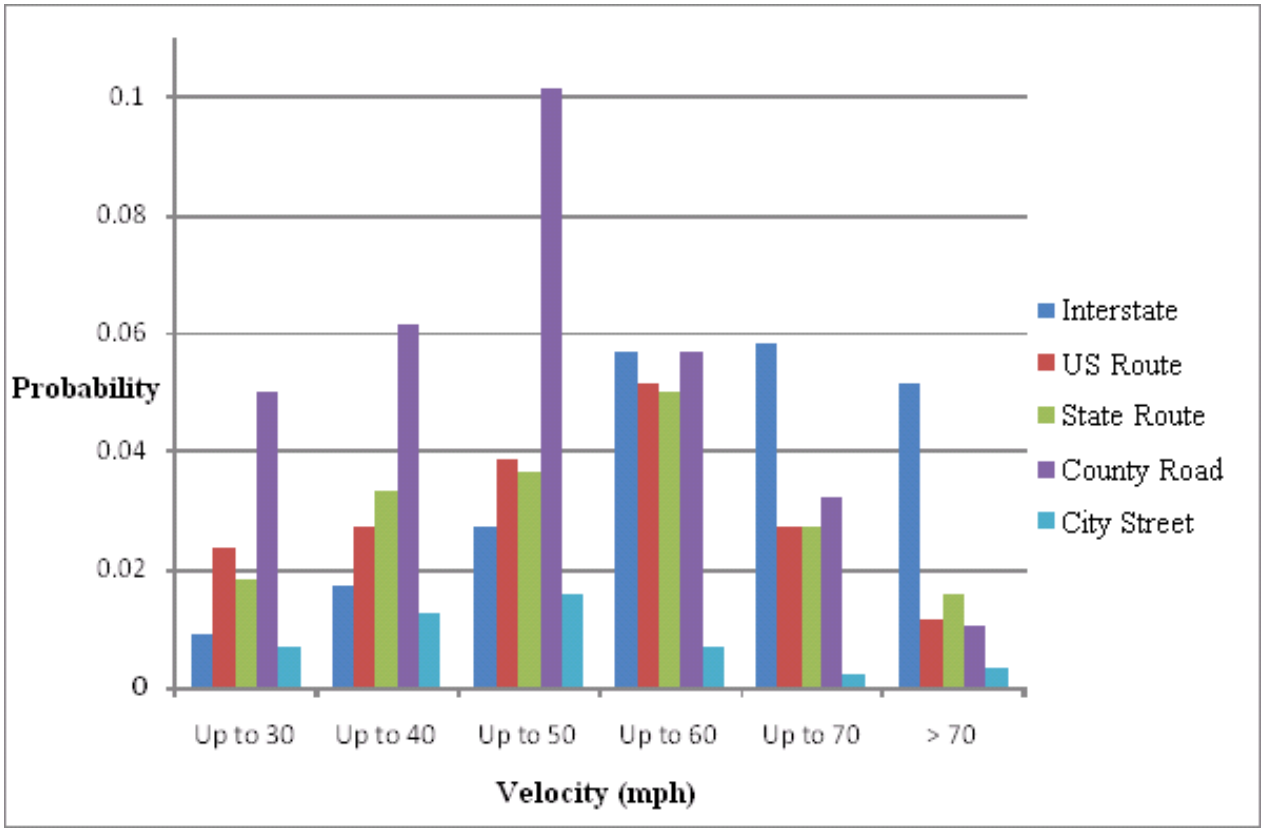


Figure E-10. Graphical Representation of Data from Table E-1

Observed Percentages								
Velocity/ Highway Class	Interstate	US Route	State Route	County Road	City Street	Other	Unknown	Total
< 30	0.00912	0.02395	0.01824	0.05017	0.00684	0.00342	0.00570	0.11745
30.1-40.0	0.01710	0.02737	0.03307	0.06157	0.01254	0.00114	0.00684	0.15964
40.1-50.0	0.02737	0.03877	0.03649	0.10148	0.01596	0.00228	0.01596	0.23831
50.1-60.0	0.05701	0.05131	0.05017	0.05701	0.00684	0.00342	0.00684	0.23261
60.1-70.0	0.05815	0.02737	0.02737	0.03193	0.00228	0.00000	0.00228	0.14937
> 70	0.05131	0.01140	0.01596	0.01026	0.00342	0.00000	0.00228	0.09464
Unknown	0.00114	0.00228	0.00228	0.00114	0.00114	0.00000	0.00000	0.00798
Total	0.22121	0.18244	0.18358	0.31357	0.04903	0.01026	0.03991	1.00000

Table E-1. Velocity probabilities by Highway Class

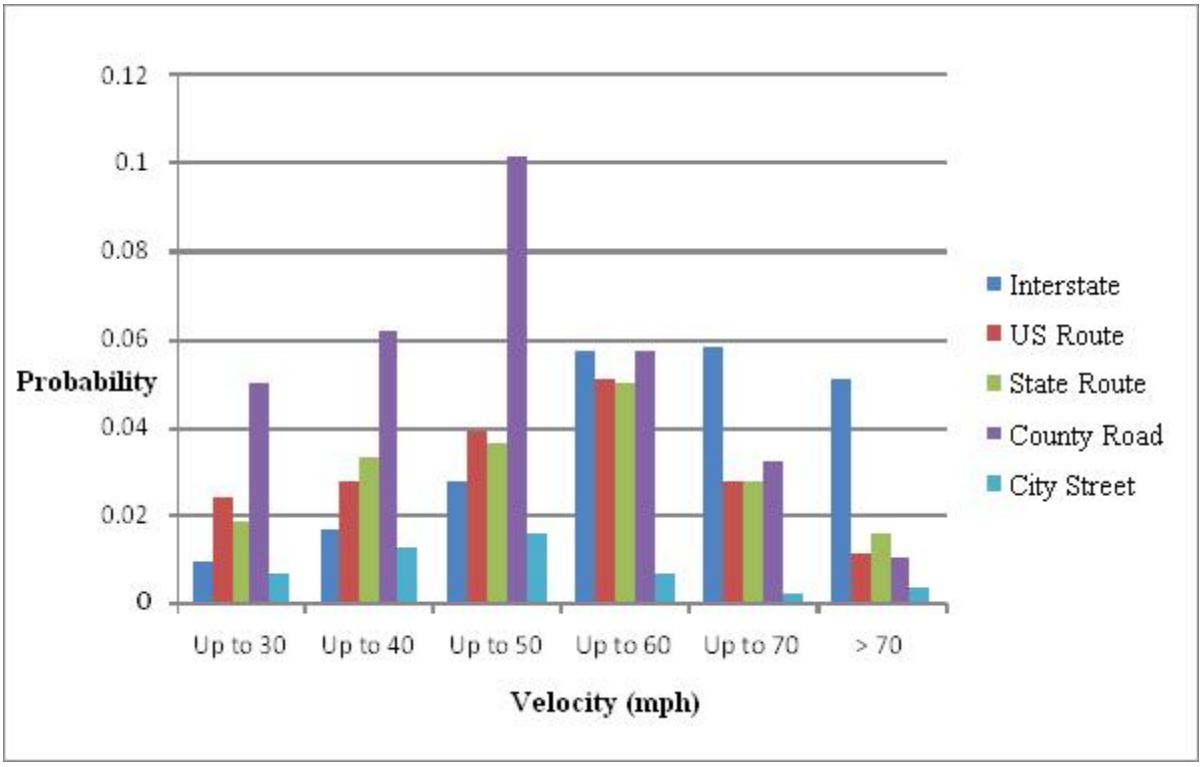


Figure E-11. Graphical Representation of Data from Table E-2

Observed Percentages								
Angle/ Highway Class	Interstate	US Route	State Route	County Road	City Street	Other	Unknown	Total
0-5	0.02737	0.01824	0.01482	0.03079	0.00456	0.00228	0.00228	0.10034
6-10	0.04219	0.04903	0.04789	0.07070	0.00798	0.00114	0.00684	0.22577
11-15	0.04789	0.03079	0.02965	0.09008	0.01482	0.00114	0.00342	0.21779
16-20	0.04105	0.02509	0.03421	0.04447	0.01026	0.00000	0.00456	0.15964
21-25	0.02166	0.01824	0.02166	0.03079	0.00798	0.00228	0.00798	0.11060
> 25	0.04105	0.04105	0.03535	0.04675	0.00342	0.00228	0.01596	0.18586
Total	0.22121	0.18244	0.18358	0.31357	0.04903	0.00912	0.04105	1.00000

