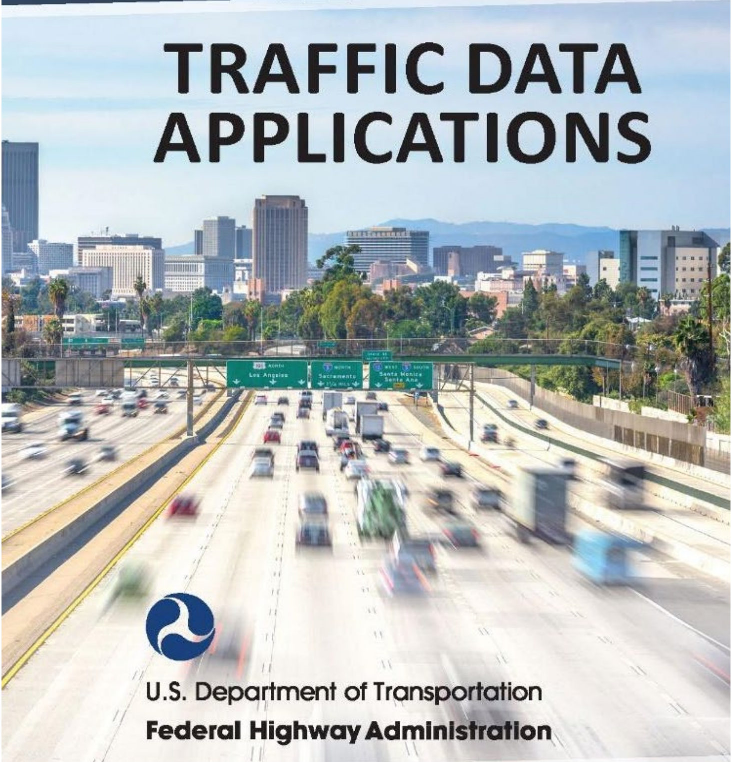
MINI MASTER HIGHLIGHTS

TRAFFIC DATA APPLICATIONS



U.S. Department of Transportation
Federal Highway Administration

Travel Monitoring and Surveys Division
Office of Highway Policy Information
Publication number FHWA- HPL-26-001

Mini Master Highlights

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Contents

1. Introduction

The Mini Master Highlights of Traffic Data Applications provides a systematic overview of how traffic data support transportation program and project development.

This Mini Master Highlights has two goals. First, it is designed to educate traffic data gathering professionals by strengthening their systematic understanding of data application and data needs, further promoting effective, efficient, and innovative data collection and processing methods and processes. Second, it aims to inform data users—including transportation planners, engineers, and analysts—about the types of traffic data available, and how different programs and projects rely on traffic data, promoting comprehensive data usage and data sharing to achieve data driven decision making.

2. What Traffic Data Are

Traffic data are measurements of the movements and behavior of people, vehicles, bicycles, and goods on transportation networks. Traffic data can be used as a performance measure to describe how people, goods, and vehicles move, where and when congestion occurs, how fast and how many users travel, and other characteristics useful for planning, design, operations, safety analysis, and research. Traffic data are often collected via both roadway and roadside based sensors, vehicle or traveler navigation and communication devices, and surveys. Some of the common types of traffic data are listed below.

Behavior
Trip rates, trip start and end times, trip modes, trip purposes, and vehicle occupancy. These parameters are often gathered from household surveys.

Count/Volume
Number of vehicles, bikes, pedestrians, tons and value of goods passing a point or segment of highway per unit time (e.g., vehicles/hour). For example, the annual average daily traffic (AADT) is a common traffic volume metric.

Classification
Vehicle types (car, truck, bus, motorcycle…), motorized vs micromobility, passenger vs. freight. FHWA 13 motorized

vehicle classification is a national adopted system for traffic monitoring, planning, design, and operations.

Free Flow Speed (FFS)
Vehicle speeds on a roadway under low traffic conditions with unconstrained interactions with other vehicles and prevailing environmental and traffic control conditions.

Incident and Event data
Crashes, roadwork, weather, and special events that affect volume and class flow.

Level of Service (LOS)
A quantitative stratification of a performance measure or measures representing quality of service. Ranging from A (best) to F (worst), these ratings are defined by the criteria established in the Highway Capacity Manual (HCM), published by the Transportation Research Board (TRB).

Origin–Destination (O–D)
Trip start and end locations, often summarized as O–D matrices. O-D traffic data are often presented in a square matrix form.

Probe Vehicle
A probe vehicle is a vehicle equipped with sensors or communication devices that collect real-time data on traffic conditions, speeds, and other roadway information as it moves through the transportation network.

Queue Length
Number of vehicles waiting (queue), length of roadway occupied, or proportion of time a sensor detects vehicle presence.

Signal Timing / Phase Data
Traffic signal states and timing plans.

Speed
Average, spot, instantaneous, and percentile speeds of vehicles. Vehicle speeds such as passenger vehicles and freight vehicles are often reported separately.

Trajectory
Time-stamped GPS or cellular traces showing exact paths and timestamps of travelers.

Travel Time / Delay
Time taken to travel between two points and any additional time taken to travel relative to free flow conditions.

Travel Time Reliability
The consistency or predictability of travel times experienced by travelers on a particular route or transportation system over a period.

Vehicle Hours Traveled (VHT)

The total number of hours traveled by motor vehicles in a region or corridor, over a certain period of time, usually over a year.

Vehicle Miles Traveled (VMT)
The total miles traveled by motor vehicles in a region or corridor, over a certain period of time, usually over a year.

Weight
Vehicle weights and vehicle axle weights are often measured through the weigh-in-motion devices.

3: Traffic Data for Planning

Transportation planning is one of the major steps in the transportation project and program decision process. Planning decisions rely on traffic data to determine what, when, and where a project should be carried out.

Topic # 3-1: Highway Traffic Inventory

Highway inventory is the foundation for the transportation planning process. During the inventory process, data associated with existing roadways, such as the Annual Average Daily Traffic (AADT), types and classes of vehicles involved, speed, and travel time are collected. The Level of Service (LOS) per roadway segment is estimated.

Along with the Vehicle Miles Traveled (VMT) for a route or within an area, crash frequencies (e.g., # of crashes per 100 million VMT) are also frequently computed. These traffic data items, as listed below, provide the basic information on existing congestion and safety issues and serve as the starting point for future actions.

- Existing peak period traffic flow volume
- Existing AADT
- Existing peak period flow volume by vehicle class
- Estimated LOS
- Derived VMT

Topic # 3-2: Travel Demand Forecasting

While the Highway Inventory activity deals with existing traffic flows, Travel Demand Forecasting focuses on future travel demand – Future AADT. This forecast often relies on complex Travel Demand Modeling software enabled by a broad range of traffic data serving as inputs.

Traffic Generating and Attracting Rates
Number of trips a family, a household, or a person by different social and demographic factors like age, sex, income, education, occupation, and others on an annual basis. This data is typically gained from household travel surveys (e.g., FHWA's National Household Travel Survey).

