Highway Safety Manual Data Needs Guide

DETAILS

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HIGHWAY SAFETY MANUAL DATA NEEDS GUIDE

This digest presents a summary of the data needed to use the methodologies in Part C of the 1st edition of the *Highway Safety Manual.* The TRB Task Force on Development of the Highway Safety Manual initiated and guided the work. Douglas W. Harwood, Midwest Research Institute, conducted the project.

SUMMARY

The purpose of this guide is to help potential users of the 1st edition of the *Highway Safety Manual* (HSM) anticipate the data needs for using the HSM. The guide focuses on the data needed to use the HSM Part C methodologies for rural two-lane highways, rural multilane highways, and urban and suburban arterials. The guide provides information for HSM users to assess whether their existing data sources contain the data needed to apply the HSM safety prediction methodologies to highways of interest.

HSM OVERVIEW

The HSM represents an effort to identify and assemble the best currently available information on safety and the provision of measures of performance, prediction, and evaluation of highway safety. The information in the HSM is intended to assist highway agencies in all aspects of safety decisionmaking during policymaking, planning, programming, project development, construction, maintenance, and operational activities.

Recent advancement in the science of safety analysis, safety impact prediction, and improved understanding of the statistical nature of crashes has led to significant gains in safety knowledge. Coupled with new analytical tools, these advancements make it possible to produce usable estimates of the impact of geometric design elements, safety-related planning, and traffic operations on the frequency and severity of crashes.

The HSM provides analytical tools that facilitate the inclusion of safety considerations in roadway planning, design, operational, and maintenance decisions based on intended safety performance. While highway safety information changes on a continual basis, the HSM is intended to provide accepted knowledge, methods, and processes usable by the highway safety community at the time of publication.

The HSM will consist of four parts:

- Part A: Introduction and fundamentals;
- Part B: Roadway safety management process;
- Part C: Predictive methods—tools for safety prediction of rural two-lane highways, rural multilane highways, and urban and suburban arterials; and
- Part D: Accident modification factors.

The HSM is designed for a wide audience of users and does not override or supersede state and local design manuals or any other related guidance documents in use by transportation authorities. Information, processes, and procedures contained

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in the HSM—when used with sound judgment—will provide transportation professionals with the best-known tools to improve safety decisionmaking and knowledge.

For more information on the HSM, visit www.highwaysafetymanual.org.

HSM METHODOLOGIES

HSM Part C will contain three chapters that present safety prediction methodologies. These are as follows:

- HSM Chapter 10—Rural two-lane highways,
- HSM Chapter 11—Rural multilane highways,
- HSM Chapter 12—Urban and suburban arterials.

The data needs for applying these chapters are presented below. The discussion first addresses the general types of data needed and then presents specific data elements used in the safety prediction methodologies. All of these data elements are normally available during the project development process and should be available for application of the appropriate safety prediction methodology.

HSM Part B provides guidance on the roadway safety management process, but does not present specific methodologies. Therefore, no specific data needs for HSM Part B are presented in this guide. Application of HSM Part B will generally require both crash data and site characteristics data (e.g., roadway segment, intersection, and ramp inventories). It is recommended that agencies integrate these data using a common geographic referencing system. The data requirements for FHWA's *SafetyAnalyst* software tools (see www.safetyanalyst.org) illustrate typical data needs for HSM Part B applications. More general guidance on crash-data needs can be found in the Model Minimum Uniform Crash Criteria (MMUCC) (see www.mmucc.us) and similar guidance being developed by FHWA that will appear as the Model Minimum Inventory of Roadway Elements (MMIRE).

TYPES OF DATA NEEDED FOR HSM PART C METHODOLOGIES

Three types of data are needed to apply the HSM safety prediction methodologies. These data types are site characteristics data, traffic-volume data, and crash data. The characteristics of two types of sites are considered: roadway segments and intersections.

Site Characteristics Data

To apply the HSM safety prediction methodologies, site characteristics data are needed for two types of sites—roadway segments and intersections. Each of these site types is discussed below.

Roadway Segments

The general types of site characteristics data used for roadway segments include area type, site length, roadway cross section, added lanes, roadway horizontal and vertical alignment, driveways, roadside conditions, and lighting.

