ISWIM Webinar:
Benefiting From Weigh in Motion Data

Office of Highway Policy Information

The Value of WIM Data for Department of Trans. Programs

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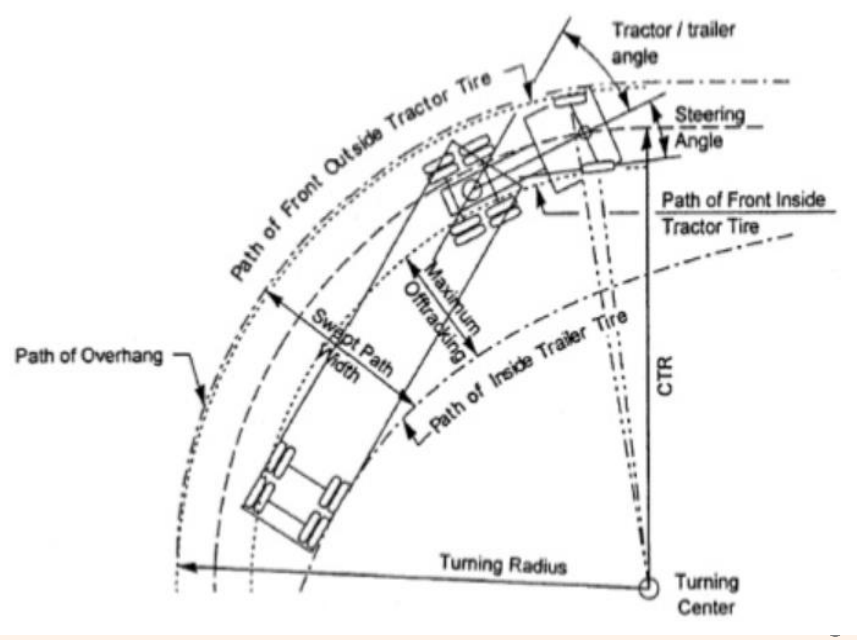
Benefits from WIM Data

- Geometric Design
- Freight Program
- Truck Size and Weight Programs
- Pavement Design
- Bridge Program
- Safety
- WIM Technologies
- WIM Products

Geometric Design – Turning Radius

- Interactive Highway Safety Design Model: estimated deceleration and acceleration rates entering and departing curves to produce the speed profiles can utilize classification and weight data.

- AASHTO – *"A Policy on Geometric Design of Highways and Streets"* Green Book includes uses of type of vehicles on the roadway for the required turning radius for intersections and curves in roadway including roundabouts



Geometric Design Considering Trucks

Weight data offers information needed for appropriate geometric design

- Acceleration and Deceleration to include stopping distances can use WIM data for local characteristics of GVW of vehicles to be known for proper design. In determining the truck lanes **WIM data is useful for local movement and loadings for vehicles** such as the number of Rocky Mountain doubles, B-train doubles, turnpike doubles, triples, and larger tractor-semitrailers are considered. (see the AASHTO Green Book)
- High wind areas may also consider types of vehicles.
- Part IIIA of the AASHTO Green Book for Intersection Sight Distance – Crossing Maneuver includes both the length of vehicle and acceleration rate which are both **obtained from WIM data**.
- Passenger Car Equivalents (PCE) for freeways also can utilize both WIM and class data for proper determination of these rates.

Geometric Design – Truck Climbing Lanes

- In determining the truck climbing lanes **WIM data is important** for local movement and loadings for vehicle such as the number of Rocky Mountain doubles, B-train doubles, turnpike doubles, triples, and larger tractor-semitrailers are considered. An extra lane for a vehicle moving slowly uphill so that other vehicles using the normal lanes are not restricted and are able to pass the slower moving vehicle (AASHTO 1994).
- AASHTO recommends that a 16-km/h reduction criterion be used as the general guide for determining critical lengths of grades and locating truck-climbing lanes:
    - upgrade traffic flow rate is in excess of 200 vehicles/hour
    - upgrade truck flow rate is in excess of 20 vehicles/hour or
    - either a 16 km/h or greater reduction in speed is expected for a typical truck, or Level-of-service E or F exists on the grade or a reduction of two or more levels of service is experienced when moving from the approach segment to the grade segment