Modal Choice Data
Modes travelers use to accomplish their trips: public transportation (bus, subways …), private vehicles, walking, bicycling … Modal Choice Data are also typically derived from household travel survey data.

Route-specific impedances
Speed, travel distance, travel time, toll from a trip's origin to destination are factors impacting travelers' decisions on route choices.

Inventory AADT Data
Past and existing AADT data are critical for travel demand model building, calibration, and validation.

4: Traffic Data for Environmental Analysis

Environmental analysis is an integral part of the transportation project development process. Two topics relying heavily on traffic data are outlined below.

Topic # 4-1: Traffic Data for Transportation Air Quality Analysis

Transportation air quality analysis involves both regional and project level emissions assessment to meet federal regulatory requirements. One type of analysis required by the Clean Air Act is called regional conformity, which examines emissions from all vehicles in an air quality non-attainment or maintenance area. The computation of an "emissions inventory " involves the use of VMT, speeds, and fleet information developed from travel demand modeling output. This information, combined with other regional information on meteorology, fuels, age of fleet, etc., is used in an emissions model (either EPA's MOVES model or California Air Resources Board's EMFAC model, depending on the state) to calculate an emissions inventory and meet regional conformity requirements.

Certain projects may also have to complete modeling to satisfy project level conformity requirements as specified in the Clean Air Act. These projects may require assessment of near-road air quality impacts for carbon monoxide and/or particulate matter. Similar to regional conformity, information on VMT, fleet mix, and speeds are provided to an emissions model, typically derived from a travel demand model. Emissions are calculated and used in a "dispersion" model to estimate pollutant concentrations around the project.

Other project level air quality activities may include calculating project-specific emissions inventories - including mobile source air toxics. These analyses similarly rely on traffic data from travel demand models processed through an emissions model.

The FHWA also deploys a database tool called Database for Air Quality and Noise Analysis (DANA). DANA can generate formatted inputs for the EPA MOVES model using traffic data from the National Performance Management Research Data Set (NPMRDS), Highway Performance Monitoring System (HPMS), and Travel Monitoring Analysis System (TMAS). Together, these sources provide speed, travel time, roadway characteristics, AADT, and vehicle classification information for estimating volumes, fleet mix, and emissions by vehicle type. The following summarizes the relevant traffic data.

Speed
The harmonic average speed for all reporting vehicles on the segment.

Travel Time
Travel time recorded in minutes or seconds. It is the ratio between the segment length and the harmonic average speed for all reporting vehicles on the segment.

HPMS_TYPE
Indicates the vehicle type percentages for HPMS vehicle types.

AADT
Annual Average Daily Traffic. If multiple HPMS segments with different attribute values are assigned to a single TMC path, the length-weighted average is assigned.

AADT (Single)
Annual Average Daily Traffic for single-unit trucks and buses. If multiple HPMS segments with different attribute values are assigned to a single TMC path, the length-weighted average is assigned.

AADT (Combination)
Annual Average Daily Traffic for Combination Trucks. If multiple HPMS segments with different attribute values are assigned to a single TMC path, the length-weighted average is assigned.

VMT by Roadway Function Class
Total Vehicle Miles Traveled (VMT) aggregated by rural and urban functional classes, including interstate, freeway, principal arterial, minor arterial, major collector, minor collector, and local roads. Used to calculate total VMT by road type for MOVES input files.

Topic # 4-2: Traffic Noise Assessment

Noise generated by vehicles operating on highways is assessed through FHWA's Traffic Noise Model (TNM). The model generates the hourly equivalent A-weighted sound level (LAeq(h)), defined as the equivalent steady-state sound level over a one-hour period. TNM relies on project-specific traffic data to provide accurate results.

Below is the traffic data needed to generate the LAeq(h). These traffic data components normally cover three-time horizons.

Existing Data

- Existing condition traffic volumes by class (automobile, medium truck, heavy truck, bus, motorcycle).
- Existing condition vehicle speeds (by vehicle class or universal)

Opening Year Data

- Opening year refers to the year the highway will open to travel.
- Opening year traffic volumes by class (automobile, medium truck, heavy truck, bus, motorcycle
- Opening year vehicle speeds (by vehicle class or universal)

Design year data

- Design year refers to the year for which the highway is designed.
- Design year traffic volumes by class (automobile, medium truck, heavy truck, bus, motorcycle
- Design year vehicle speeds (by vehicle class or universal).

5: Traffic Data for Highway Engineering

Traffic data lays the foundation for highway engineering, ranging from pavement and geometric layout to structures. The topics listed below provide specific information regarding how traffic data support different engineering designs.

Topic # 5-1: Pavement Design

Pavement design relies on traffic data associated with both the traditional ESAL method and the new MEPDG method. Quality traffic data ensures pavement is not over or under designed for the desired performance.

5-1a: ESAL Method

The Equivalent Single Axle Load (ESAL) method is a classical pavement design approach. An ESAL is a unit that converts the damaging effect of any axle load and configuration on a pavement into the equivalent number of standard 18,000-pound (typically 80-kN) single axle loads. Cumulative ESAL represents the total loads a pavement is expected to carry over its design life. ESALs are calculated by using vehicle classification counts and their corresponding Load Equivalency Factors (LEF). The necessary traffic data are explained below.

Axle Type
Classification of axle configuration (e.g., single, tandem, tridem) for traffic loading purposes.

Axle Load
The weight carried by a single axle converted by axle configuration (single, tandem, tridem, quad).

LEF (Load Equivalency Factor)
A multiplier that converts axle loads to ESALs, representing the equivalent number of 18,000-lb loads based on pavement damage. LEFs vary by axle group, pavement type, and serviceability, and are also called ESAL per-axle factors.

Cumulative Number of Axles
The total forecasted number of axles, by axle load group, expected over the pavement's service life based on traffic forecasting.

ESALs per Vehicle Class
The equivalent single axle loads for each axle load group, calculated by multiplying the load equivalency factor (LEF) by the cumulative number of axles.

W18 (Cumulative ESAL)
Total number of 18-kip equivalent single-axle loads over the pavement design life, summed across both directions.

Calculated by multiplying the number of axles (by type and load) by their respective LEFs.

D_D (Directional factor)
Directional traffic split of a two-way roadway.

D_L (Lane splitting factor)
The % trucks in the design lane.

W_{18} (Design Lane ESAL)
Total number of 18-kip equivalent single-axle loads applied to the lane with heaviest traffic over the design life. Computed by applying directional and lane distribution factors to the total cumulative two-way ESAL.

Final Computation Equation

$$W_{18(Cumulative)} = \sum (Cumulative\ number\ of\ axles\ X\ LEF)$$

(summed over all axle load vehicle classes, in kips)

Where:
$w_{18\_design\_lane} = D_D \times D_L \times W_{18\ (Cumulative)}$
Where:
D_D=traffic directional factor for a two-way roadway.
D_L= The % trucks in the design lane.
$W_{18\ (Cumulative)}$= cumulative two-way ESAL projected for a roadway segment.