Table E-2. Angle probabilities by Highway Class

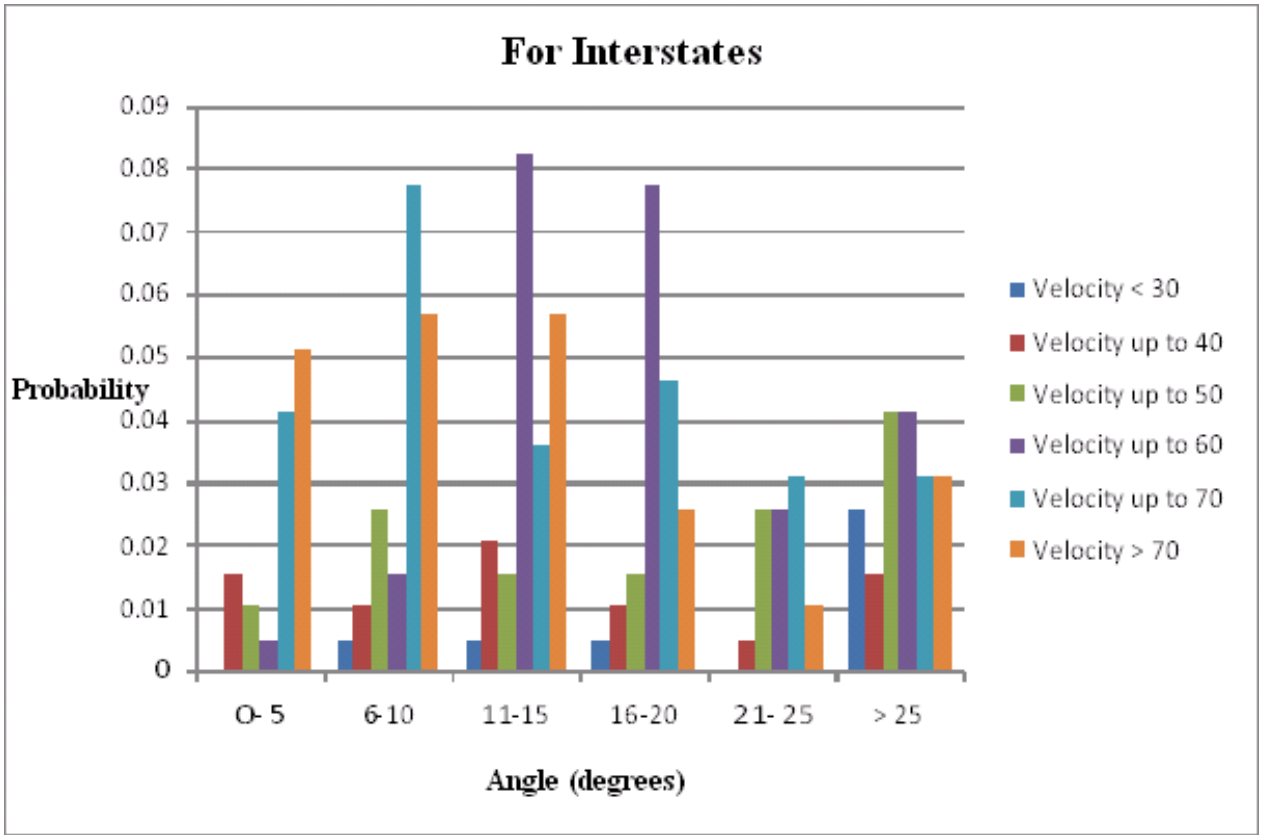


Figure E-12. Graphical Representation of Data in Table E-3

Observed Percentages for Interstate							
Velocity/Angle	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	> 25	Total
< 30	0.00000	0.00515	0.00515	0.00515	0.00000	0.02577	0.04124
30 - 40	0.01546	0.01031	0.02062	0.01031	0.00515	0.01546	0.07732
40 - 50	0.01031	0.02577	0.01546	0.01546	0.02577	0.04124	0.13402
50 - 60	0.00515	0.01546	0.08247	0.07732	0.02577	0.04124	0.24742
60 - 70	0.04124	0.07732	0.03608	0.04639	0.03093	0.03093	0.26289
> 70	0.05155	0.05670	0.05670	0.02577	0.01031	0.03093	0.23196
Unknown	0.00000	0.00000	0.00000	0.00515	0.00000	0.00000	0.00515
Total	0.12371	0.19072	0.21649	0.18557	0.09794	0.18557	1.00000

Table E-3. Joint probabilities for Interstates

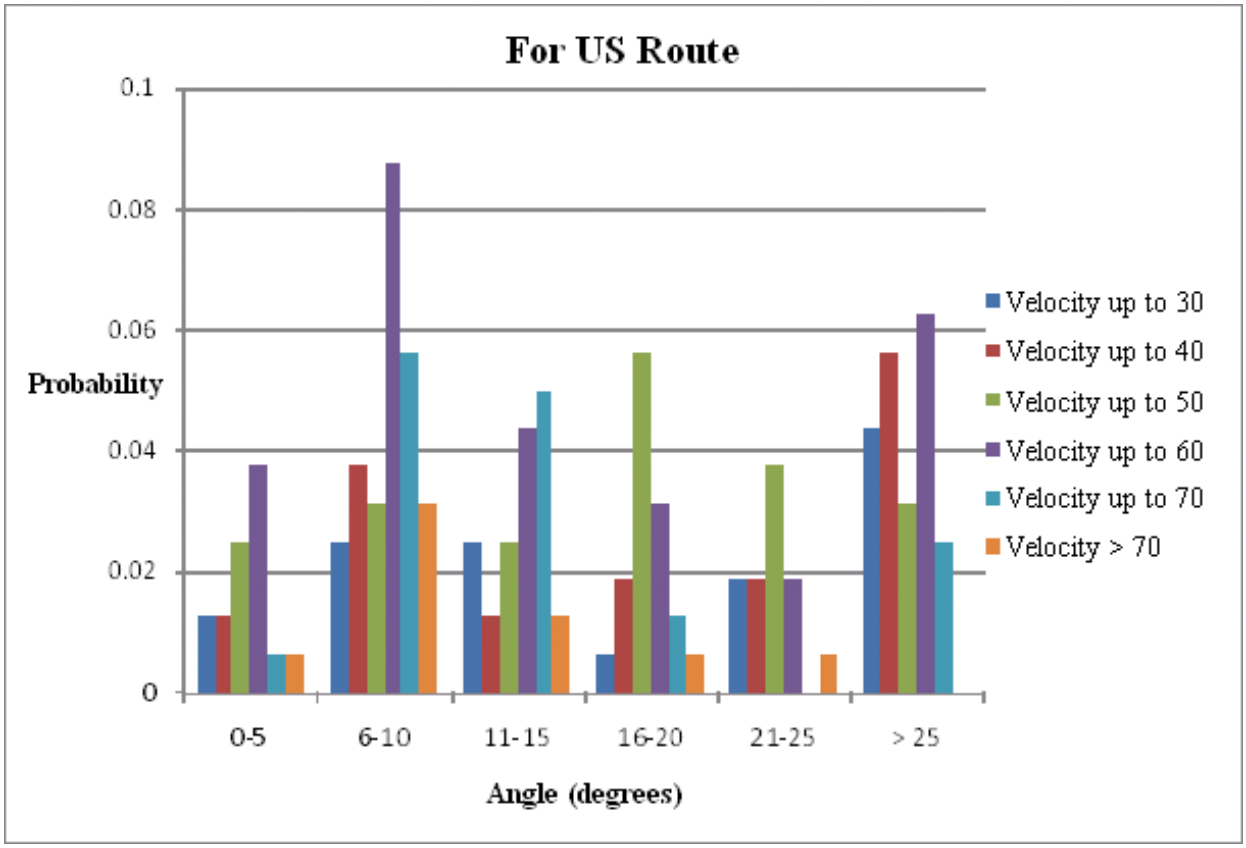


Figure E-13. Graphical Representation of Data in Table E-4

Observed Percentages for US Route							
Velocity /Angle	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	> 25	Total
< 30	0.01250	0.02500	0.02500	0.00625	0.01875	0.04375	0.13125
30 - 40	0.01250	0.03750	0.01250	0.01875	0.01875	0.05625	0.15625
40 - 50	0.02500	0.03125	0.02500	0.05625	0.03750	0.03125	0.20625
50 - 60	0.03750	0.08750	0.04375	0.03125	0.01875	0.06250	0.28125
60 - 70	0.00625	0.05625	0.05000	0.01250	0.00000	0.02500	0.15000
> 70	0.00625	0.03125	0.01250	0.00625	0.00625	0.00000	0.06250
Unknown	0.00000	0.00000	0.00000	0.00625	0.00000	0.00625	0.01250
Total	0.10000	0.26875	0.16875	0.13750	0.10000	0.22500	1.00000

Table E-4. Joint probabilities for US Route Highways

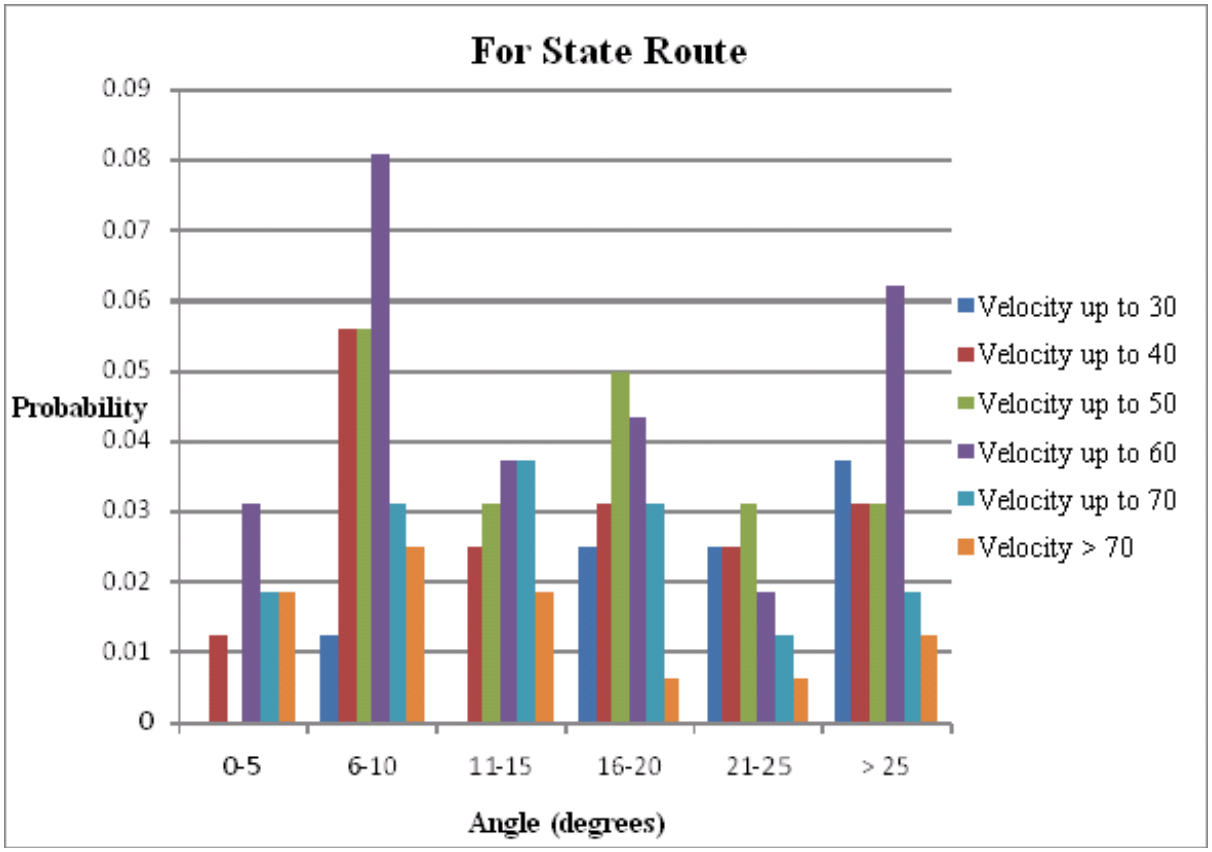


Figure E-14. Graphical Representation of Data in Table E-5

Observed Percentages for State Route							
Velocity /Angle	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	> 25	Total
< 30	0.00000	0.01242	0.00000	0.02484	0.02484	0.03727	0.09938
30 - 40	0.01242	0.05590	0.02484	0.03106	0.02484	0.03106	0.18012
40 - 50	0.00000	0.05590	0.03106	0.04969	0.03106	0.03106	0.19876
50 - 60	0.03106	0.08075	0.03727	0.04348	0.01863	0.06211	0.27329
60 - 70	0.01863	0.03106	0.03727	0.03106	0.01242	0.01863	0.14907
> 70	0.01863	0.02484	0.01863	0.00621	0.00621	0.01242	0.08696
Unknown	0.00000	0.00000	0.01242	0.00000	0.00000	0.00000	0.01242
Total	0.08075	0.26087	0.16149	0.18634	0.11801	0.19255	1.00000