Utilizing WIM for the Freight Program

- Freight Networks – FAST Act reference:

https://ops.fhwa.dot.gov/freight/pol_plng_finance/policy/index.htm

- Empty vs. loaded tables TMAS WGT5 report.
- FHWA US Vehicle Inventory report of over 650 unique vehicles throughout the US.
- WIM data is unique in that it provides real data from all vehicles as they travel our roadways. This detailed by vehicle data can be used for many uses in freight analysis.

WIM for Truck Size and Weight Program

FHWA is responsible for certifying state compliance with Federal truck size and weight standards.

WIM data and the utilization of WIM technology encompasses a key part of the enforcement program.

Pavement Design
Equivalent Single Axle Load (ESAL)

- ESAL values and truck factors define the damage to pavement per pass by axle group in question relative to the damage per pass of a standard 18-k axle. (1 ESAL=18 kips) A 4^{th} power equation for different pavement types.
- Used since the 1960's for both pavement design and life expectancy.
- Depends on:
  - **Actual loadings (only available from WIM sites)**
  - Type of pavement
  - Thickness / structural capacity
  - Terminal condition
  - Theoretical analysis Nf(18)/Nf(X)
  - Based on experience (AASHTO Road Test)

ESAL is the abbreviation for equivalent single axle load. ESAL is a concept developed from data collected at the American Association of State Highway Officials (AASHO) Road Test to establish a damage relationship for comparing the effects of axles carrying different loads.

Pavement Design Guide (PDG) AASHTOware© Pavement ME Design

- Truck Volumes
  - Lane distribution
  - Directional distribution
  - Class distribution
  - By hour distribution
  - Growth factors by vehicle class
  - Tire width and tire wander

Pavement Design Guide (PDG) AASHTOware© Pavement ME Design

- Axle load distribution (Load Spectrum) provided by vehicle class and axle group
  - Single axle groups
  - Tandem axle groups
  - Tridem axle groups
  - Quad axle groups *(note:TMAS does penta/penta plus)*
- Number of axles per truck by axle group
- Axle spacing
- Wheelbase
- Speed