5-1b: MEPDG Method

The AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) is the latest FHWA recommended pavement design method, where pavement performance can be modeled with very specific traffic-related parameters. The MEPDG method requires traffic data from both demand forecasting and field monitoring covering both vehicle classification and axle weight. Specific traffic data and traffic input are presented below.

Directional Design-Hour Volume (DDHV)
DDHV is the proportion of AADT in the peak hour and predominant traffic direction, calculated as AADT × K-factor × D-factor. It helps estimate needed capacity for a desired LOS, balancing cost and adequacy.

Peak Hour Factor (PHF)
PHF measures variation in traffic demand within an hour, calculated as hourly volume divided by four times the peak 15-minute flow. The 15-minute period is used as it reflects stable flow. PHF influences the lanes needed to maintain the desired LOS.

MSFi
Maximum service flow rate for level of service i.

f_{HV}
Heavy vehicle adjustment factor.

fp
Road user familiarity adjustment factor.

Annual Average Daily Truck Traffic
The average daily volume of truck traffic on a road segment for a year. Trucks are defined as vehicles of classes 4 through 13 in the FHWA's 13-category vehicle classification system. AADTT can be computed in two ways, i.e., the simple average and AASHTO methods shown below.

Simple Average Method Formula

$$AADTT = \frac{1}{n}\sum_{k=1}^{n}(Truck\ VOL)_k$$

AASHTO Method Formula

$$AADTT = \frac{1}{12}\sum_{m=1}^{12}\left[\frac{1}{7}\sum_{j=1}^{7}\left(\frac{1}{n_{jm}}\sum_{i=1}^{n_{jm}}(Truck\ VOL)_{ijm}\right)\right]$$

Where:
$TruckVOL_k$ = daily truck volume on the k^{th} day of the year.
$Truck\ VOL_{ijm}$ = daily truck volume for i^{th} occurrence of the j^{th} day of week within the m^{th} month.
n = number of days in a year (365 or 366).
i = occurrences of day j in month m for which truck traffic data are available.
j = day of week (1 to 7).
m = month of year (1 to 12).

njm = number of occurrences of day j in month m for which truck traffic data are available.

Note:
Percent of Truck Traffic in Design Direction =Percentage of truck traffic in the design direction. Unless a roadway has an unbalanced travel for trucks, it should always be 50%.

Percent of Truck Traffic in Design Lane
This is the percentage of truck traffic for the design lane. The design lane is typically the outside lane in a multilane highway (more than one lane in each travel direction).

Monthly Adjustment Factor
Seasonal variations in truck volumes. For each FHWA vehicle class (Classes 4–13), 12 monthly factors are computed by dividing the average daily truck traffic for each month (MADTT) by the total MADTT for the year, then multiplying by 12. This results in a total of 120 factors representing seasonal distribution across all vehicle classes.

Vehicle Class Distribution
AADTT distribution among the 10 vehicle types (FHWA vehicle class 4 to 13), expressed in percentages.

Hourly Adjustment Factor
Truck hourly distribution factor refers to the percentage of hourly AADTT among a 24-hour period starting at midnight.

Axle Load Distribution Factors
Percentage of axle counts within specific load bins (i.e. a weight range 0 to 3,000 lbs.) for FHWA vehicle classes 4–13 by axle type (single, tandem, tridem, quad). They are developed monthly based on axle load data if at least 7 days of data are available; otherwise, adjacent month averages or annual summaries are used.

Number of Axles per Truck Class for Each Axle Group
The number of axles per vehicle class for a given axle configuration is an annual average number of axles per vehicle category (per vehicle class and vehicle axle configuration).

Axle Spacing
The distance between two consecutive tandem, tridem, and quad axles.

Average Axle Width
The distance between the two outside edges of an axle.

Wheelbase
The distance between the steering and the first device axle of a tractor or a heavy single unit.

Annual Average Daily Traffic (AADT)
AADT estimates the average daily traffic volume for a location over an entire year. It measures how busy a road is,

serves as a key input for transportation planning, and is used for funding allocation.

K-Factor
Proportion of AADT in the design hour volume (DHV). K-30, K-50, and K-100 are the 30th, 50th, and 100th highest hourly volumes as a percentage of AADT. K-30 is often used for design, but not always.

D-Factor
Directional Factor (D-factor) is the percentage of traffic in the peak direction during the peak hour. D-30 uses the 30th highest hourly volume of the year for design capacity analysis, while D-100 uses the 100th for LOS calculations.

Topic # 5-2: Geometric Design

Geometric design refers to the determinations of lane width, number of lanes, turning lanes, intersection layout, truck climbing lanes, and other horizontal and vertical alignment related design elements.

5-2a: Lane Width

Lane widths influence driver comfort, operations, and crash likelihood.

Typical widths range from 9 to 12 ft, with 12 ft predominant on high-speed, high-volume highways.

Auxiliary lanes at intersections and interchanges should match through-lane width and not be less than 10 ft.

Continuous two-way left-turn lanes should be 10 to 16 ft. For local and collector roads carrying fewer than 2,000 AADT, alternative criteria may be appropriate on very low-volume roads.

When AADT exceeds 10,000, the highway is often considered as a high-volume roadway with an implied speed over 45 MPH.

5-2b: Number of Lanes

The number of lanes is determined by a design-hour analysis that uses directional peak-hour demand.

The directional design-hour volume often called the peak-hour volume in the predominant direction is derived from AADT using K and D factors.

The typical HCM based steps and traffic data involved are illustrated below.

Monthly Average Daily Traffic (MADT) Formula

$$MADT_m = \frac{\sum_{j=1}^{7} w_{jm} \sum_{h=1}^{24} \left[\frac{1}{n_{hjm}} \sum_{i=1}^{n_{hjm}} VOL_{ihjm} \right]}{\sum_{j=1}^{7} w_{jm}}$$

Where:
VOL_{ihjm} = total traffic volume for ith occurrence of the h^{th} hour of day within j^{th} day of week during the m^{th}month.
i = occurrence of a particular hour of day within a particular day of the week in a particular month (i=1,… n_{hjm}) for which traffic volume is available.
h = hour of the day (h=1,2,…24) – or other temporal interval.
j = day of the week (j=1,…7).
n_{hjm} = the number of times the h^{th} hour of day within the j^{th} day of week during the m^{th} month has available traffic volume (n_{hjm} ranges from 1 to 5 depending on hour of day, day of week, month, and data availability).
w_{jm} = the weighting for the number of times the j^{th} day of week occurs during the m^{th} month (either 4 or 5); the sum of the weights in the denominator is the number of calendar days in the month (i.e., 28, 29, 30, or 31).