Table E-5. Joint probabilities for State Route Highways

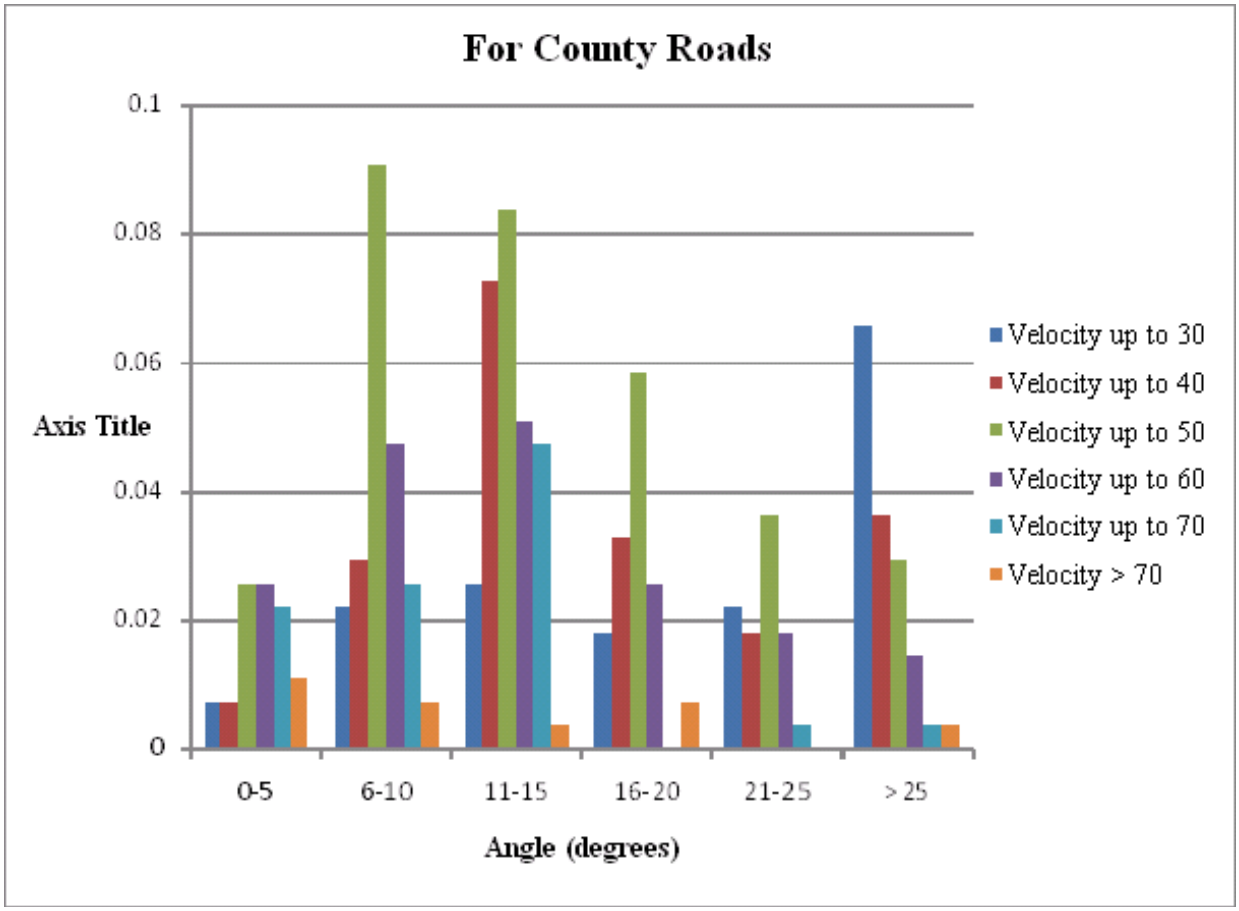


Figure E-15. Graphical Representation of Data in Table E-6

Observed Percentages for County Road							
Velocity /Angle	0 – 5	6 - 10	11 - 15	16 - 20	21 - 25	> 25	Total
< 30	0.00727	0.02182	0.02545	0.01818	0.02182	0.06545	0.16000
30 - 40	0.00727	0.02909	0.07273	0.03273	0.01818	0.03636	0.19636
40 - 50	0.02545	0.09091	0.08364	0.05818	0.03636	0.02909	0.32364
50 - 60	0.02545	0.04727	0.05091	0.02545	0.01818	0.01455	0.18182
60 - 70	0.02182	0.02545	0.04727	0.00000	0.00364	0.00364	0.10182
> 70	0.01091	0.00727	0.00364	0.00727	0.00000	0.00364	0.03273
Unknown	0.00000	0.00364	0.00000	0.00000	0.00000	0.00000	0.00364
Total	0.09818	0.22545	0.28364	0.14182	0.09818	0.15273	1.00000

Table E-6. Joint probabilities for County roads

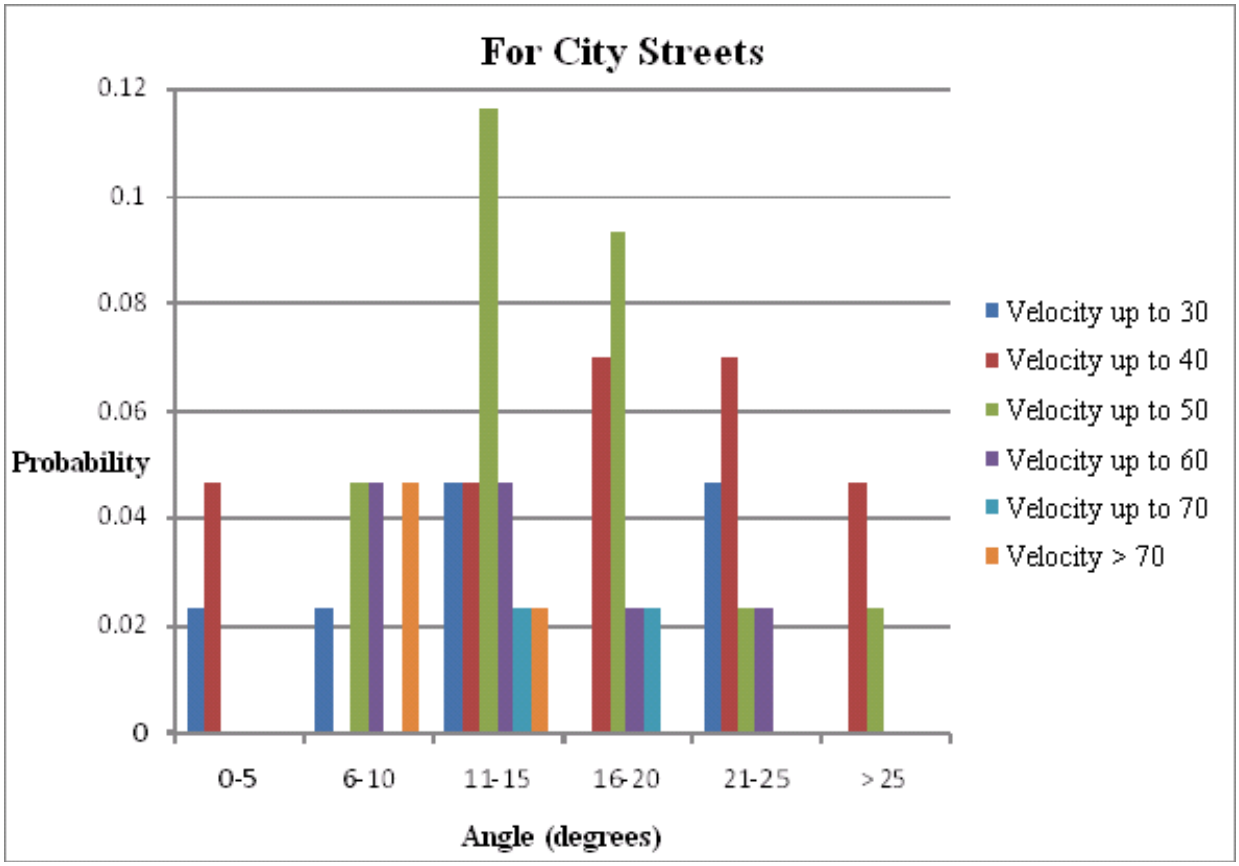


Figure E-16. Graphical Representation of Data in Table E-7

Observed Percetanges for City Street							
Velocity /Angle	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	> 25	Total
< 30	0.02326	0.02326	0.04651	0.00000	0.04651	0.00000	0.13953
30 - 40	0.04651	0.00000	0.04651	0.06977	0.06977	0.04651	0.27907
40 - 50	0.00000	0.04651	0.11628	0.09302	0.02326	0.02326	0.30233
50 - 60	0.00000	0.04651	0.04651	0.02326	0.02326	0.00000	0.13953
60 - 70	0.00000	0.00000	0.02326	0.02326	0.00000	0.00000	0.04651
> 70	0.00000	0.04651	0.02326	0.00000	0.00000	0.00000	0.06977
Unknown	0.02326	0.00000	0.00000	0.00000	0.00000	0.00000	0.02326
Total	0.09302	0.16279	0.30233	0.20930	0.16279	0.06977	1.00000

Table E-7. Joint probabilities for City streets

APPENDIX F. Proposed Data Collection Forms Continuous Sampling Subsystem

PROPOSED DATA COLLECTION FORMS - CONTINUOUS SAMPLING SUBSYSTEM

The proposed field data collection forms for the continuous sampling subsystem of the long-term field data collection effort are presented in this Appendix. The proposed data collection forms are similar to those used in the current study, as previously shown in Appendix C.