WIM for the Pavement Design Guide

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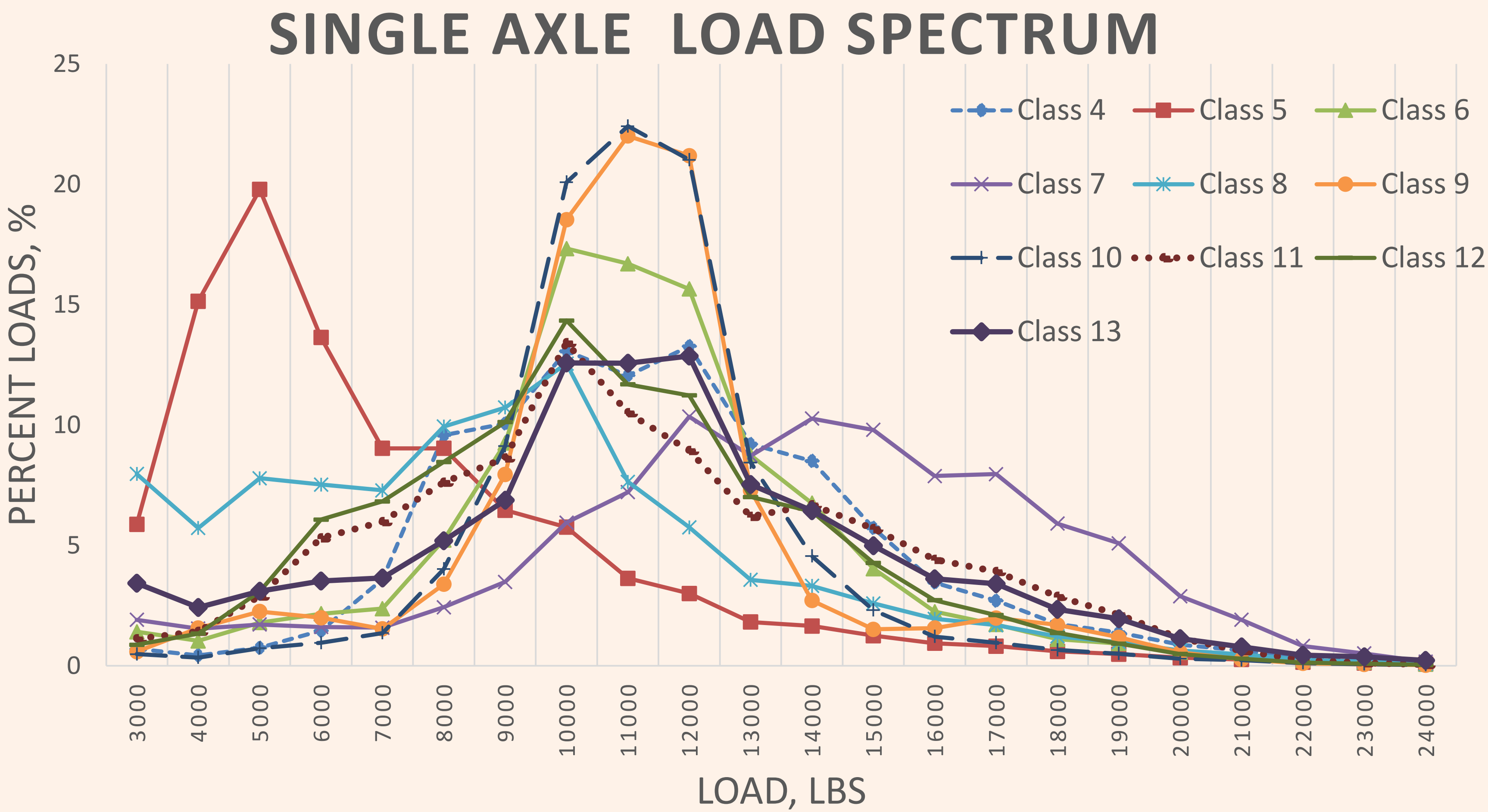


Loading on Bridges

- The Federal-Aid Highway Act Amendments of 1974 established the bridge formula as law, along with the gross weight limit of 80,000 pounds (23 U.S.C. 127).
- The Bridge Formula establishes **the maximum weight any set of axles on a motor vehicle may carry on the interstate highway system.**
- Exception 1: two consecutive sets of tandem axles may carry 34,000 pounds (15,000 kg) each if the overall distance between the first and last axles of these tandems is 36 feet (11 m) or more.
- **Exception 2: grandfathered loading and non-interstate load limits specific to a given geographic area.**
- Load and Resistance Factor Design (LRFD)
- FAST Act Truck Size and Weight:

https://ops.fhwa.dot.gov/freight/pol_plng_finance/policy/fastact/tswprovisions/index.htm

Loading on Bridges

- **Gross Weight** – the weight of a vehicle combination and any load thereon. The federal gross weight limit on the interstate system is 80,000 pounds
- **Single-Axle Weight** – The total weight on one or more axles whose centers are spaced no more than 40 inches apart. The federal single-axle weight limit on the interstate system is 20,000 pounds
- **Tandem-Axle Weight** – The total weight on tow or more consecutive axles whose centers are spaced more than 40 inches apart but not more than 96 inches apart. The federal tandem-axle weight limit on the interstate system is 34,000 pounds