Annual Average Daily Traffic (AADT) Formula

$$AADT = \frac{\sum_{m=1}^{12} d_m \ * MADT_m}{\sum_{m=1}^{12} d_m}$$

Where:
MADTm = monthly average daily traffic for month m
m = month (m=1,…12).
dm = the weighting for the number of days (i.e., 28, 29, 30, or 31) for the m^{th} month in the particular year.

K-Factor

$$K - factor = \frac{K^{th}\ highest\ volume}{AADT} \times 100\%$$

Peak Hour Factor (PHF)

$$PHF = \frac{V}{Maximum\ flow\ rate} = \frac{V}{4 \times V_{m15}}$$

Where:
V = hourly volume in vehicles/h.
V_{m15} = maximum volume during the peak 15-min of the analysis period (vehicles/15-min).

D-Factor

$$D - factor = \frac{K^{th}\ highest\ volume\ in\ direction}{Volume\ in\ both\ directions} \times 100\%$$

Directional Design-Hour Volume (DDHV)

$$DDHV = AADT \times K \times D$$

Where:
K = the proportion of AADT occurring in the peak hour, i.e., the K-factor.
D = peak-hour volume proportion in the major direction, i.e., the D-factor.

Heavy Vehicle Adjustment Factor (f_{HV})

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)}$$

Where:
PT = proportion of SUTs and TTs in the traffic stream (decimal).
ET = passenger car equivalent to one heavy vehicle in the traffic stream (PCEs).

Number of Lanes (N) Computation

$$N = \frac{DDHV}{PHF \times MSF_i \times f_{HV} \times f_p}$$

5-2c: Truck Climbing Lanes

Climbing lanes on uphill sections of two-lane highways are a comparatively inexpensive way to restore capacity and improve operations when slow trucks and higher volumes cause congestion on grades. They are applied where truck speeds or LOS on the grade are substantially worse than on the approach.

According to AASHTO's Policy on Geometric Design of Highways and Streets (AASHTO's "Green Book"), a climbing lane is warranted when the following three criteria are satisfied:

1. Upgrade traffic flow rate exceeds 200 vehicles per hour.
2. Upgrade truck flow rate exceeds 20 trucks per hour.
3. At least one of the following conditions is met:

- A typical heavy truck is expected to lose at least 10 mph on the grade.
- The grade operates at Level of Service (LOS) E or F.
- The LOS drops by two or more levels from approach to grade segment.

5-2d: Continuous Two-Way Left-Turn Lanes (COTWLTL)

Continuous two-way left-turn lanes (COTWLTL) can be used to reduce midblock left-turn conflicts on suburban and urban arterials where driveway spacing and turning volumes make conventional turn lanes or full access restrictions impractical. Left-turn movements can create congestion and safety issues by conflicting with both opposing and same-direction traffic, but COTWLTLs provide access to roadside properties while improving operations in a cost-effective manner, according to NCHRP Report 279: Intersection Channelization Design Guide. The traffic data used in Report 279 regarding such needs are listed below.

Vehicle Speed
Posted speeds should be under 45 mph to warrant a TWLTL, with design guidance applying to highways operating at 50 mph or less.

Turning Volumes / Peak Hour Traffic Volumes

70 midblock left turns per 1,000 ft during peak hour left-turn peak-hour volume of 20 percent or more of total volume.

Vehicle Mix / Proportion of heavy vehicles (HVs)
Wider lanes of 15–16 ft may be appropriate where heavy left-turn truck volumes are present, but these widths can encourage side-by-side opposing use, which is hazardous.

5-2e: Dedicated Right Turn Lane

Dedicated right turning (RT) lanes typically improve through motorized traffic capacity significantly by reducing conflicts between through and turning vehicles. However, dedicated RT lanes may increase the time pedestrians need to cross the street. While no exact turning traffic volume is defined as the “sole” criterion for implementing a dedicated RT lane, the following traffic flows are on state DOT practices throughout the nation.

- 100 RT vehicles per hour during peak period warrants consideration.
- 200 RT vehicles per hour during peak time warrants the design engineer to seriously review the design option.
- 300 RT vehicles per hour during peak period warrants a dedicated right turn lane.

Topic # 5-3: Structural Design and Evaluation

In the U.S., bridge design is primarily governed by Load and Resistance Factor Design (LRFD) methodology (via traffic loading model HL-93) to ensure structural integrity and longevity. Weigh-in-Motion (WIM) data can be used to refine these models under specific conditions.

New Design (23 CFR 625): With the proper approval, WIM data may be used to modify codified provisions, typically reserved for high-traffic sites.

In-Service Evaluation (23 CFR 650): The Manual for Bridge Evaluation (MBE) more broadly permits WIM data to assess existing structures, subject to approval.

For both design and evaluation, the following WIM parameters are required:

- Axle weight and spacing
- Vehicle classification
- Lane-specific truck counts
- Wheel weights (left and right)
- Timestamps
- Gauge width

A summary of what traffic data are used in LRFD is provided below.

Traffic Data Needed for Fatigue Design
LRFD fatigue design evaluates the cumulative stress effects from repeated truck passages to prevent fatigue failure in steel bridges. It uses a calibrated fatigue truck model (HS-20 with fixed axle spacing of 30 ft. Its weight is 72 kips.) to estimate typical repetitive stress cycles. LRFD Article 3.6.1.4 suggests that designers consult traffic engineers.

- Single-lane Average Daily Truck Traffic (ADTT) (used to estimate load frequency)
- Truck growth rate

Traffic Data Needed for Deck Design
LRFD specifications rely on standard axle groups. While Empirical and yield-line methods are still used, standard models may miss side-by-side axle effects and state-specific load limits.

- Axle loads (design axle and tandem)
- Axle spacing (used in transverse strip method)
- Axle configurations (tridem, quad not currently modeled)
- Specialized vehicle types (i.e. concrete mixer)
- Legal axle load (state-specific exemptions)
- Multiple axle group presence (side-by-side effects)

6: Traffic Data for Operations

Highway Operations is to operate existing highway facilities to achieve their fully designed and constructed potential through a broad range of measures and activities but without significant physical earth moving efforts. Operations rely heavily on determining Travel Time Reliability.

Travel time reliability refers to the consistency and dependability of travel times from day to day, helping travelers manage unexpected delays. This is quantified using three key metrics: the Travel Time Index, which compares average peak travel time to free-flow conditions to show overall congestion; the Buffer Time Index, which represents the extra "time cushion" (as a percentage of the average) travelers add to ensure on-time arrival 95% of the time; and the Planning Time Index, which represents the total travel time needed (including both typical and unexpected delay) relative to free-flow speeds. Together, these measures allow drivers and planners to account for both average conditions and the worst-case delays experienced on a route.

The measures and activities for traffic operations include demand management, traveler information system, Automated Traffic Signal Performance Measures (ATSPMs), incident management and other activities.

Topic # 6-1: Transportation Demand Management (TDM)

Transportation Demand Management, also known as TDM, is a set of policies, strategies, and methods that aim to maximize traveler choices.