There are basically two sets of data forms: One set is for use by PSU investigators in field data collection and Zone Center personnel for quality control. The second set is for use by the independent contractor to reconstruct the crashes to estimate impact conditions and to assess the impact performance of the struck object.

The field data collection forms include the following:

- Supplemental highway data collection form
- Object struck data collection forms:
- Barrier
    - Crash Cushion
    - Embankment
    - Pole Support
    - Tree
    - Other Struck Object

In addition, photographs are to be taken to document the crash site, the struck object(s), available scene evidence such as vehicle trajectory, and the impacting vehicle.

The field data, scaled diagram, and photographs are then used by the independent contractor to reconstruct the crashes to estimate impact conditions and to assess the impact performance of the struck object. The following coding forms are provided:

- Reconstruction Coding Form:
    - First Harmful Event
    - Subsequent Harmful Event
- Performance Assessment Form (copies of the field data collection and coding forms are presented below)

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

GENERAL HIGHWAY DATA

4. Land Use ___

___(1) Urban
___(2) Rural
___(9) Unknown

5. Class Trafficway ___

___(1) Interstate
___(2) U. S. route
___(3) State route
___(4) County road
___(5) City street
___(8) Other: (Specify) _____

6. Highway Type ___

___(1) Two-lane undivided
___(2) Multi-lane undivided
___(3) Multi-lane divided
___(4) One-way roadway
___(5) Ramp
___(8) Other: (Specify) _____

7. Access Control ___

___(1) Full
___(2) Partial
___(3) Uncontrolled

8. Illumination ___

___(0) None
___(1) Luminaire lighting
___(2) High mast lighting
___(8) Other: (Specify) _____

9. Rumble Strip ___

___(0) None
___(1) Right side only
___(2) Left side only
___(3) Both sides

10. Total Number of Lanes ___ ___

___ (1-16) Code actual number of lanes
___ (17) 17 or more slopes.

11. Average Lane Width ___ . ___ m

___(3.0) 3 m or narrower
___(3.1-4.9) Code actual lane width to nearest 0.1 m
___(5.0) 5 m or wider

12. Roadway Alignment at Point of Departure ___

___(1) Straight
___(2) Curve right
___(3) Curve left

13. Radius of Curve

Measure the radius of curve using the middle ordinate method.

At point of departure: R = ___ ___ ___ ___ m

Length of chord, C = _____ m

Middle ordinate, M = _____ mm

At point of maximum curvature within 100 m upstream of point of departure:

R = ___ ___ ___ ___ m

Length of chord, C = _____ m

Middle ordinate, M = _____ mm

14. Roadway Profile at Point of Departure ___

___(0) Level (< 2%)
___(1) Upgrade
___(2) Downgrade
___(3) Crest
___(4) Sag

15. Vertical Grade

Measure the vertical grade using a digital inclinometer. See Coding Manual for field procedures.

At point of departure: +/- ___ ___ . ___ %

At point of maximum vertical grade within 100 m upstream of point of departure:

+/- ___ ___ . ___ %

ROADSIDE DATA

16. Curb Presence ___

___(0) No curb
___(1) Barrier curb
___(2) Mountable curb

17. Curb Height ___ ___ ___ mm

___(000) No curb
___(001-998) Code actual curb height to nearest mm.

18. Shoulder Type ___

___(0) No shoulder
___(1) Paved shoulder
___(2) Gravel/Dirt shoulder
___(3) Grassy shoulder

19 Shoulder Width ___ . ___ m

___(0.0) No shoulder
___(0.1-9.8) Code actual shoulder width to nearest 0.1 m

SLOPE DATA

Slope data are to be collected at the point of departure and pertains to the first 100 m from the edge of the travelway.

20. Roadside Cross Section ___

___ Choose the diagram that best describes the roadside cross section.
___(8) Other (Sketch)

21. Number of Slopes ___

___ (1-6) Code actual number of slopes
___ (7) 7 or more slopes.

Code for each of the first six slopes the following data:

22. Lateral Offset to Beginning of Slope
Code actual lateral offset from edge of travelway to beginning of slope to nearest 0.1 m.

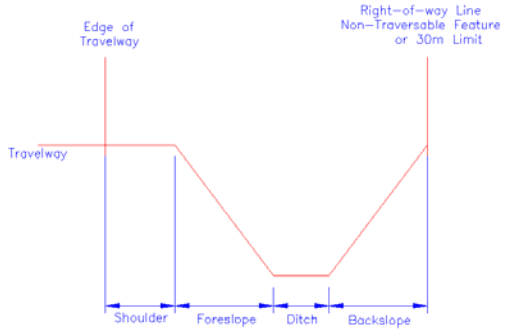
23. Rate of Slope
Measure the rate of slope using a smart level. See Coding Manual for field procedures.

24. Width of Slope
Code actual width of slope to nearest 0.1 m.

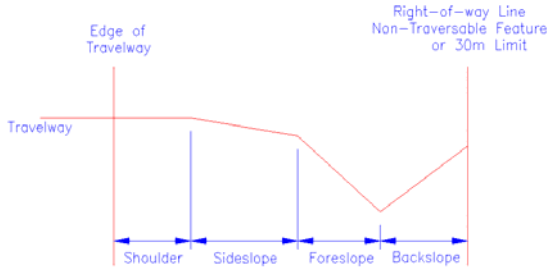
Slope	(22) Lateral Offset to Beginning of Slope	(23) Rate of Slope	(24) Width of Slope
1	0 0 . 0 m	+/- ___ ___ . ___ %	___ ___ . ___ m
2	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
3	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
4	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
5	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m
6	___ ___ . ___ m	+/- ___ ___ . ___ %	___ ___ . ___ m

25. Object at End of Last Slope ___

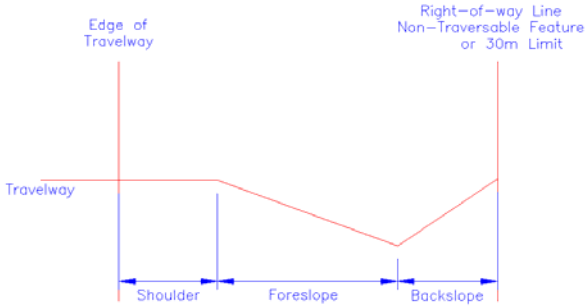
___(0) No Object (Another Slope)
___(1) Guardrail
___(2) Concrete Barrier
___(3) Rock Wall
___(4) Fence
___(5) Trees
___(6) Vertical Drop-Off
___(7) Other: (Specify) _____



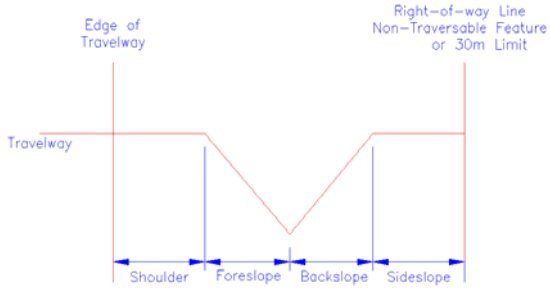
Code 1
Slope = 4



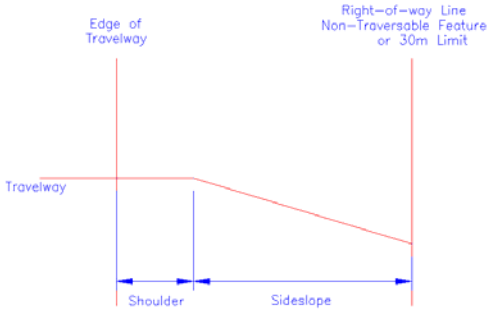
Code 2
Slope = 4



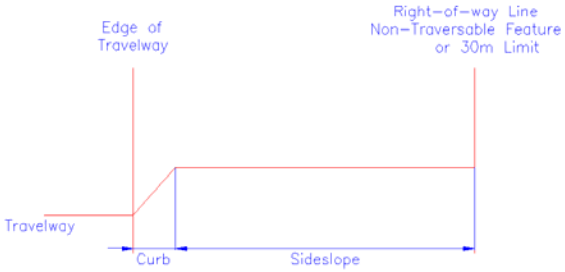
Code 3
Slope = 3



Code 4
Slope = 4



Code 5
Slope = 2



Code 6
Slope = 2

TYPICAL ROADSIDE CROSS SECTIONS

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. – Stratum ___ ___ ___ ___

4. Impact No. ___

GENERAL BARRIER DATA

5. Barrier Type ___

___(1) Cable Barrier
___(2) Box-beam Barrier
___(3) W-beam Barrier
___(4) Thrie-beam Barrier
___(5) Concrete Barrier
___(6) Bridge Rail
___(8) Other (specify) _____
___(9) Unknown

6. Barrier Location ___

___(1) Guardrail, Roadside
___(2) Guardrail, Median
___(3) Median Barrier
___(4) Bridge Structure
___(8) Other (specify) _____
___(9) Unknown

7. Construction Zone ___

___(1) Yes
___(2) No
___(9) Unknown

8. Lateral Offset ___ ___ . ___ m

Enter actual lateral offset distance from edge of travelway to face of undeformed barrier to the nearest 0.1 m.

___(0.1-19.9) Actual lateral offset distance to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

9. Length of Damage/Contact

Direct ___ ___ . ___ m

Total ___ ___ . ___ m

Enter length of direct and total damage/contact to the barrier to the nearest 0.1 m.

___(0.1-99.7) Actual length of damage/contact to nearest 0.1 m.
___(99.8) 99.8 m or more
___(99.9) Unknown

10. Damage Profile

Enter extent of deflection or damage, D(i), of barrier, measured from the face of the undeformed barrier to the face of the deformed barrier

___(0.0-9.7) Actual extent of deflection or damage to nearest 0.1 m.
___(9.9) Unknown

D1 = ___ . ___ m D2 = ___ . ___ m

D3 = ___ . ___ m D4 = ___ . ___ m

D5 = ___ . ___ m D6 = ___ . ___ m

11. Maximum Damage/Deflection ___ . ___ m

Enter maximum deflection/damage to nearest 0.1 m. Note that the location of the maximum deflection/ damage may or may not coincide with one of the damage profile points.