WIM for Loading

- WIM Axle Grouping Configurations in TMAS
  - Single axle with single or dual tires
  - Tandem axles with single or dual tires
  - Tridem (3 axles)
  - Quadrum (4 axles)
  - Penta or larger (5+ axles)
- Overweight by Axle Grouping
- Overweight by Type of Vehicle
- Overweight by Bridge Formula

Loading on Bridges

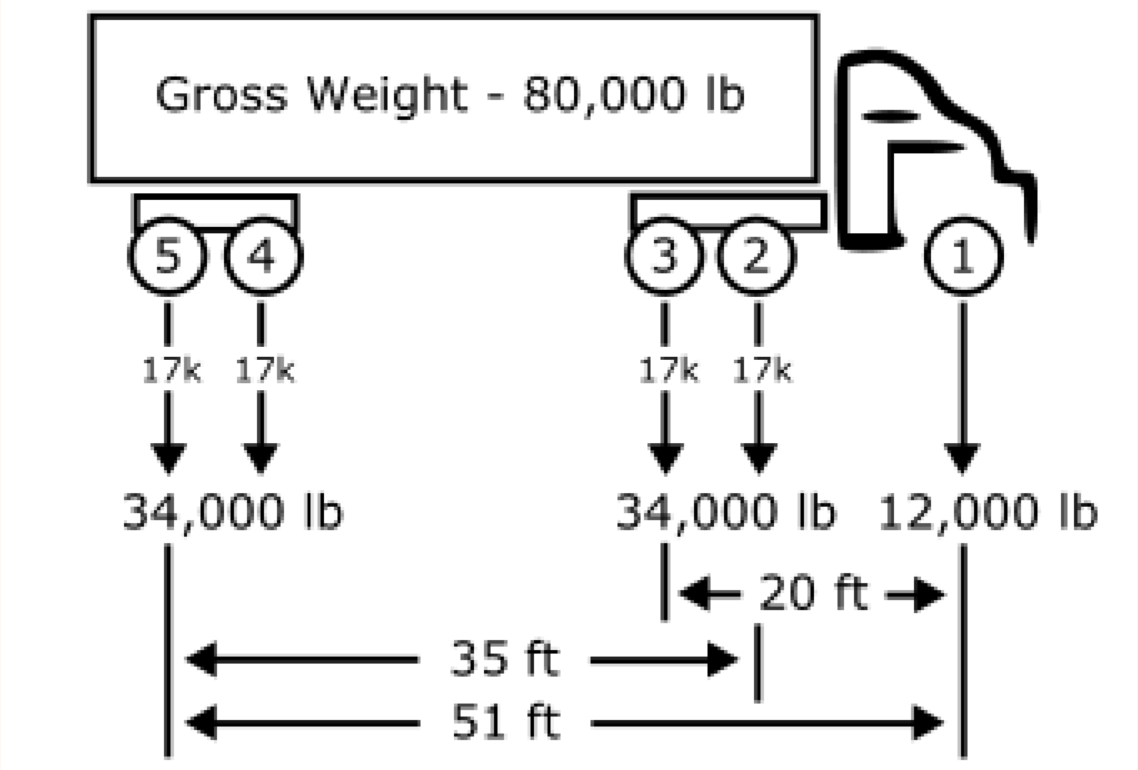
$$W = 500\left[\frac{LN}{N-1} + 12N + 36\right]$$

W = the overall gross weight on any group of two or more consecutive axles to the nearest 500 pounds.

L = the distance in feet between the outer axles of any group of two or more consecutive axles.

N = the number of axles in the group under consideration.