All efforts are aimed at minimizing, reducing, and balancing traffic flows on the highways. Traffic data, such as the ones listed below, are often used to measure and gauge the effectiveness of such efforts.

Vehicle Occupancy
The number of people in a vehicle. Reducing single-occupancy vehicle trips is often the goal.

Transit and Other Micromobility Modes
The modal share information provides insights regarding travelers' choices among auto, bus, bike, and other travel modes. Percentages of travelers using auto vs. other modes are often used to gauge program effectiveness

Tolls and Fees
By implementing congestion pricing, parking fees, and other tolls, agencies generate revenue while simultaneously reducing and balancing traffic flow. To evaluate the

effectiveness of these pricing strategies, planners typically monitor changes in VMT and AADT.

Topic # 6-2: Traveler Information Systems

Traveler Information Systems provide real-time or near-real-time updates to the public on current traffic conditions, incidents, speed, and travel time. Information may be delivered pre-trip (e.g., websites, apps), in-vehicle (e.g., GPS routing), or roadside (e.g., dynamic message signs). These systems enhance situational awareness and enable travelers to make informed routing decisions. Traffic data supporting this process includes:

- Travel time
- Traffic volume
- Vehicle speed
- Incident detection
- Incident condition
- Mode-specific data (e.g., auto, truck, bicycle)

Topic # 6-3: Optimizing Traffic Signal Timing and Synchronization

Traffic signal optimization and synchronization are essential for improving traffic flow, reducing congestion, minimizing stops, and enhancing road safety. FHWA's Traffic Signal Timing Manual provides a list of key traffic data items as illustrated below.

Traffic Volume
Number of vehicles approaching the intersection in a given time.

Vehicle Speed
Average speed of vehicles on a road segment.

Queue Length
Number of vehicles waiting at an intersection.

Vehicle Classification
Classes of vehicles (e.g., cars, trucks, buses).

Occupancy
The percentage of time a detector is occupied by a vehicle.

Pedestrian and Bicycle Counts
The volume of pedestrians or bicycles.

Signal Timing Data
Current signal phase and timing at intersections.

Topic # 6-4: Ramp Metering

Ramp metering controls surges in traffic demand by regulating entry onto a roadway segment, typically via ramp signals or arterial gates. Dynamic systems use real-time traffic flow performance metrics to adjust metering rates, while static systems rely on historical traffic demand and periodic monitoring. Traffic data supporting this process includes:

- Historical demand traffic volume data.
- Real-time traffic volume and system performance.
- Observed facility conditions in terms of queueing and delay.

Topic # 6-5: Incident Management

Traffic Incident Management (TIM) is the ability to detect traffic incidents and crashes and respond effectively to ensure smooth operation of highways, minimize delay, improve travel time reliability, and save lives. Traffic data plays a critical role in this process and is discussed below.

Incident Detection
Real-time traffic speeds, volumes, and occupancy data: identify abnormal congestion or stopped traffic. Automated Incident Detection algorithms analyze traffic data to trigger alerts.

Verification
Traffic video and sensor feed data verify the incident type, location, severity, and lanes affected.

Response Coordination
Data informs dispatch of emergency responders, tow trucks, traffic control personnel, and maintenance crews. Traffic volumes and speed guide selection of alternate routes for responders and travelers.

Traveler Information
Updated travel times and congestion data feed dynamic message signs (DMS), 511 phone and web systems, mobile apps, and navigation platforms. Real-time info encourages drivers to use alternate routes or modes.

Clearance & Recovery
Continuous monitoring of post-incident traffic flow. Detects whether lanes reopen or if residual queues persist, guiding adjustments in traffic controls. The four national TIM performance measures are:

- Roadway clearance time (RCT) is the time between the first recordable awareness of the incident to time all lanes open for traffic flow.
- Incident clearance time (ICT) is the time between the first recordable awareness of the incident to the time at which the last responder has left the scene.
- Secondary Crash is a crash that occurs at the scene of an original crash or in the queue, including the opposite direction.
- Responder Struck By records any instance that a responder is struck by a vehicle while working the scene of an incident.

Performance Evaluation
Archived incidents and traffic data help analyze incident response times, clearance durations, and recurring hotspot locations.

7: Traffic Data for Safety Analysis

Traffic data is critical in ensuring highway safety. Traffic data enables the identification of congestion and conflict zones, certain travel behavior (e.g., speeding), and hot spot or zonal safety analysis.

Topic # 7-1: Model Inventory of Roadway Elements (MIRE)

MIRE provides a national model and standardized framework for collecting and managing roadway and traffic data.

MIRE offers a comprehensive listing of roadway and traffic elements with a data dictionary and linkages to other Federal datasets, supporting state and local agencies to use their own data for analysis instead of default values, improving safety evaluations and supporting data-driven investment decisions. Below lists the standard traffic data items called for by MIRE. MIRE Fundamental Data Elements (FDEs) are denoted by an asterisks "*".

Roadway Segment
Route Number*, Route/Street Name*, Begin Point Segment Descriptor*, End Point Segment Descriptor*, Type of Governmental Ownership*, Segment Identifier, Segment

Length*, Direction of Inventory, Functional Class*, Rural/Urban Designation*, Federal-Aid, Route Type*, Access Control*, Surface Type*, Number of Through Lanes*, Median Type, Annual Average Daily Traffic (AADT)*, AADT Year*, One/Two-Way Operations*, County Name, County Code, Highway District, Specific Governmental Ownership, City/Local Jurisdiction Name, City/Local Jurisdiction Urban Code, Route Signing, Route Signing Qualifier, Coinciding Route Indicator, Coinciding Route – Minor Route Information, Total Paved Surface Width, Surface Friction, Surface Friction Date, International Roughness Index (IRI), International Roughness Index (IRI) Date, Pavement Condition (Present Serviceability Rating [PSR]), Pavement Condition (PSR) Date, Outside Through Lane Width, Inside Through Lane Width, Cross Slope, Auxiliary Lane Presence/Type, Auxiliary Lane Length, Managed Lane Operations Type, Managed Lanes, Reversible Lanes, Presence/Type of Bicycle Facility, Width of Bicycle Facility, Number of Peak Period Through Lanes, Right Shoulder Type, Right Shoulder Total Width, Right Paved Shoulder Width, Right Shoulder Rumble Strip Presence/Type, Left Shoulder Type, Left Shoulder Total Width, Left Paved Shoulder Width, Left Shoulder Rumble Strip Presence/Type, Sidewalk Presence, Curb Presence, Curb Type, Median Width, Median Barrier Presence/Type, Median (Inner) Paved Shoulder Width, Median Shoulder Rumble Strip Presence/Type, Median Sideslope, Median Sideslope Width, Median Crossover/Left-Turn Lane Type, Roadside