Intersections

The general types of site characteristics used for intersections include intersection configuration, type of traffic control, presence of enforcement devices, turn lanes, intersection angle, sight distance, enforcement devices, terrain, and lighting.

Traffic Volume Data

The traffic volume-data needed are annual average daily traffic volumes for the road in question for analysis of roadway segments or average daily traffic volumes of intersecting roads in the case of intersections.

Crash Data

The HSM prediction methodology can be applied without crash history data for the site being investigated. However, the use of crash-history data, when available, allows the crash counts predicted by the HSM methodology and the observed crash counts from the site being investigated to be combined. Combining the predicted and observed crash counts using a weighting procedure based on the Empirical Bayes (EB) method provides a more reliable estimate of the expected crash count at the site than could be made with either the predicted or observed crash counts by themselves. Crash data are also used in calibrating the HSM methodologies.

ASPECTS OF HSM PART C FOR WHICH DATA ARE NEEDED

There are four aspects of the HSM safety prediction methodologies, for which data are needed:

- Dividing roadway sections or projects into homogeneous roadway segments and intersections,

- Calibrating models,
- Applying the methodology to specific roadway segments and intersections, and
- Performing EB weighting with observed crash data.

Dividing Roadway Sections or Projects into Homogeneous Roadway Segments and Intersections

The first application of data in each of the HSM safety prediction methodologies is to divide a roadway or project into homogeneous roadway segments and intersections for analysis. Each intersection within a site or project is treated as a separate unit in the analysis. Intersections also form boundaries at which the roadway is divided into segments for analysis purposes. Each HSM chapter has procedures for dividing the roadway into relatively homogeneous segments using some, but not necessarily all, of the data elements that are used in predicting safety.

Calibrating Models

The base models for the HSM safety prediction methodologies were developed with data from specific highway agencies. To apply these models to geographical areas other than those used in developing the models, and even to other years of data for the same geographic areas, calibration of the base models is needed.

The general approach to calibration of an HSM methodology for a particular type of roadway segment or intersection is to

- Identify a set of sites of that type and obtain site characteristics, traffic volume, and crash data for those sites;
- Apply the HSM methodology to predict crash counts for those sites; and
- Compute a calibration factor as the ratio of the observed crash count divided by the predicted crash count.

Normally, the calibration process is repeated for each year for which crash and traffic-volume data are available. The details of the calibration procedure are currently under development and will be presented in the HSM.

The data needed for the calibration process potentially include all of the data needed to apply the safety prediction methodology for a selected set of roadway segments or intersections plus observed crash counts for a selected time period for those same sites. To further refine the calibration process, the default crash type and severity distributions, or other specific factors, may be replaced with equivalent values derived using crash data from local geographic areas.

Applying the Methodology to Specific Roadway Segments and Intersections

The key portion of each HSM safety prediction methodology is the application of the methodology to specific roadway segments and intersections. The safety prediction methodologies are presented in detail in the HSM chapters. The specific data elements discussed below are needed to apply the methodology to specific roadway segments or intersections. The predicted crash counts for individual roadway segments and intersections are then summed across all roadway segments and intersections that make up a roadway section or project of interest.

Performing EB Weighting with Observed Crash Data

The final application presented in the HSM methodologies is an EB–weighting methodology used to derive expected crash counts by combining predicted crash counts from the application described with observed crash counts from historical crash data. The only additional user-supplied data needed for application of the EB method are observed crash counts. The EB method can be applied most effectively if the crash counts are obtained for individual roadway segments and intersections rather than for the roadway facility or project as a whole. Crash counts for individual roadway segments and intersections are generally available if the crashes are mileposted or if the crash locations are identified in some equivalent manner, such that each crash can be assigned to a specific roadway segment or intersection.

SPECIFIC SITE CHARACTERISTIC AND TRAFFIC VOLUME-DATA ELEMENTS

Table 1 identifies, for both roadway segments and intersections, the specific data elements needed to use each of the HSM safety prediction methodologies. Each of these data elements is discussed below. It will be noted in Table 1 that some data elements are used in all three HSM methodologies, while others are considered in only one or two of the methodologies.