___(0.1-9.7) Actual maximum deflection/damage to nearest 0.1 m.
___(9.9) Unknown

SPECIFIC BARRIER DATA

A separate form is provided for each of the barrier types under Item 5. Continue and complete only the section on barrier characteristics for the applicable barrier type. Leave the other sections on barrier characteristics blank.

CABLE BARRIER CHARACTERISTICS

CB1. Barrier Height ___ ___ ___ ___ mm

Measure and enter rail height from ground to top of top cable.

___(250) 250 mm or lower
___(251-9997) Actual height to nearest mm
___(9999) Unknown

CB2. Number of Cables ___

Enter number of cables, which typically ranges from 1 to 4.

___(1-8) Actual number of cables
___(9) Unknown

CB3. Vertical Spacing ___ ___ ___ mm

Measure and enter the vertical spacing between consecutive pair of cables. If the spacing is not a constant, code the average value.

___(001-997) Actual spacing to nearest mm.
___(998) 998 mm or more
___(999) Unknown

CB4. Post Type ___

___(1) Wood, round
___(2) Wood, rectangle
___(3) Steel, round
___(4) Steel, I-beam
___(5) Concrete
___(8) Other (specify) _____
___(9) Unknown

CB5. Post Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter post dimensions. For round posts, enter the diameter and code depth as 999 for not applicable.

___(001-997) Actual dimension to nearest mm.
___(998) 998 mm or more
___(999) Unknown or not applicable

CB6. Post Spacing ___ . ___ m

Measure and enter the spacing or distance between posts.

___(0.1-9.7) Actual post spacing to nearest 0.1 m.
___(9.8) 9.8 m or more
___(9.9) Unknown

CB7. Impact Location ___

___(1) Beyond 10 m from either end
___(2) Within 10 m of downstream end
___(3) Within 10 m of upstream end
___(9) Unknown

CB8. Point of Initial Contact ___ . ___ m

If the impact location is within 10 m of the downstream or upstream end of the barrier, measure the distance from the center of the end post to the point of initial contact.

___(0.0-9.8) Actual distance to nearest 0.1 m.
___(9.9) Unknown

BOX-BEAM BARRIER CHARACTERISTICS

BB1 Barrier Height ___ ___ ___ mm

Measure and enter rail height from ground to top of box beam.

___(250) 250 mm or lower
___(251-9997) Actual height to nearest mm.
___(9998) 9998 mm or more
___(9999) Unknown

BB2. Rail Type ___

___(1) 6" x 6" Steel Tube
___(2) 6" x 8" Steel Tube
___(8) Other _____
___(9) Unknown

BB3. Post Type ___

___(1) Steel, I-beam
___(2) Steel, Other _____
___(8) Other _____
___(9) Unknown

BB4. Post Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter post dimensions. For round posts, enter the diameter and code depth as 999 for not applicable.

___(001-997) Actual dimension to nearest mm.
___(998) 998 mm or more
___(999) Unknown or not applicable

BB5. Post Spacing ___ ___ . ___ m

Measure and enter the spacing or distance between posts.

___(0.1-9.7) Actual post spacing to nearest 0.1 m.
___(9.8) 9.8 m or more
___(9.9) Unknown

BB6. Impact Location ___

___(1) Beyond 10 m from either end
___(2) Within 10 m of downstream end
___(3) Within 10 m of upstream end
___(9) Unknown

BB7. Point of Initial Contact ___ . ___ m

If the impact location is within 10 m of the downstream or upstream end of the barrier, measure the distance from the center of the end post to the point of initial contact.

___(0.0-9.8) Actual distance to nearest 0.1 m.
___(9.9) Unknown

BB8. Rail Rupture ___

___(0) No
___(1) Yes, at splice
___(2) Yes, not at splice
___(8) Other (specify) _____
___(9) Unknown

If yes and not at splice (Code 2), measure the point of rupture from the nearest splice. ___ . ___ m

W-BEAM BARRIER CHARACTERISTICS

WB1. Barrier Height ___ ___ ___ mm

Measure and enter rail height from ground to top of W beam.

___(250) 250 mm or lower
___(251-9997) Actual height to nearest mm.
___(9998) 9998 mm or more
___(9999) Unknown

WB2. Post Type ___

___(1) Wood, round
___(2) Wood, rectangle
___(3) Steel, I-beam
___(4) Steel, other (specify) _____
___(8) Other (specify) _____
___(9) Unknown

WB3. Post Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter post dimensions. For round posts, enter diameter and code depth as 999 for not applicable.

___(001-997) Actual dimension to nearest mm.
___(998) 998 mm or more
___(999) Unknown or not applicable

WB4. Blockout Type ___

___(0) No blockout
___(1) Steel
___(2) Wood, routed
___(3) Wood, not routed
___(4) Composite, routed
___(5) Composite, not routed
___(8) Other (specify) _____
___(9) Unknown

WB5. Blockout Dimensions

Width (at connection to rail) ___ ___ ___ mm

Depth ___ ___ ___ mm

___(001-997) Actual dimension to nearest mm.
___(999) Unknown or not applicable

WB6. Post Spacing ___ ___ . ___ m

Measure and enter the spacing or distance between posts.

___(0.1-9.7) Actual post spacing to nearest 0.1 m.
___(9.8) 9.8 m or more
___(9.9) Unknown

WB7. Impact Location ___

___(1) Beyond 10 m from either end
___(2) Within 10 m of downstream end
___(3) Within 10 m of upstream end
___(9) Unknown

WB8. Point of Initial Contact ___ . ___ m

If the impact location is within 10 m of the downstream or upstream end of the barrier, measure the distance from the center of the end post to the point of initial contact.

___(0.0-9.8) Actual distance to nearest 0.1 m.
___(9.9) Unknown

WB9. Rail Rupture ___

___(0) No
___(1) Yes, at splice
___(2) Yes, not at splice
___(8) Other (specify) _____
___(9) Unknown

If yes and not at splice (Code 2), measure the point of rupture from the nearest splice. ___ . ___ m

THRIE-BEAM BARRIER CHARACTERISTICS

TB1. Barrier Height ___ ___ ___ mm

Measure and enter rail height from ground to top of thrie beam.

___(250) 250 mm or lower
___(251-9997) Actual height to nearest mm.
___(9998) 9998 mm or more
___(9999) Unknown

TB2. Post Type ___

___(1) Wood, round
___(2) Wood, rectangle
___(3) Steel, I-beam
___(4) Steel, other (specify) _____
___(8) Other (specify) _____
___(9) Unknown

TB3. Post Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter post dimensions. For round posts, enter diameter and code depth as 999 for not applicable.

___(001-997) Actual dimension to nearest mm.
___(998) 9998 mm or more
___(999) Unknown or not applicable

TB4. Blockout Type ___

___(0) No blockout
___(1) Steel
___(2) Wood, routed
___(3) Wood, not routed
___(4) Composite routed
___(5) Composite, not routed
___(8) Other (specify) _____
___(9) Unknown

TB5. Blockout Dimensions

Width (at connection to rail) ___ ___ ___ mm

Depth ___ ___ ___ mm

___(001-997) Actual dimension to nearest mm.
___(999) Unknown or not applicable

TB6. Post Spacing ___ ___ . ___ m

Measure and enter the spacing or distance between posts.

___(0.1-9.7) Actual post spacing to nearest 0.1 m.
___(9.8) 9.8 m or more
___(9.9) Unknown

TB7. Impact Location ___

___(1) Beyond 10 m from either end
___(2) Within 10 m of downstream end
___(3) Within 10 m of upstream end
___(9) Unknown

TB8. Point of Initial Contact ___ ___ . ___ m

If the impact location is within 10 m of the downstream or upstream end of the barrier, measure the distance from the center of the end post to the point of initial contact.

___(0.0-9.8) Actual distance to nearest 0.1 m.
___(9.9) Unknown

TB9. Rail Rupture ___

___(0) No
___(1) Yes, at splice
___(2) Yes, not at splice
___(8) Other (specify) _____
___(9) Unknown

If yes and not at splice (Code 2), measure the point of rupture from the nearest splice. ___ . ___ m

CONCRETE BARRIER CHARACTERISTICS

CN1. Barrier Height ___ ___ ___ mm

Measure and enter barrier height from ground to top of barrier.

___(250) 250 mm or lower
___(251-9997) Actual height to nearest mm.
___(9998) 9998 mm or more
___(9999) Unknown

CN2. Barrier Shape ___

___(1) Vertical wall
___(2) Single slope
___(3) Safety shaped
___(4) Other (specify) _____
___(9) Unknown or N/A

CN3. Barrier Width ___ ___ ___ mm

Measure and enter width at top of barrier.

___(001-997) Actual width to nearest mm.
___(998) 998 mm or more
___(999) Unknown

CN4. Barrier Section Length ___ . ___ m

Measure and enter the length of the barrier section if the barrier is constructed in sections and connected at the adjoining ends. Enter 9.8 for a continuous concrete barrier.

___(0.1-9.6) Actual section length to nearest 0.1 m.
___(9.7) 9.7 m or more
___(9.8) Continuous concrete barrier
___(9.9) Unknown

CN5. Impact Location ___

___(1) Beyond 10 m of either end
___(2) Within 10 m of downstream end
___(3) Within 10 m of upstream end
___(9) Unknown

CN6. Point of Initial Contact ___ . ___ m

If the impact location is within 10 m of the downstream or upstream end of the barrier, measure the distance from the end of the barrier to the point of initial contact.

___(0.0-9.8) Actual distance to nearest 0.1 m.
___(9.9) Unknown

CN7. Temporary Barrier ___

___(1) Yes
___(2) No
___(9) Unknown

CN8. Barrier Rupture ___

___(0) No
___(1) Yes, at barrier section connection
___(2) Yes, crushed section of concrete
___(8) Other (specify) _____
___(9) Unknown

BRIDGE RAIL CHARACTERISTICS

BR1. Bridge Rail Type ___

___(1) Steel, post-and-beam design
___(2) Concrete, post-and-beam design
___(3) Concrete, continuous design
___(8) Other (specify) _____
___(9) Unknown

BR2. Bridge Rail Height ___ ___ ___ mm

Measure and enter barrier height from ground to top of bridge rail.