Clear Zone Width, Right Sideslope, Right Sideslope Width, Left Sideslope, Left Sideslope Width, Roadside Rating, Tapered Edge, Major Commercial Driveway Count, Minor Commercial Driveway Count, Major Residential Driveway Count, Minor Residential Driveway Count, Major Industrial/Institutional Driveway Count, Minor Industrial/Institutional Driveway Count, Other Driveway Count, Terrain Type, AADT Annual Escalation Percentage, Percent Single Unit Trucks or Single Truck AADT, Percent Combination Trucks or Combination Truck AADT, Percentage Trucks or Truck AADT, Total Daily Two-Way Pedestrian Count/Exposure, Bicycle Count/Exposure, Motorcycle Count or Percentage, Hourly Traffic Volumes (or Peak and Off peak AADT), K-Factor, Design Hour Directional Factor, Speed Limit, Truck Speed Limit, Nighttime Speed Limit, 85th Percentile Speed, Mean Speed, School Zone Indicator, On-Street Parking Presence, On-Street Parking Type, Roadway Lighting, Toll Charged, Toll Type, Edgeline Presence/Width, Centerline Presence/Width, Centerline Rumble Strip Presence/Type, Passing Zone Percentage, Bridge Numbers for Bridges in Segment.

At-Grade Intersection or Junction
Unique Junction Identifier*, Location Identifier for Road 1 Crossing Point*, Location Identifier for Road 2 Crossing Point*, Intersection/Junction Geometry*, Intersection/Junction Traffic Control*, Type of Intersection/Junction, Location Identifier for Additional Road Crossing Points, Intersection/Junction Number of

Legs, School Zone Indicator, Railroad Crossing Number, Intersecting Angle, Intersection/Junction Offset Distance, Signalization Presence/Type, Intersection/Junction Lighting, Circular Intersection - Number of Circulatory Lanes, Circular Intersection - Circulatory Lane Width, Circular Intersection - Inscribed Diameter, Circular Intersection - Bicycle Facility, Unique Approach Identifier*, Intersection Identifier for this Approach, Approach AADT, Approach AADT Year, Approach Mode, Approach Directional Flow, Number of Approach Through Lanes, Left-Turn Lane Type, Number of Exclusive Left-Turn Lanes, Length of Exclusive Left-Turn Lanes, Amount of Left-Turn Lane Offset, Right-Turn Channelization, Traffic Control of Exclusive Right-Turn Lanes, Number of Exclusive Right-Turn Lanes, Length of Exclusive Right-Turn Lanes, Approach Median Type, Approach Traffic Control, Approach Left-Turn Protection, Signal Progression, Crosswalk Presence/Type, Pedestrian Signal Activation Type, Pedestrian Signal Presence/Type, Crossing Pedestrian Count/Exposure, Left/Right-Turn Prohibitions, Right-Turn-On-Red Prohibitions, Left-Turn Counts/Percent, Year of Left-Turn Counts/Percent, Right-Turn Counts/Percent, Year of Right-Turn Counts/Percent, Transverse Rumble Strip Presence, Circular Intersection – Entry Width, Circular Intersection – Number of Entry Lanes, Circular Intersection – Presence/Type of Exclusive Right-Turn Lane, Circular Intersection – Exit Width, Circular Intersection – Number of Exit Lanes, Circular Intersection – Exit Radius, Circular Intersection –

Pedestrian Facility, Circular Intersection – Crosswalk Location, Circular Intersection – Island Width, Circular Intersection – Entry Radius.

Interchange/Ramp
Unique Interchange Identifier*, Interchange Type*, Ramp Length*, Ramp AADT*, Year of Ramp AADT*, Roadway Type at Beginning Ramp Terminal*, Location Identifier for Roadway at Beginning Ramp Terminal*, Roadway Type at Ending Ramp Terminal*, Location Identifier for Roadway at Ending Ramp Terminal*, Interchange Location Identifier for Road 1 Crossing Point, Interchange Location Identifier for Road 2 Crossing Point, Interchange Location Identifier for Additional Road Crossing Points, Interchange Lighting, Interchange Entering Volume, Interchange Identifier for this Ramp, Unique Ramp Identifier, Ramp Acceleration Lane Length, Ramp Deceleration Lane Length, Ramp Number of Lanes, Ramp Metering, Ramp Advisory Speed Limit, Roadway Feature at Beginning Ramp Terminal, Location of Beginning Ramp Terminal Relative to Mainline Flow, Roadway Feature at Ending Ramp Terminal, Location of Ending Ramp Terminal Relative to Mainline Flow.

Topic # 7-2: Safety Exposure

Highway safety exposure data measures how often people, vehicles, or travel are exposed to the risk of crashes on the road network. It quantifies opportunities for crashes to occur and serves as the denominator used to interpret crash counts and calculate meaningful safety rates and risks. The specific traffic data needed are:

VMT

Cumulative vehicle miles traveled for a given area, a given function class of roadway way, or any roadway, timing and date groupings.

$$VMT = \sum_{k=i}^{n} (AADT_i \ x \ Length_i)$$

VHT

Cumulative vehicle hours traveled for a given area, a given function class of roadway way, or any roadway, timing and date groupings.

$$VHT = \sum_{k=i}^{n} (VMT_i \ / \ Speed_i)$$

AADT or Other Flow Data

AADTs associated with individual links can be used as the denominator to normalize crashes or incidents.

Topic # 7-3: Analysis of Vehicle Crash Contributing Factors

Vehicle crash causation analysis is the systematic process of identifying factors and the sequence of events that result in crashes. From a traffic standpoint, the data listed below are typically gathered.

- Traffic volumes (AADT, hourly counts), vehicle mix (e.g., percent heavy vehicles).
- Speed data (e.g., spot speeds, speed distribution, 85th percentile).
- Turning/approaching volumes at intersections.
- Vehicle kinematic data (e.g., pre-crash speed)

8: Traffic Data for Performance Management

Transportation Performance Management (TPM) is a strategic approach that uses system information to make investment and policy decisions to achieve national performance goals in 23 U.S.C 150(b). TPM focuses on setting performance targets, monitoring progress, and using data to inform decision-making and resource allocation to ensure the most efficient investment of Federal transportation funds. Starting with the Moving Ahead for Progress in the 21st Century Act (MAP-21), the Federal-aid highway program was transformed to increase accountability and transparency by focusing on performance outcomes for key national performance goals. As a result, State transportation agencies and metropolitan planning organizations are required to adopt TPM by implementing the national performance management measures codified in 23 CFR Part 490. Traffic data serves as one of the essential foundations of the TPM framework. Consequently, the requirements in 23 CFR Part 490 heavily rely on this data to accurately assess highway performance and prioritize investment strategies.

Topic # 8-1 Annual Hours of Peak Hour Excessive Delay Per Capita (PHED Measure)

The PHED Measure (23 CFR Part 490 Subpart G) assesses traffic congestion on the National Highway System (NHS) within urbanized areas exceeding 200,000 in population. Notably, if any part of an urbanized area is designated as a nonattainment or maintenance area for ozone (O_3), carbon monoxide (CO), or particulate matter (PM_{10} and $PM_{2.5}$) National Ambient Air Quality Standards, the entirety of its NHS network within that urbanized area becomes subject to the measure. Below outlines how the traffic data (i.e., 15-minute travel time data from the National Performance Management Research Dataset (NPMRDS)) is used to derive this performance measure.