Table 1 Site characteristic and traffic-volume variables used in HSM safety predictions

Variables	Chapter 10 Rural two-lane highways	Chapter 11 Rural multilane highways	Chapter 12 Urban and suburban arterials
Roadway Segments			
Area type (rural/suburban/urban)	X	X	X
Annual average daily traffic volume	X	X	X
Length of roadway segment	X	X	X
Number of through lanes	X	X	X
Lane width	X	X	
Shoulder width	X	X	
Shoulder type	X	X	
Presence of median (divided/undivided)		X	X
Median width		X	
Presence of concrete median barrier		X	
Presence of passing lane	X		
Presence of short four-lane section	X		
Presence of two-way left-turn lane	X		X
Driveway density	X		
Number of major commercial driveways			X
Number of minor commercial driveways			X
Number of major residential driveways			X
Number of minor residential driveways			X
Number of major industrial/institutional driveways			X
Number of minor industrial/institutional driveways			X
Number of other driveways			X
Horizontal curve length	X		
Horizontal curve radius	X		
Horizontal curve superelevation	X		
Presence of spiral transition	X		
Grade	X		
Roadside hazard rating	X		
Roadside slope		X	
Roadside fixed-object density			X
Roadside fixed-object offset			X
Percent of length with on-street parking			X
Type of on-street parking			X
Presence of lighting			X
Intersections			
Area type (rural/suburban/urban)	X	X	X
Major-road average daily traffic volume	X	X	X
Minor-road average daily traffic volume	X	X	X
Number of intersection legs	X	X	X
Type of intersection traffic control	X	X	X
Left-turn signal phasing (if signalized)			X
Presence of right turn on red (if signalized)			X
Presence of red-light cameras			X
Presence of median on major road		X	
Presence of major-road left-turn lane(s)	X	X	X
Presence of major-road right-turn lane(s)	X	X	X
Presence of minor-road left-turn lane(s)		X	
Presence of minor-road right-turn lane(s)		X	

Table 1 (Continued)

Variables	Chapter 10 Rural two-lane highways	Chapter 11 Rural multilane highways	Chapter 12 Urban and suburban arterials
Intersection skew angle	X	X	
Intersection sight distance	X	X	
Terrain (flat vs. level or rolling)		X	
Presence of lighting		X	X

Some data elements may be relevant only to one specific facility type. In other cases, the safety effect of a specific data element may be understood for one or two facility types, but not for others. As safety knowledge grows, the data elements discussed here may be included in more safety prediction methodologies in later editions of the HSM.

Roadway Segments

Discussed below are the specific site characteristic data elements used in the HSM safety prediction methodologies for roadway segments on rural two-lane highways, rural multilane highways, and urban and suburban arterials (as summarized in Table 1).

Area Type (Rural/Urban/Suburban)

The methodologies for two-lane and multilane highways presented in HSM Chapter 10 and 11, respectively, apply only to highways in rural areas. The methodology for arterials presented in HSM Chapter 12 applies only to urban and suburban areas. Therefore, to decide which HSM methodology should be applied to a particular site, the area type must be known.

Most highway agencies have data that classify locations as rural or urban because classification by area type is needed for planning. The distinction between rural and urban (or suburban) locations should not be based on municipal boundaries because there are many areas with urban development outside city limits and some areas that are clearly rural inside city limits. In most cases, the distinction between rural and urban (or suburban) areas in highway agency data is based on official limits established by FHWA for urbanized areas (greater than 50,000 population) and urban areas (5,000 to 50,000 population). Areas outside the FHWA urban limits, including undeveloped areas and towns with populations less than 5,000, are considered rural.

There is no clearly accepted distinction between urban and suburban areas. The safety prediction methodology for arterials in HSM Chapter 12 makes a distinction between urban and suburban areas in only one limited situation—an interim procedure for estimating pedestrian safety that may be replaced before the first edition of the HSM is finalized. Therefore, distinguishing between urban and suburban areas will not be critical to the methodologies in the first edition of the HSM. Where this distinction is needed, it is recommended that roadways with operating or posted speeds of 30 mph or less be classified as urban and roadways with operating or posted speeds greater than 30 mph be classified as suburban.