___(250) 250 mm or lower
___(251-9997) Actual height to nearest mm.
___(9998) 9998 mm or more
___(9999) Unknown

BR3. Curb Presence ___

___(0) No curb
___(1) Barrier curb
___(2) Mountable curb

BR4. Curb Height ___ ___ ___ mm

___(000) No curb
___(001-998) Code actual curb height to nearest mm.

BR5. Curb Width ___ . ___ m

___(0.0) No curb
___(0.1-9.8) Code actual curb width to nearest 0.1 m.

BR6. Impact Location ___

___(1) Beyond 10 m of either end
___(2) Within 10 m of downstream end
___(3) Within 10 m of upstream end
___(9) Unknown

BR7. Point of Initial Contact ___ . ___ m

If the impact location is within 10 m of the downstream or upstream end of the barrier, measure the distance from the point of initial contact to the center of the end post for a post-and-beam design or to the end of the bridge rail for a continuous rail design.

___(0.0-9.8) Actual distance to nearest 0.1 m.
___(9.9) Unknown

Post-and-Beam Design

For bridge rails of the post-and-beam design (i.e., codes 1 and 2 for Variable BR1), please enter the following information on rail and post characteristics.

BR8. Number of Rails ___

___(1-8) Code actual number of rail elements
___(9) Unknown

BR9. Rail Dimensions:

	Depth	Height
Top Rail	___ ___ ___ mm	___ ___ ___ mm
Second Rail	___ ___ ___ mm	___ ___ ___ mm
Third Rail	___ ___ ___ mm	___ ___ ___ mm
Fourth Rail	___ ___ ___ mm	___ ___ ___ mm

Measure and enter the dimensions for each applicable rail element, starting from the top. For round posts, enter diameter as height and code depth as 999 for not applicable.

___(001-997) Actual dimension to nearest mm.
___(998) 998 mm or more
___(999) Unknown or not applicable

BR10. Vertical Spacing between Rails:

Top to Second Rail ___ ___ ___ mm

Second to Third Rail ___ ___ ___ mm

Third to Fourth Rail ___ ___ ___ mm

Measure and enter, to the nearest mm, the vertical spacing for the first three consecutive pairs of horizontal rail elements, starting from the top.

___(001-997) Actual spacing to nearest mm.
___(998) 998 mm or more
___(999) Unknown

BR11. Post Type ___

___(1) Steel, rectangle
___(2) Steel, I-beam
___(3) Concrete, rectangle
___(4) Other (specify) _____
___(9) Unknown

BR12. Post Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter post dimensions. For round posts, enter diameter and code depth as 999 for not applicable.

___(001-997) Actual dimension to nearest mm.
___(998) 998 mm or more
___(999) Unknown or not applicable

BR13. Post Spacing ___ . ___ m

Measure and enter the spacing or distance between posts.

___(0.1-9.7) Actual post spacing to nearest 0.1 m.
___(9.8) 9.8 m or more
___(9.9) Unknown

BR14. Rail Rupture ___

___(0) No
___(1) Yes
___(8) Other (specify) _____
___(9) Unknown

If yes, measure the point of rupture ___ . ___ m
from the upstream end of the bridge rail.

Concrete Bridge Rail

For concrete bridge rails of continuous construction (i.e., code 3 for Variable BR1), please complete this section on the concrete bridge rail characteristics.

BR15. Barrier Shape ___

___(1) Vertical wall
___(2) Single slope
___(3) Safety shaped
___(4) Other (specify) _____
___(9) Unknown or N/A

BR16. Barrier Width ___ ___ ___ mm

Measure and enter width at top of barrier.

___(001-997) Actual width to nearest mm.
___(998) 998 mm or more
___(999) Unknown

BR17. Barrier Rupture ___

___(0) No
___(1) Yes, crushed section of concrete
___(8) Other (specify) _____
___(9) Unknown

If yes, measure the point of rupture ___ . ___ m
from the upstream end of the bridge rail.

OTHER BARRIER CHARACTERISTICS

Please provide a description of the barrier:

_____

_____

_____

_____

_____

OB1. Barrier Height ___ ___ ___ mm

Measure and enter rail height from ground to top of barrier.

___(250) 250 mm or lower
___(251-9997) Actual height to nearest mm
___(9999) Unknown

OB2. Impact Location ___

___(1) Beyond 10 m of either end
___(2) Within 10 m of downstream end
___(3) Within 10 m of upstream end
___(9) Unknown or N/A

OB3. Point of Initial Contact ___ . ___ m

If the impact location is within 10 m of the downstream or upstream end of the barrier, measure the distance from the point of initial contact to the center of the end post for a post-and-beam design or to the end of the bridge rail for a continuous rail design.

___(0.0-9.8) Actual distance to nearest 0.1 m.
___(9.9) Unknown

B4. Barrier Rupture ___

___(0) No
___(1) Yes
___(8) Other (specify) _____
___(9) Unknown

If yes, measure the point of rupture ___ . ___ m from the end of the barrier.

PHOTOGRAPHY

As a minimum, the following photographs should be taken of the struck barrier:

- General views of barrier from at least two different angles.
- Close-up photograph(s) showing details of:
- Rail element.
- Post.
- For impacts within 10 m of the downstream or upstream end of barrier, close-up photograph(s) showing details of:
- End post.
- Anchorage.
- For concrete barrier, close-up photograph(s) showing detail of:
- Barrier shape.
- Connection between barrier sections, if applicable.

All photographs should be taken with a scale to provide a frame of reference for the dimensions.

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

4. Impact No. ___

CRASH CUSHION DATA

5. Crash Cushion Location ___

___(1) Off right side of roadway
___(2) Off left side of roadway
___(3) In gore area
___(8) Other (specify) _____
___(9) Unknown

6. Lateral Offset ___ ___ . ___ m

Enter actual lateral offset distance, measured from the edge of travelway to the center of the nose of the crash cushion to the nearest 0.1 m.

___(0.1-19.9) Actual lateral offset distance to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

7. Crash Cushion Length ___ ___ . ___ m

Measure and enter the undeformed length from the nose to the base of the crash cushion along the centerline to the nearest 0.1 m.

___(0.1-19.9) Actual length to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

8. Crash Cushion Width

Nose ___ . ___ m

Base ___ . ___ m

Measure and enter the undeformed width of the crash cushion at the nose and at the base.

___(0.1-9.7) Actual width to nearest 0.1 m
___(9.9) Unknown

9. Width of Shielded Hazard ___ ___ . ___ m

Measure and enter the width of the shielded hazard.

___(0.1-9.7) Actual width to nearest 0.1 m.
___(9.9) Unknown

10. Deformed Crash Cushion Length ___ ___ . ___ m

Measure and enter the length from the deformed nose to the base of the crash cushion along the centerline to the nearest 0.1 m.

___(0.1-19.9) Actual length to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

11. Impact Location ___

___(1) Nose of crash cushion
___(2) Side of crash cushion
___(8) Other (Specify _____)
___(9) Unknown

PHOTOGRAPHY

As a minimum, the following photographs should be taken of the struck crash cushion:

- General views of crash cushion from at least three different angles: nose, base, and side.
- General view of shielded hazard.

All photographs should be taken with a scale to provide a frame of reference for the dimensions.

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

4. Impact No. ___

GENERAL EMBANKMENT DATA

5. Embankment Location ___

___(1) Off right side of roadway
___(2) Off left side of roadway
___(3) In median
___(8) Other (specify) _____
___(9) Unknown or N/A

6. Lateral Offset ___ ___ . ___ m

Measure and enter the lateral offset distance from the toe of the struck embankment to the edge of the roadway to the nearest 0.1 m.

___(0.1-19.9) Actual lateral offset distance to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

7. Embankment Height ___ ___ . ___ m

Measure or estimate the height of struck embankment to the nearest m.

___(01-19) Actual lateral offset distance to nearest 0.1 m.
___(20) 20 m or more
___(99) Unknown

8. Rate of Slope ___ . ___

___(0.0) Vertical Face
___(0.1-9.7) Actual rate of slope
___(9.8) 9.8:1 or flatter
___(9.9) Unknown

Enter the rate of slope of the struck embankment. The rate of slope is determined as horizontal versus vertical distance (= H/V : 1)

Horizontal Distance (H) = ___ . ___ m

Vertical Distance (V) = ___ . ___ m

H/V = ___ . ___

PHOTOGRAPHY

As a minimum, two general views of the struck embankment should be taken from two different angles. Multiple photographs should be taken for each view to provide as complete coverage as possible. All photographs should be taken with a scale to provide a frame of reference for the dimensions.

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

4. Impact No. ___

GENERAL POLE SUPPORT DATA

5. Pole Type ___

___(1) Utility pole
___(2) Luminaire pole
___(3) Sign support
___(8) Other (specify) _____
___(9) Unknown

6. Pole Location ___

___(1) Off right side of roadway
___(2) Off left side of roadway
___(3) In median
___(8) Other (specify) _____
___(9) Unknown

7. Lateral Offset ___ ___ . ___ m

Enter extent of lateral offset from edge of roadway to face of pole to the nearest 0.1 m.

___(0.1-19.9) Actual lateral offset distance to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

8. Pole Height ___ ___ m

Measure or estimate the pole height and enter the pole height to the nearest m.

___(01-97) Actual pole height to nearest m.
___(99) Unknown

9. Height of Concrete Base ___ ___ ___ mm

Enter height of concrete base above ground. If there are multiple concrete bases with varying heights, code the maximum height.

___(000) No concrete base
___(001) Concrete base flush with ground
___(002-997) Actual height to nearest mm.
___(998) 998 mm or higher
___(999) Unknown

SPECIFIC POLE SUPPORT DATA

A separate section is provided for each pole type under Item 5. Continue and complete only the section on pole characteristics for the applicable pole type. Leave other sections on pole characteristics blank.