Threshold Speed
Defined as the greater of 20 mph or 60 percent of the posted speed limit for each reporting segment in an applicable urbanized area (applicable reporting segment).

Excessive Delay Threshold Travel Time ($EDTTT$)
For each applicable reporting segment, EDTTT is the travel time on the segment above which delay would be incurred.

Observed travel times exceeding EDTTT are recorded as segment delay.

$$EDTTT_s = \left(\frac{SL_s}{Threshold\ Speed_s}\right) \times 3{,}600$$

Where:
s = A reporting segment in an applicable urbanized area (applicable reporting segment).
SL_s= Total length of segment to the nearest thousandth of a mile for reporting segment "s".

Reporting Segment Delay (RSD)
For each 15-minute bin (increment) of each applicable reporting segment, Reporting Segment Delay (RSD) is computed as follows:

$$RSD_{s,b} = TravelTime_{s,b} - EDTTT_s$$

Where:
s = A reporting segment in an applicable urbanized area (applicable reporting segment).
$TravelTime_{s,b}$ = travel time of all vehicles on segment "s" and 15-minute time bin "b" during peak-hours. Peak-hours are: 6:00–10:00 a.m. weekdays from January 1st through December 31st of the same year; and 3:00–7:00 p.m. (or 4:00–8:00 p.m.) weekdays from January 1st through December 31st of the same year.
$RSD_{s,b}$ = travel time segment delay for a 15-minute bin "b" of applicable reporting segment "s" during peak-hours for a calendar year. $RSD_{s,b}$ value not to exceed 900 seconds.

Excessive Delay (ED)
For each 15-minute bin (increment) of each applicable reporting segment, Excessive Delay (ED) is computed as follows:

$$Excessive\ Delay_{s,b} = \frac{RSD_{s,b}}{3{,}600}\ when\ RSD_{s,b} \geq 0$$
$$or\ 0\ when\ RSD_b < 0$$

Average Vehicle Occupancy (AVO)
Annual average vehicle occupancy (AVO) factor for cars, buses, and trucks in an applicable urbanized areas is computed as follows:

$$AVO = (P_c \times AVO_c) + (P_b \times AVO_b) + (P_t \times AVO_t)$$

Where:
$AVO_{c/t/b}$ = *Average vehicle occupancies of cars, trucks, and buses.*
$P_{c/t/b}$ = *Traffic proportions of cars, trucks, and buses.*

Total Delay (TD)
For each 15-minute bin (increment) of each applicable reporting segment, Total Delay (TD) is computed as:

$$TD_{s,b} = AVO \times ED_{s,b} \times Volume15_{s,b} \times (nhs\_pct \times 0.01)$$

Where:
s = A reporting segment in an applicable urbanized area (applicable reporting segment).

nhs_pct = percent of the applicable reporting segment ("s") length on the National Highway System.
$Volume15$ = 15-minute ("b") traffic volume for the applicable reporting segment "s".

Peak Hour Excessive Delay $(PHED)$
For each applicable reporting segment, compute total annual person-hours of excessive delay during peak hours($PHED_s$) by summing the total delay (TD) over all 15-minute bins that occur within the defined weekday peak periods throughout the calendar year.

$$PHED_s = \sum_b TD_{s,b}$$

Annual Hours of PHED per capita

$$AH\_PHEDPC = \frac{\sum_s^T PHED_s}{TotalPopulation}$$

Where:
Annual Hours of Excessive Delay per Capita = The cumulative hours of excessive delay, to the nearest tenth, experienced by all traffic traveling through all reporting segments in the applicable urbanized area for the full calendar year.
s = A reporting segment within an urbanized area (applicable reporting segment).
T = All reporting segments in the applicable urbanized area.
$PHED_s$ = Total hours of excessive delay for all traffic traveling through applicable reporting segment "s" during the calendar year.

Total Population = the total population in the applicable urbanized area from the most recent annual population published by the U.S. Census at the time that the State Biennial Performance Period Report is due to FHWA.

Topic # 8-2: Freight Reliability on the Interstate System

The freight reliability measure (TTTR Index) evaluates truck travel time reliability (or consistency) on the Interstate System using the Truck Travel Time Reliability (TTTR) metric, which reflects the greatest unreliability level rather than congestion. The freight reliability measure is another national performance management measure (23 CFR Part 490 Subpart F).

Truck Travel Time Reliability (TTTR)

For each reporting segment, 15-minute interval truck travel times in the NPMRDS are ranked for each of the five time periods (see note below). Then for each reporting segment, the ratio of the 95th percentile to the 50th percentile of truck travel time (TTTR) is calculated for each of the five time periods.

$$TTTR_{s,i} = \frac{95th\ Percentile\ Travel\ Time_{s,i}}{50th\ Percentile\ Travel\ Time_{s,i}}$$

Where:
s = A travel time reporting segment on the Interstate System.
i *= A time period.*
Note: Compute $TTTR_{s,i}$ *for five time periods: 6:00–10:00 a.m. weekdays from January 1st through December 31st of the same year; 10:00 a.m.–4:00 p.m. weekdays from January 1st through December 31st of the same year; 4:00–8:00 p.m. weekdays from January 1st through December 31st of the same year; 8:00 p.m.–6:00 a.m. all days from January 1st through December 31st of the same year; 6:00 a.m.–8:00 p.m. weekends from January 1st through December 31st of the same year. Round each* $TTTR_{s,i}$ *value to the nearest hundredth.*

Freight Reliability Measure (TTTR Index)

For each reporting segment "s", select the maximum of the five-period specific $TTTR_{s,i}$ values and denote this value as $maxTTTR_s$. The freight reliability measure is computed to the nearest hundredth as follows:

$$TTTR\ Index = \frac{\sum_s^T (SL_s \times maxTTTR_s)}{\sum_i^T SL_s}$$

Where:
s = A travel time reporting segment on the Interstate System in a State.
T = All travel time reporting segments on the Interstate System in that State.
SL_s *= Segment length, to the nearest thousandth of a mile, of Interstate System reporting segment "s".*

$maxTTTR_s$ = The maximum $TTTR_{s,i}$ of the five time periods, to the nearest hundredth, of Interstate System reporting segment "s".

Topic # 8-3: Travel Time Reliability Measures

The Travel Time Reliability Measures are used to evaluate the reliability (or consistency) of travel times across the Interstate and non-Interstate NHS in accordance with 23 CFR Part 490 Subpart E.