Traffic Volume

The traffic-volume data needed for the HSM methodologies is the average daily traffic volume (ADT) for the roadway segment, expressed in vehicles per day. The best ADT measure is the annual average daily traffic volume (AADT), which is based on multiple counts during the year or is developed from a single count with adjustments to account for seasonal variations in traffic volume. Where AADT data are not available, HSM users should use the best available ADT estimate.

Traffic volumes typically change from year to year. At most sites, traffic volumes grow from year to year, but annual decreases in traffic volume are also possible. The HSM methodologies are applied to one year at a time, so the best available estimate of the traffic volume for the year of interest should be used. For multi-year analysis periods, the HSM methodology should be applied multiple times. The traffic volumes for each year of the analysis period should be forecast from the ADT for the most recent available year and the best available estimate of the rate of traffic volume growth (or decrease).

Length of Roadway Segment

The length of the roadway segment to be evaluated (to the nearest hundredth of a mile) is needed to apply the HSM methodologies. If a roadway segment boundary is located at an intersection, the roadway segment length should be measured from the center of the intersection. Roadway segment lengths can be determined from existing data in computerized roadway inventory files, roadway or milepost logs, or as-built plans. Where no existing data are available, roadway segment lengths should be measured in the field.

Number of Through Lanes

The number of through lanes on a roadway segment addressed by the HSM methodologies is typically two, four, or six lanes. Through travel lanes include only those lanes used by through traffic. Auxiliary lanes such as turning lanes, passing lanes, or other lanes added to the roadway for only a limited distance should not be counted as through lanes.

Lane Width

The average lane width on the roadway segment, expressed to the nearest 0.5 ft, is used as an input variable to the HSM methodologies for rural two-lane and rural multilane highways. The average lane width is the total width of through traffic lanes divided by the number of through lanes.

The average lane width should normally be determined for all through traffic lanes in both directions of travel. However, in applying the safety prediction methodologies, if the average lane widths for the two directions of travel on a roadway segment differ by more than 0.5 ft, the average width in each direction should be considered separately in determining the lane width accident modification factor (AMF) and the results for the two directions of travel should then be averaged. Lane widths may be determined from computerized roadway inventory files, from as-built plans, or from field measurements.

Shoulder Width

The average shoulder width on the roadway segment, expressed to the nearest 0.5 ft, is used as an input variable to the HSM methodologies for rural two-lane and rural multilane highways. The width of a shoulder is the combined width of all shoulder surface types. The shoulder type is also considered in safety predictions with the rural two-lane and rural multilane highway methodologies (see below).

The average shoulder width for both sides of the roadway should normally be determined and used in segmenting the facility. However, in applying the safety prediction methodology, if the shoulder widths for the two sides of the roadway differ by more than 0.5 ft, the width on each side of the roadway should be applied separately in determining the shoulder width AMF and the results for both sides of the roadway should then be averaged. Shoulder widths may be determined from computerized roadway inventory files, from as-built plans, or from field measurements.

Shoulder Type

The type of shoulder is considered in the HSM methodologies for rural two-lane and rural multilane highways. Shoulder type should be classified based on the shoulder material. There are four different shoulder types considered in the methodology: paved, gravel, turf, and composite. A composite shoulder is a shoulder that is paved for part of its width and is gravel or turf for the remainder of its width. If the shoulder types for the two sides of the road differ, the shoulder type AMF should be determined separately for each side of the road and then averaged.

Where a shoulder is paved for part of its width and is gravel or turf for the remainder of its width, the shoulder should be classified as a composite shoulder. Shoulder types may be determined from computerized roadway inventory files, from as-built plans, or from field or photolog review.

Presence of Median (Divided/Undivided)

The rural two-lane highway methodology considers only undivided roadways. The rural multilane highway and urban and suburban arterial methodologies consider both divided and undivided roadways. A divided roadway is a roadway with a median of any width, other than a painted centerline or a flush divider, such as a two-way left-turn lane (TWLTL). The presence of a median may be determined from computerized roadway inventory files, from as-built plans, or from field or photolog review.