UTILITY POLE CHARACTERISTICS

UP1. Pole Material ___

___(1) Wood
___(2) Steel, single pole
___(3) Steel, tower
___(4) Concrete
___(5) Other (Specify) _____
___(9) Unknown or N/A

UP2. Pole Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter the cross-sectional dimensions of the pole at the base. Note that the cross-sectional dimensions are those of the pole support and not the concrete base. For round or polygonal poles, enter the diameter and code depth as 999 for not applicable. For steel towers, enter the outside dimensions.

___(001-997) Actual dimension to nearest mm.
___(998) 9998 mm or more
___(999) Unknown or not applicable

UP3. Pole Spacing ___ ___ ___ m

Measure and enter the spacing or distance between the poles to the nearest m.

___(001-997) Actual post spacing to nearest m.
___(999) Unknown

LUMINAIRE POLE CHARACTERISTICS

LP1. Pole Material ___

___(1) Wood
___(2) Steel, single pole
___(3) Steel, tower
___(4) Concrete
___(5) Other (Specify) _____
___(9) Unknown or not applicable

LP2. Pole Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter the cross-sectional dimensions of the pole at the base. Note that the cross-sectional dimensions are those of the luminaire support and not the concrete base. For round or polygonal poles, enter the diameter and code depth as 999 for not applicable. For steel towers, enter the outside dimensions.

___(001-997) Actual dimension to nearest mm.
___(998) 998 mm or more
___(999) Unknown or not applicable

LP3. Pole Spacing ___ ___ . ___ m

Measure and enter the spacing or distance between consecutive luminaire poles.

___(001-997) Actual post spacing to nearest m.
___(999) Unknown

SIGN SUPPORT CHARACTERISTICS

SS1. Sign Support Configuration ___

___(1) Single support
___(2) Dual supports
___(3) Three supports
___(4) Overhead
___(5) Sign bridge
___(6) Other (specify) _____
___(9) Unknown or N/A

SS2. Support Material ___

___(1) Wood
___(2) Steel
___(3) Concrete
___(4) Other (specify) _____
___(9) Unknown or N/A

SS3. Support Cross-Sectional Shape ___

___(1) Round/polygon
___(2) Square/rectangle
___(3) I-beam
___(4) U-channel
___(5) Other (specify) _____
___(9) Unknown

SS4. Support Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter the cross-sectional dimensions of the sign support at the base. Note that the cross-sectional dimensions are those of the support support and not those of the concrete base. For round or polygonal poles, enter the diameter and code depth as 999 for not applicable. For overhead or sign bridge supports, enter the outside dimensions of the sign support support.

___(001-997) Actual dimension to nearest mm.
___(998) 9998 mm or more
___(999) Unknown or not applicable

OTHER POLE SUPPORT

OP1. Description of pole support (Annotate)

_____

_____

_____

_____

_____

OP2. Pole Material ___

___(1) Wood
___(2) Steel
___(3) Concrete
___(8) Other (Specify) _____
___(9) Unknown or N/A

OP3. Pole Dimensions

Width or Diameter ___ ___ ___ mm

Depth ___ ___ ___ mm

Measure and enter the cross-sectional dimensions of the pole at the base. Note that the cross-sectional dimensions are those of the pole support and not the concrete base. For round or polygonal poles, enter the diameter and code depth as 999 for not applicable. For steel towers, enter the outside dimensions.

___(001-997) Actual dimension to nearest mm.
___(998) 9998 mm or more
___(999) Unknown or not applicable

PHOTOGRAPHY

As a minimum, the following photographs should be taken of the struck pole support:

- General views of struck pole support from at least two different angles.
- Close-up photograph(s) showing details of base of struck pole support from at least two different angles. If the pole support breaks away, close-up photographs of both the base of the separated pole structure and the stub remaining in the ground should be provided.

Multiple photographs should be taken for each view to provide as complete coverage as possible. All photographs should be taken with a scale to provide a frame of reference for the dimensions.

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

4. Impact No. ___

GENERAL TREE DATA

5. Configuration ___

___(1) Single tree
___(2) Cluster of trees
___(8) Other (specify) _____
___(9) Unknown

6. Location ___

___(1) Off right side of roadway
___(2) Off left side of roadway
___(3) In median
___(4) Other (specify) _____
___(9) Unknown

7. Lateral Offset ___ ___ . ___ m

Enter actual lateral offset distance, measured from the edge of travelway to the edge of the tree closet to the roadway, to the nearest 0.1 m.

___(0.1-19.9) Actual lateral offset distance to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

8. Diameter ___ ___ ___ mm

Measure and enter diameter of tree at the base. If there is a cluster of trees, enter the diameter of the largest tree.

___(100) 100 mm or less
___(101-997) Actual diameter to nearest mm.
___(998) 998 mm or more
___(999) Unknown

PHOTOGRAPHY

As a minimum, two general views of the struck tree should be taken from two different angles. Multiple photographs should be taken for each view to provide as complete coverage as possible. All photographs should be taken with a scale to provide a frame of reference for the dimensions

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

4. Impact No. ___

GENERAL STRUCK OBJECT DATA

Please provide a description of the struck object:

_____

_____

_____

_____

_____

5. Location ___

___(1) Off right side of roadway
___(2) Off left side of roadway
___(3) In median
___(8) Other (specify) _____
___(9) Unknown or N/A

6. Lateral Offset ___ ___ . ___ m

Enter extent of lateral offset the struck object to the edge of the roadway to the nearest 0.1 m.

___(0.1-19.9) Actual lateral offset distance to nearest 0.1 m.
___(20.0) 20 m or more
___(99.9) Unknown

7. Material ___

___(1) Wood
___(2) Steel
___(3) Concrete
___(4) Combination
___(8) Other (Specify) _____
___(9) Unknown or N/A

8. Dimensions

Length ___ ___ . ___ m

Width ___ ___ . ___ m

Height ___ ___ . ___ m

Measure and enter dimensions of the struck object.

___(0.1-99.7) Actual lateral offset distance to nearest 0.1 m.
___(99.8) 99.8 m or more
___(99.9) Unknown

PHOTOGRAPHY

As a minimum, two general views of the struck object should be taken from two different angles. Multiple photographs should be taken for each view to provide as complete coverage as possible. All photographs should be taken with a scale to provide a frame of reference for the dimensions.

RECONSTRUCTION CODING FORM - FIRST EVENT

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

ENCROACHMENT DATA

4. Departure Angle ___ ___ ___ ^{o}

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of departure.

5. Vehicle Heading Angle ___ ___ ___ ^{o}

Enter vehicle heading angle in relation to edge of travelway at point of departure.

VEHICLE TRAJECTORY DATA

6. Driver Action ___

___(1) None
___(2) Braking only
___(3) Steering only
___(4) Braking and steering
___(9) Unknown

Supporting Data: _____

_____

_____

7. Longitudinal Distance of Travel ___ ___ ___ m

Measure longitudinal distance of travel from point of departure to point of impact for first event and sketch the vehicle path in the space below:

8. No. of Trajectory Profile Points ___ ___

Enter number of points used for the trajectory profile. General guidelines:

Longitudinal Distance of Travel	No. of Trajectory Profile Points
<= 30 m	6
30 - 100 m	12
> 100 m	18

9. Lateral Offset of Trajectory Profile Points

Enter lateral offset, D(i), of each applicable trajectory project point to the nearest 0.1 meter (m).

D1 = ___ ___ . ___ m D2 = ___ ___ . ___ m

D3 = ___ ___ . ___ m D4 = ___ ___ . ___ m

D5 = ___ ___ . ___ m D6 = ___ ___ . ___ m

D7 = ___ ___ . ___ m D8 = ___ ___ . ___ m

D9 = ___ ___ . ___ m D10 = ___ ___ . ___ m

D11 = ___ ___ . ___ m D12 = ___ ___ . ___ m

D13 = ___ ___ . ___ m D14 = ___ ___ . ___ m

D15 = ___ ___ . ___ m D16 = ___ ___ . ___ m

D17 = ___ ___ . ___ m D18 = ___ ___ . ___ m

Comments:_____

_____

_____

10. Maximum Lateral Offset

Enter longitudinal distance, L(max), from point of departure to point of maximum lateral offset and extent of lateral offset , D(max).

L(max) ___ ___ ___ m

D(max) ___ ___ . ___ m

IMPACT CONDITIONS - FIRST EVENT

11. Location of Impact

Enter location of point of impact for first event in relation to point of departure for longitudinal location and to edge of travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

12. NASS CDS Data

Copy the following data items from the NASS CDS forms for first event:

Object Struck ___ ___

Collision Deformation Classification (CDC):

___ ___ ___ ___ ___ ___ ___

Point of Impact on Vehicle: _____

_____

_____

Vehicle Damage Profile:

Length of Damage (L): ___ ___ ___ ___ cm

Damage Profile (C1-C6):

C1 = ___ ___ . ___ cm C2 = ___ ___ . ___ cm

C3 = ___ ___ . ___ cm C4 = ___ ___ . ___ cm

C5 = ___ ___ . ___ cm C6 = ___ ___ . ___ cm

13. Impact Angle ___ ___ ___ °

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of impact for first event.

14. Vehicle Heading Angle at Impact ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of impact for first event.

SEPARATION CONDITIONS - FIRST EVENT

15. Location of Separation

Enter location of point of separation for first event in relation to point of departure for longitudinal location and edge of the travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

16. Separation angle ___ ___ ___ °

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of separation for first event.

17. Vehicle Heading Angle at Separation ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of separation for first event.

SUBSEQUENT EVENT/FINAL REST

18. Subsequent Event ___

___(1) Yes
___(2) No - Final Rest

If yes, code variables 19 and 20 as "Not Applicable" and proceed with coding of the subsequent event form for the second event. If no, continue with variables 19 and 20.

19. Location of Final Rest

Enter location of point of final rest.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

20. Vehicle Heading Angle at Final Rest ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of final rest.

RECONSTRUCTION CODING FORM - SUBSEQUENT EVENT

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. - Stratum ___ ___ ___ ___

4. Impact No. ___

VEHICLE TRAJECTORY DATA

5. Driver Action ___

___(1) None
___(2) Braking only
___(3) Steering only
___(4) Braking and steering
___(9) Unknown

Supporting Data: _____

_____

_____

6. Longitudinal Distance of Travel ___ ___ ___ m

Measure longitudinal distance of travel from point of separation of prior event and sketch the vehicle path in the space below:

7. No. of Trajectory Profile Points ___ ___

Enter number of points used for the trajectory profile. General guidelines:

Longitudinal Distance of Travel	No. of Trajectory Profile Points
<= 30 m	6
30 - 100 m	12
> 100 m	18

8. Lateral Offset of Trajectory Profile Points

Enter lateral offset, D(i), of each applicable trajectory project point to the nearest 0.1 meter (m).