The summary below outlines the traffic data elements (i.e., 15-minute increment travel times in the NPMRDS) used to calculate reliability measures for the Interstate and Non-Interstate NHS networks. This compares longer versus normal travel times, combined with vehicle occupancy, to determine the person-miles traveled on segments that are consistent and predictable. Reliability is based on the Level of Time Travel Reliability (LOTTR). The person-miles traveled on these reliable segments are then used to compute the performance measures.

Level of Time Travel Reliability ($LOTTR$)
Calculated by ranking average travel times recorded in 15-minute intervals from GPS-enabled probe vehicles. These intervals are grouped into four time periods (see note below) which are based on 23 CFR Part 490 Subpart E.

The 50th percentile represents the normal travel time, and the 80th percentile is the value below which 80% of observations fall. A segment is classified as a “reliable” segment if its LOTTR value is less than 1.50 in all four time periods.

An LOTTR for a time period of a reporting segment is computed as follows:

$$LOTTR_{s,i} = \frac{80th\ Percentile\ Travel\ Time_{s,i}}{50th\ Percentile\ Travel\ Time_{s,i}}$$

Where:
s = A travel time reporting segment on the National Highway System in a State.
i = Time period.
Note: Round LOTTR to the nearest hundredth. Time periods are the four NHPP periods defined as: 6–10 a.m. weekdays from January 1st through December 31st of the same year, 10 a.m.–4 p.m. weekdays from January 1st through December 31st of the same year, 4–8 p.m. weekdays from January 1st through December 31st of the same year, and 6 a.m.–8 p.m. weekends from January 1st through December 31st of the same year.

Travel Time Reliability Measure
Travel Time Reliability Measures (to the nearest tenth of a percent) for the Interstate System or Non-Interstate NHS is computed as follows:

$$NHPP\ RM = \frac{\sum_r^R SL_r \times AV_r \times OF_r}{\sum_s^T SL_s \times AV_s \times OF_r} \times 100$$

Where:

SL_r = *length of "reliable" segment "r" (nearest thousandth) for the highway system being considered (Interstate or non-Interstate NHS). A "reliable" segment is a reporting segment that has LOTTR values less than 1.50 for all 4 time periods.*

AV_r = *annual traffic volume of "reliable" segment* "r" *. (=* $AADT\ *\ Directional\ Factor\ *\ number\ of\ days\ in\ the\ calendar\ year$).

Directional Factor = factor for splitting AADT by direction (use 0.5 for two-way roadways and 1.0 for one-way roadways.)

OF_r = *average occupancy factor for vehicles on the "reliable" segment "r".*

R = All Interstate or all non-Interstate "reliable" segments in a state (reporting segments with LOTTR values less than 1.50 for all 4 time periods).

SL_s = *the length of the reporting segment "s" (nearest thousandth) for the highway system being considered (Interstate or non-Interstate NHS).*

AV_s = *annual traffic volume of reporting segment* "s" *. (=* $AADT\ *\ Directional\ Factor\ *\ number\ of\ days\ in\ the\ calendar\ year$).

Directional Factor = factor for splitting AADT by direction (use 0.5 for two-way roadways and 1.0 for one-way roadways.)
OF_s *= average occupancy factor for vehicles on the reporting segment "s"..*
T *= All Interstate or all non-Interstate reporting segments within the state.*

Topic # 8-4: Safety: Rate of Fatalities and Serious Injuries per 100 million

The rate of fatalities and the rate of serious injuries assess the number of traffic-related deaths and serious injuries for every 100 million vehicle-miles traveled (VMT), respectively. 23 CFR Part 490 Subpart B stipulates that the rates, of these two national performance management measures, are assessed on a five-year rolling average basis.

Along with the number of total annual fatalities and series injuries, the rate measures use all statewide public roads VMT from the FHWA Highway Statistics Series Table VM-2. The statewide total of annual VMT for all public roads is converted to a per-100-million-mile for the denominator for rate of fatalities and the rate of serious injuries per 100 million VMT.

The rate of fatalities measure and the rate of serious injuries measure are computed (rounding to the thousandth decimal place) as follows:

Rate of Fatalities

$$\frac{\begin{gathered}Rate\ of\ Fatalities\ Measure\ _{PY} = \\ [\left(\frac{Fatalities_{PY-4}}{Total\ VMT_{PY-4}}\right) + \left(\frac{Fatalities_{PY-3}}{Total\ VMT_{PY-3}}\right) \\ + \left(\frac{Fatalities_{PY-2}}{Total\ VMT_{PY-2}}\right) + \left(\frac{Fatalities_{PY-1}}{Total\ VMT_{PY-1}}\right) \\ + \left(\frac{Fatalities_{PY}}{Total\ VMT_{PY}}\right)]\end{gathered}}{5}$$

Rate of Serious Injuries

$$\frac{\begin{gathered}Rate\ of\ Serious\ Injuries\ Measure\ _{PY} = \\ [\left(\frac{Serious\ Injuries_{PY-4}}{Total\ VMT_{PY-4}}\right) + \left(\frac{Serious\ Injuries_{PY-3}}{Total\ VMT_{PY-3}}\right) \\ + \left(\frac{Serious\ Injuries_{PY-2}}{Total\ VMT_{PY-2}}\right) + \left(\frac{Serious\ Injuries_{PY-1}}{Total\ VMT_{PY-1}}\right) \\ + \left(\frac{Serious\ Injuries\ _{PY}}{Total\ VMT_{PY}}\right)]\end{gathered}}{5}$$

Where:
PY = performance year (the current year being evaluated).
PY-1 ..PY-4 = the four prior calendar years.
Fatalities = annual total number of fatalities in a state.
Serious Injuries = annual total number of serious injuries in a state.
Total VMT = annual vehicle-miles traveled per 100 million on all public roads in a state.

9: Summary

Traffic data underpin every stage of transportation programming—from planning and environmental analysis to engineering, operations, safety, and performance management. It demonstrates that quality traffic data are essential for making informed, effective choices that enhance transportation efficiency and safety.

Key Takeaways for the Future of Transportation

Enhancing Knowledge for the Modern Data Professional

Structured Scope: Covering areas such as data types, collection methods, and specific applications across planning, design, operations, safety, and performance management helps professionals understand how to systematically gather and process relevant and needed data.

Detailed Topics: Including inventory, demand forecasting, pavement design, geometric features, safety analyses, and performance measures provide concrete examples of data needs and methods, fostering innovative, efficient practices.

Driving Informed Decision-Making Across Disciplines

Comprehensive Data Overview

Listing data types aligned with specific programs enables users to identify relevant data sources for their analyses.

Connection to Program Goals

Explaining how data support planning, environmental, safety, operational, and performance objectives promotes integrated, data-driven decision making.

Encouraging Data Sharing

Highlighting shared metrics and cross-cutting data functions fosters collaboration and comprehensive data use across projects and agencies.

Overall, this Mini Master Highlights illustrates how traffic data drive transportation outcomes and equips professionals and users with the knowledge to enhance data collection, sharing, and application—ultimately supporting a data-driven transportation system.

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