Median Width

The median width for a divided highway is used as an input variable in the HSM methodology for rural multilane highways. Median width is measured between the edges of the through travel lanes in each direction of travel at a location where the width of the median is not affected by the presence of intersections. Since median width is measured from the edges of the through travel lanes, auxiliary lanes and inside shoulders are included in the median width. Median width may be determined from computerized roadway inventory files, from as-built plans, or from field review.

Presence of Concrete Median Barrier

The presence of a concrete median barrier is used as an input variable to the HSM methodology for rural multilane highways. Barrier types other than concrete barrier are not considered by the methodology. The presence of concrete median barrier may be determined from computerized roadway inventory files, from as-built plans, or from field or photolog review.

Presence of Passing Lane

A passing lane is an added lane in one or both directions of travel intended to increase the passing opportunities on a rural two-lane highway. The presence of a passing lane is an input variable in applying the HSM methodology for rural two-lane highways. Transition zones should be considered as part of the passing lane. Passing lane locations can be determined from existing data in computerized roadway inventory files, from as-built plans, or from photolog or field review.

Short Four-Lane Locations

Short four-lane sections on a rural two-lane highway are essentially side-by-side passing lanes provided to increase passing opportunities. Short four-lane sections up to 2 miles in length on a rural two-lane highway are treated as lanes added to increase passing opportunities and not as a change in the basic number of through lanes. The presence of a short four-lane section is an input variable in applying the HSM methodology for rural two-lane highways. Transition zones should be considered as part of the short four-lane section. Locations of short four-lane sections can be determined from existing data in computerized roadway inventory files, from as-built plans, or from photolog or field review.

Two-Way Left-Turn Lanes

TWLTLs are used to create a sheltered storage area for use in left-turning vehicles from either direction of travel on a two-lane highway. The presence of a TWLTL is an input variable in applying the HSM safety prediction methodologies for rural two-lane highways and urban and suburban arterials. Locations of TWLTLs can be determined from existing data in computerized roadway inventory files, from as-built plans, or from photolog or field review.

Driveway Density

Driveways are connections along a roadway that provide access to and from roadside development and activity centers. The driveway density on the roadway segment, expressed as the number of driveways per mile for both sides of the road combined, is used as an input variable to the HSM methodology for rural two-lane highways. Driveways of all types in active use along the roadway segment should be considered. If a driveway does not appear to be in active daily use, it may be omitted from the computation of driveway density. Driveway densities data are seldom available in roadway inventory files; thus, in applying the safety prediction methodology, driveway densities should be determined from photologs, from aerial photographs, or, where practical, in the field. Estimates of driveway density may be made where no better data are available.

Number of Driveways by Driveway Type

The numbers of driveways for each of seven specific driveway types are used as input variables to the HSM methodology for urban and suburban arterials. The seven driveway types considered are as follows:

1. Major commercial driveways,
2. Minor commercial driveways,
3. Major residential driveways,
4. Minor residential driveways,
5. Major industrial/institutional driveways,
6. Minor industrial/institutional driveways, and
7. Other driveways.

Major driveways are those that serve sites with 50 or more parking spaces. Minor driveways are those that serve sites with fewer than 50 parking spaces. Commercial driveways provide access to establishments that serve retail customers. Residential driveways serve single- and multiple-family dwellings. Industrial/institutional driveways serve factories, warehouses, schools, hospitals, churches, offices, public facilities, and other places of employment. The number and type of driveways should be determined from photologs, from aerial photographs, or in the field.

Horizontal Curve Length

Horizontal curves are considered in the HSM methodology for rural two-lane highways. The length of each horizontal curve is needed to apply the HSM methodology. This length is the distance along the roadway centerline from the beginning of the curve or point of curvature (PC) to the end of the curve or point of tangency (PT), expressed to the nearest hundredth of a mile. For curves with spiral transitions, the curve length includes the length of the circular portion of the curve plus the length of the spiral transitions. If a horizontal curve is split between two roadway segments for analysis, the horizontal curve length used in the analysis of each segment should be the length of the entire horizontal curve. Horizontal curve lengths may be determined from computerized roadway inventory files, from as-built plans, or from photolog or field review.