D1 = ___ ___ . ___ m D2 = ___ ___ . ___ m

D3 = ___ ___ . ___ m D4 = ___ ___ . ___ m

D5 = ___ ___ . ___ m D6 = ___ ___ . ___ m

D7 = ___ ___ . ___ m D8 = ___ ___ . ___ m

D9 = ___ ___ . ___ m D10 = ___ ___ . ___ m

D11 = ___ ___ . ___ m D12 = ___ ___ . ___ m

D13 = ___ ___ . ___ m D14 = ___ ___ . ___ m

D15 = ___ ___ . ___ m D16 = ___ ___ . ___ m

D17 = ___ ___ . ___ m D18 = ___ ___ . ___ m

Comments: _____

_____

_____

9. Maximum Lateral Offset

Enter longitudinal distance, L(max), from point of separation of prior event to point of maximum lateral offset and extent of lateral offset , D(max).

L(max) ___ ___ ___ m

D(max) ___ ___ . ___ m

IMPACT CONDITIONS

11. Location of Impact

Enter location of impact for this event in relation to point of separation for prior event for longitudinal location and to edge of travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

12. NASS CDS Data

Copy the following data items from the NASS CDS forms for first event:

Object Struck ___ ___

Collision Deformation Classification (CDC):

___ ___ ___ ___ ___ ___ ___

Point of Impact on Vehicle: _____

_____

_____

Vehicle Damage Profile:

Length of Damage (L): ___ ___ ___ ___ cm

Damage Profile (C1-C6):

C1 = ___ ___ . ___ cm C2 = ___ ___ . ___ cm

C3 = ___ ___ . ___ cm C4 = ___ ___ . ___ cm

C5 = ___ ___ . ___ cm C6 = ___ ___ . ___ cm

13. Impact Angle ___ ___ ___ °

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of impact.

14. Vehicle Heading Angle at Impact ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of impact.

SEPARATION CONDITIONS

15. Location of Separation

Enter location of point of separation for this event in relation to point of separation of prior event for longitudinal location and edge of the travelway for lateral offset.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

16. Separation angle ___ ___ ___ °

Enter vehicle C. G. direction of travel in relation to edge of travelway at point of separation.

17. Vehicle Heading Angle at Separation ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of separation.

SUBSEQUENT EVENT/FINAL REST

18. Subsequent Event ___

___(1) Yes
___(2) No - Final Rest

If yes, code variables 19 and 20 as Not Applicable and proceed with coding of the subsequent event form for the next event. If no, continue with variables 19 and 20.

19. Location of Final Rest

Enter location of point of final rest.

Longitudinal ___ ___ ___ m

Lateral ___ ___ . ___ m

20. Vehicle Heading Angle at Final Rest ___ ___ ___ °

Enter vehicle heading angle in relation to edge of travelway at point of final rest.

Complete this Performance Assessment Form for each impact involving the following safety devices:

- Barrier,
- Crash cushion, and
- Pole structure.

Note that this form is to be completed by the project staff responsible for the assessment of the impact performance of these safety devices, and not by NASS researchers.

CASE IDENTIFICATION

1. Year ___ ___

2. PSU No. ___ ___

3. Case No. – Stratum ___ ___ ___ ___

4. Impact No. ___

5. Safety Device Struck ___

___(1) Barrier
___(2) Crash Cushion
___(3) Pole Structure

Complete the corresponding section for the safety device struck and leave the other sections blank for not applicable.

BARRIER

B1. Barrier Type ___

___(1) Cable barrier
___(2) Box-beam barrier
___(3) W-beam barrier
___(4) Thrie-beam barrier
___(5) Concrete barrier
___(6) Bridge rail
___(8) Other barrier (specify) _____
___(9) Unknown

Provide specific information on the barrier type and any pertinent barrier characteristics, e.g., standard G4(2S) W-beam guardrail with composite blocks. For proprietary products, identify manufacturer and trade name.

_____

_____

_____

B2. Pre-existing Conditions? ___

___(1) Yes
___(2) No
___(9) Unknown

Identify and describe any pre-existing conditions that could potentially affect the impact performance of the barrier or its terminal, e.g., low barrier height, saturated soil, etc.

_____

_____

_____

B3. Impact Location ___

___(1) Length-of-need
___(2) Terminal, length-of-need (LON)
___(3) Terminal, impact prior to LON
___(4) Terminal, end-on
___(4) Transition
___(8) Other (specify) _____
___(9) Unknown

B4. Impact Conditions

Impact Speed = ___ ___ ___ . ___ km/h

Impact Angle = ___ ___ °

Vehicle Orientation = ___ ___ °

Length-of-Need Impact

B5. Impact Performance (LON Impact) ___

___(1) Barrier contained and redirected impacting vehicle
___(2) Vehicle overrode barrier
___(3) Vehicle underrode barrier
___(4) Vehicle penetrated barrier
___(5) Vehicle rolled over
___(8) Other (specify) _____
___(9) Unknown

Explain any unsatisfactory barrier impact performance.

_____

_____

_____

B6. Rail Rupture ___

___(0) No
___(1) Yes, at splice
___(2) Yes, not at splice
___(8) Other (specify) _____
___(9) Unknown

Terminal/Transition

Complete the following data elements if the impact involved the terminal or transition section; otherwise, leave this section blank.

B7. Terminal Type ___ ___

Cable Barrier
___(01) Non-breakaway end anchor
___(02) Breakaway end anchor
___(08) Other (specify) _____

Box-Beam Barrier
___(11) Sloped end terminal
___(12) WYBET
___(13) BEAT
___(18) Other (specify) _____

W-Beam Barrier
___(21) Blunt end
___(22) Turndown
___(23) BCT
___(24) Energy absorbing terminal
___(25) Gating terminal
___(28) Other (specify) _____

Thrie-Beam Barrier
___(31) Blunt end
___(32) Turndown
___(33) Transition to W-beam barrier
___(38) Other (specify) _____

Concrete Barrier
___(41) Blunt end
___(42) Sloped end
___(43) Shielded by approach guardrail
___(44) Shielded by crash cushion
___(48) Other (specify) _____

Bridge Rail
___(51) Blunt end
___(52) Sloped end
___(53) Transitioned to approach guardrail
___(54) Shielded by crash cushion
___(58) Other (specify) _____
___(98) Terminal for other barrier type
___(99) Unknown

Provide specific information on the terminal type and any pertinent terminal characteristics. For proprietary products, identify manufacturer and trade name.

_____

_____

_____

_____

_____

_____

B8. Impact Performance (Terminal Impact) ___

___(1) Terminal brought vehicle to safe and controlled stop
___(2) Terminal gated as designed and vehicle came to safe and controlled stop
___(3) Vehicle was brought to abrupt stop
___(4) Element of terminal penetrated vehicle
___(5) Vehicle sustained excessive deformation/intrusion
___(6) Vehicle rolled over
___(8) Other (specify) _____
___(9) Unknown

Explain any unsatisfactory terminal impact performance.

_____

_____

_____

_____

B9. Non-Tracking Impact (End-on Terminal Impacts Only) ___

___(1) Yes
___(2) No
___(9) Unknown

CRASH CUSHION

C1. Crash Cushion Type ___

Identify the crash cushion type and specific information pertaining to the crash cushion. For proprietary products, identify manufacturer and trade name.

_____

_____

_____

_____

_____

C2. Impact Conditions

Impact Speed = ___ ___ ___ . ___ km/h

Impact Angle = ___ ___ °

Vehicle Orientation = ___ ___ °

C3. Impact Location ___

___(1) Nose of crash cushion
___(2) Side of crash cushion, < L/2
___(3) Side of crash cushion, > L/2
___(4) Reverse direction impact
___(8) Other (specify) _____
___(9) Unknown

C4. Pre-existing Conditions ___

___(1) Yes
___(2) No
___(9) Unknown

Identify any pre-existing conditions that could adversely affect the impact performance of the crash cushion.

_____

_____

_____

_____

C5. Crash Cushion Impact Performance ___

___(1) Vehicle brought to safe and controlled stop by crash cushion
___(2) Vehicle redirected by crash cushion and came to safe and controlled stop
___(3) Vehicle was brought to abrupt stop
___(4) Element of crash cushion penetrated vehicle
___(5) Vehicle sustained excessive deformation/intrusion
___(6) Vehicle rolled over
___(8) Other (specify) _____
___(9) Unknown

Explain any unsatisfactory crash cushion impact performance.

_____

_____

_____

_____

_____

_____

POLE STRUCTURE

P1. Breakaway Pole Structure? ___

___(1) Yes
___(2) No
___(9) Unknown

P2. Breakaway Device Type ___

___(1) Luminaire, frangible transformer base
___(2) Luminaire, slip base
___(3) Luminaire, other (specify) _____
___(4) Sign support, frangible base
___(5) Sign support, uni-directional horizontal slip base
___(6) Sign support, omni-directional horizontal slip base
___(7) Sign support, sloped slip base
___(8) Sign support, other (specify) _____
___(9) Unknown

Identify the breakaway device type and specific information pertaining to the device. For proprietary products, identify manufacturer and trade name.

_____

_____

_____

_____

P3. Impact Conditions

Impact Speed = ___ ___ ___ . ___ km/h

Impact Angle = ___ ___ °

Vehicle Orientation = ___ ___ °

P4. Pre-existing Conditions ___

Identify any pre-existing conditions that could adversely affect the impact performance of the breakaway device, e.g., approach slope, curb presence, etc.

_____

_____

_____

_____

_____

P5. Breakaway Device Impact Performance ___

___(1) Breakaway device functioned as designed
___(2) Breakaway device did not activate
___(3) Element of pole structure penetrated vehicle
___(4) Vehicle sustained excessive deformation/ intrusion
___(5) Vehicle rolled over
___(8) Other (specify) _____
___(9) Unknown

Explain any unsatisfactory breakaway device impact performance.

_____

_____

_____

_____

_____