Horizontal Curve Radius

Horizontal curve radius is used in the HSM methodology for rural two-lane highways. The horizontal curve radius, expressed in feet, is used as an input variable in HSM methodology. Horizontal curve radii can be determined from computerized roadway inventory files or from as-built plans. Horizontal curve radii can also be estimated from field measurements by measuring the middle ordinate of the curve.

Horizontal Curve Superelevation

The superelevation of horizontal curves is used as an input variable in the HSM methodology for rural two-lane highways. Superelevation is the pavement cross slope on the horizontal curve provided to counteract the tendency of vehicles to move toward the outside of the curve. As a measure of cross slope, superelevation is a ratio of two lengths and is therefore a dimensionless quantity, although many standard geometric design references assign it units of ft/ft. The HSM methodology considers the difference between the actual superelevation and the superelevation recommended by AASHTO policy. Superelevation affects safety in the HSM methodology only when this difference exceeds 0.01. Superelevation rates can be determined from existing data in computerized roadway inventory files, from as-built plans, or from field measurements.

Presence or Absence of Spiral Transitions

The presence or absence of spiral transitions for horizontal curves is used as an input variable in the HSM methodology for rural two-lane highways. Spiral transition curves are used by some highway agencies to provide a smooth transition from tangent to curved and curved to tangent alignments. The presence or absence of spiral transitions may be determined from computerized roadway inventory files or from as-built plans. The presence or absence of a spiral transition is difficult to determine reliably in the field. However, knowledge of highway agency policies can help because many agencies consistently either use or do not use spirals.

Grades and Locations of Points of Change

Roadway grades are considered in the HSM methodology for rural two-lane highways. The percent grade for the roadway between each point of change in grade is an input variable to the safety prediction methodology. The sign of the grade is irrelevant because each grade on a two-lane highway is an upgrade for one direction of travel and a downgrade for the other. The HSM methodology does not consider vertical curvature; roadway grades are considered to run from one point of vertical intersection (PVI) to the next. The roadway grade may be determined from existing data in computerized roadway inventory files, from as-built plans, or from field measurements.

Roadside Hazard Rating

The HSM methodology for rural two-lane highways represents the safety implications of roadside design by a roadside hazard rating. The roadside hazard rating takes integer values from one to seven and represents the average level of hazard in the roadside environment along the roadway segment. If the roadside hazard ratings for the two sides of the roadway differ, the rating in each direction should be applied separately in determining the roadside hazard rating AMF and the results should then be averaged. Roadside hazard ratings are seldom available in roadway segment inventory files. Definitions have been developed for the roadside hazard rating categories and should be used in conjunction with field or photolog review to assign appropriate values; the definitions for the roadside hazard rating categories can be found in Appendix D of FHWA Report No. FHWA-RD-99-207 (www.tfhrc.gov/safety/pubs/99207/appd.htm or see Appendix D at www.tfhrc.gov/safety/pubs/99207.pdf).

Roadside Slope

The HSM methodology for rural multilane highways uses the roadside slope as an input variable. Roadside slope is represented by the slope ratio for the foreslope immediately outside the roadway shoulder (i.e., 1V:2H or flatter through 1V:7H or steeper).

Roadside Fixed-Object Density and Offset

The HSM methodology for urban and suburban arterials uses roadside fixed-object density and offset as input variables. Roadside fixed objects are defined as objects at least 4 in. in diameter and not of breakaway design that are located on the roadside within 30 ft of the traveled way. Multiple roadside objects located within 70 ft of one another should be counted as a single object; roadside objects located behind other objects should not be counted. The roadside fixed-object density is determined as the number of roadside fixed objects on both sides of the roadway within the roadway segment divided by the length of the segment. The roadside fixed offset is the typical or average distance from the edge of the traveled way to fixed objects within the roadway segment. Most highway agencies do not have inventories of roadside fixed objects, although one state highway agency is currently developing such an inventory. Roadside fixed-object density will need to be developed from photolog or field review.

On-Street Parking

The HSM methodology for urban and suburban arterials uses the extent and type of on-street parking as an input variable. The extent of on-street parking is the proportion of total curb length for which on-street parking is permitted and occurs regularly. The maximum extent of parking within a roadway segment is twice the segment length since parking may potentially be permitted on both sides of the roadway. Thus, for a roadway segment with on-street parking permitted on both sides of the roadway throughout the segment, the proportion with on-street parking is 1.0; for a roadway segment with on-street parking on one side of the street throughout the segment, the proportion with on-street parking is 0.5. The type of parking is classified as either parallel or angle. The extent and type of on-street parking may be determined from computerized roadway inventory files, from as-built plans, or from photolog or field review.

Lighting

The HSM methodology for urban and suburban arterials considers the presence of lighting along the roadway segment as an input variable. Unless the roadway segment is very short, lighting should be considered as present only if lighting is provided continuously along the roadway segment, not just at intersections. The presence of lighting may be determined from computerized roadway inventory files, from as-built plans, from highway agency lighting records, or from photolog or field review.

Intersections

The specific site characteristic data elements used in the HSM safety prediction methodologies for intersections on rural two-lane highways, rural multilane highways, and urban and suburban arterials, as summarized in Table 1, are discussed below.

Area Type (Rural/Urban/Suburban)

The methodologies for intersections on two-lane and multilane highways presented in HSM Chapters 10 and 11, respectively, apply only to intersections in rural areas. The methodology for arterials presented in HSM Chapter 12 applies only to intersections in urban and suburban areas. Therefore, to decide which HSM methodology should be applied to a particular intersection, the area type must be known.

Most highway agencies have data that classify locations as rural or urban because classification by area type is needed for planning. The distinction between rural and urban (or suburban) locations should not be based on municipal boundaries because there are many areas with urban development outside city limits and some areas that are clearly rural inside city limits. In most cases, the distinction between rural and urban (or suburban) areas in highway agency data is based on official limits established by FHWA for urbanized areas (greater than 50,000 population) and urban areas (5,000 to 50,000 population). Areas outside the FHWA urban limits, including undeveloped areas and towns with populations less than 5,000 are considered rural. No distinction between urban and suburban locations is needed for the HSM intersection methodologies.

Traffic Volume

The traffic-volume data needed for the HSM intersection methodologies are the ADT for the major- and minor-road legs of the intersection, expressed in vehicles per day. The best ADT measure is the AADT, which is based on multiple counts during the year or is developed from a single count with adjustments to account for seasonal variations in traffic volume. Where AADT data are not available, HSM users should use the best available ADT estimate. For an intersection with two major-road legs with differing ADTs, the larger of the ADTs for the two major-road legs should be used in the HSM methodology. Similarly, for an intersection with two minor-road legs with differing ADTs, the larger of the ADTs for the two minor-road legs should be used in the HSM methodology.

Traffic volumes typically change from year to year. At most sites, traffic volumes grow from year to year, but annual decreases in traffic volume are also possible. The HSM methodologies are applied to one year at a time, so the best available estimate of the traffic volume for the year of interest should be used. For multi-year analysis periods, the HSM methodology should be applied multiple times. The traffic volumes for each year of the analysis period should be forecast from the ADT for the most recent available year and the best available estimate of the rate of traffic volume growth (or decrease).

Number of Intersection Legs

The number of intersection legs is an input variable for all of the HSM intersection methodologies. The current methodologies consider only three- and four-leg intersections. The number of legs of an intersection can be determined from existing data in computerized roadway or intersection inventory files, from as-built plans, or from photolog or field review.

Type of Intersection Traffic Control

The type of traffic control at an intersection is an input variable in applying all of the HSM intersection methodologies. The current methodologies consider signalized intersections and intersections with minor-road STOP control. The type of traffic control at an intersection can be determined from existing data in computerized roadway or intersection inventory files, or from photolog or field review.

Left-Turn Signal Phasing

The HSM methodology for intersections on urban and suburban arterials considers the type of left-turn signal phasing as an input variable for signalized intersections. Types of left-turn signal phasing considered by the HSM methodology include none, protected, and protected/permissive. The type of left-turn signal phasing can be determined from existing data in computerized roadway or intersection inventory files, signal plans, or from photolog or field review.

Number of Intersection Approaches with Right-Turn-on-Red Operation

The HSM methodology for intersections on urban and suburban arterials considers the number of intersection approaches with right-turn-on red operation as an input variable for signalized intersections. Right-turn-on-red operation is generally permitted unless a sign is present that prohibits right turn on red on a specific intersection approach. The presence of right-turn-on-red operation for specific intersection approaches is not typically included in computerized roadway or intersection inventory files. The presence of right-turn-on-red operation can be determined from photolog or field review.

Presence of Red-Light Cameras

The HSM methodology for intersections on urban and suburban arterials considers the presence of cameras for enforcement of red-light violations as an input variable for signalized intersections. The presence of red-light cameras for specific intersections is not typically included in computerized roadway or intersection inventory files. The presence of cameras for enforcement of red-light violations can be determined from lists of automated enforcement locations or from field review.

Presence of Median on Major Road

The HSM methodology for rural multilane highways considers the presence of a median on the major road as an input variable. The definitions of divided and undivided roadways have been presented above in the discussion of the presence of medians for roadway segments. The presence of medians can be determined from existing computerized inventory files for intersections or for adjacent roadway segments and can also be determined from photolog or field review.

Presence of Intersection Left-Turn Lanes

The presence of left-turn lanes on the major-road approaches to an intersection is an input variable for all of the HSM intersection methodologies. The input data needed for the HSM methodology is whether there are zero, one, or two major-road approaches with left-turn lanes. No distinction is made for the number of lanes turning left from any specific intersection approach. The presence of intersection left-turn lanes can be determined from computerized roadway or intersection inventories, from as-built plans, or from photolog or field review.

Presence of Intersection Right-Turn Lanes

The presence of right-turn lanes on the major-road approaches to an intersection is an input variable in applying the safety prediction methodology. The input data needed for the methodology is whether there are zero, one, or two major-road approaches with right-turn lanes. The presence of intersection right-turn lanes can be determined from computerized roadway or intersection inventories, from as-built plans, or from photolog or field review.

Intersection Skew Angle

The skew angle of an intersection, representing the angle at which the legs of an intersection meet, is an input variable used in applying the HSM methodology for rural two-lane and rural multilane highways. The skew angle for an intersection is defined as the absolute value of the difference between 90° and the actual intersection angle (e.g., for the base condition of an intersection angle of 90°, the skew would be 0°). For three-leg STOP-controlled intersections, the skew is applied to the angle between the major-road leg in the direction of increasing stations and a leg to the right or left. For four-leg STOP-controlled intersections, the skew is expressed as one-half of the angle to the right minus one-half of the angle to the left for the angles between the major-road leg in the direction of increasing stations and right and left legs, respectively. Intersection skew angles are not typically included in computerized intersection or roadway data bases. The intersection skew angle can be determined from as-built plans, aerial photographs, or field review.

Intersection Sight Distance

The presence of limited intersection sight distance on intersection approaches is an input variable in applying the HSM methodology for rural two-lane highways. Sight distance in an intersection quadrant is considered limited if the available sight distance is less than the sight distance specified by AASHTO policy for a design speed of 10 mph less than the major-road design speed. This data element applies only to intersections with minor-road STOP control. Intersection sight distance restrictions must generally be determined from field review. Automated field procedures for measuring intersection sight distance are currently being developed and tested.

Terrain

The type of terrain in which an intersection is located is considered as an input variable in the HSM methodology for intersections on rural multilane highways. Terrain is classified in the HSM methodology as flat or not flat (i.e., rolling or mountainous). Terrain can typically be determined from existing computerized intersection or roadway data bases or from field review.

Lighting

The HSM methodology for intersections on rural multilane highways and on urban and suburban arterials considers the presence of lighting at the intersection as an input variable. The presence of lighting may be determined from computerized roadway inventory files, from as-built plans, from highway agency lighting records, or from photolog or field review.

SPECIFIC CRASH DATA ELEMENTS

The crash data elements that are likely to be needed in calibrating the HSM methodologies and in combining observed and predicted crash frequencies to obtain an estimate of the expected crash frequency are as follows:

- Date (year);
- Location (milepost/log mile/coordinate);
- Severity level (fatal/injury/property damage only);
- Relationship to intersection (at-intersection/intersection-related/not-intersection-related); and
- Distance from intersection.

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