Loading on Bridges

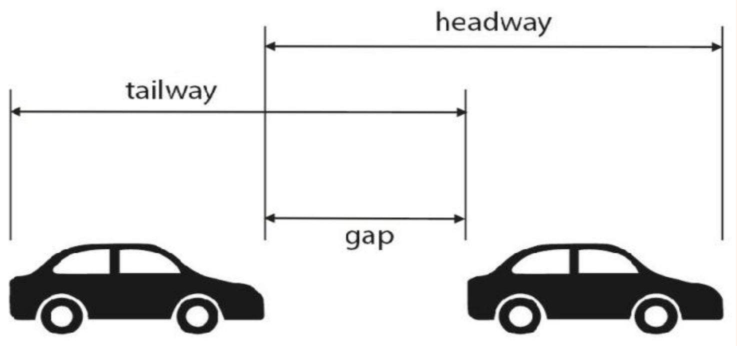


- Axles 1 to 5, W=500*(51*5/(5-1)+12*5+36)=80,000 lbs
- Axles 2 to 5, W=500*(35*4/(4-1)+12*4+36)=65,500 lbs

Safety Use of WIM

- Unbiased real application of roadway loadings
- Vehicle gap and headways:

  time between vehicles



- Truck payload distributions/stopping distance
- Vehicle speed differentials

WIM Technologies and Arrays

- **Loadcell (LC)** – often the most expensive, most intrusive and also most accurate. Weighs each axle 300 times per scale deck.
- **Bending Plate** – proven long lasting technology. Second most intrusive sensor. Weighs each axle 150 times per weigh pad.
- **Quartz piezo** – point sensor (line) with little temperature dependency. Pulse output that's height is proportional to the weight.
- **In-line strain gauge** – point sensor (line) with similar characteristics of quartz. Newer technology – started in 2012.
- **Polymer or coax piezo** – point sensor (line) with temperature dependency of 20% to 50% variability depending on sensor, grout and pavement. Least cost of WIM sensors and minimal installation cost. Pulse output that's height is weight dependent.
- **2016 Traffic Monitoring Guide** recommends a 16 foot (4.88 m) double threshold array. (TMG pages 3-72 to 3-74)

WIM Data Visualization and QC

- FHWA Pooled Fund **Web-based Traffic Data Visualization and Analysis Tools** website:

  https://www.pooledfund.org/Details/Study/516
- FHWA Travel Monitoring Analysis System (TMAS) provides traffic site mapping coordinates
- TMAS QC methods - 2016 Traffic Monitoring Guide
- Private vendor analysis software provides analysis capabilities
- FHWA Pooled Fund QC findings: Minn. DOT study

Virtual WIM Applications

- Traditional WIM sites used together with state enforcement activities allows for Virtual WIM.
  - WIM sites are calibrated or verified accurate.
  - WIM together with video systems are used to capture the side image of the vehicle together with the weights and spacings of each axle.
  - Data is transmitted to enforcement officers for use in live applications or in other actions.
- A few states are doing Virtual WIM.

Virtual WIM Applications

- FHWA has completed Concept of Operations and Architecture for Virtual Weigh Stations.
- FHWA has constructed two model VWS deployment sites: one on I-25 in Unicoi County, Tennessee, and one on US 25 in Laurel County, Kentucky.
- WIM is a key technology included in USDOT's Smart Roadside Initiative, a partnership between FHWA and FMCSA to move traditional weigh station operations to the roadside.
- In support of the use of WIM for screening truck weights on highway mainline facilities, FHWA led an effort to amend NIST's Handbook #44 that provides specifications and tolerances for weighing equipment. The amendment adopting WIM into HB #44 was approved in the summer of 2015.

WIM for Axle Correction Factors

- The per vehicle data from WIM sites is uniquely suited to provide the best possible classification data along with the number of axles for each type of vehicle which is used by State DOTs to obtain yearly axle correction factors.
- These axle correction factors (ACF) are used to properly annualize portable or short term single tube roadway axle counts into Annual Average Daily Counts (AADT).
- Without proper use of current ACF values, AADT data can be overestimated by 20% or more.

WIM for Classification Factors

- HPMS requires annualization of SU and CU data.
- HPMS requires VMT weighting for at least 6 vehicle types for the Summary Travel by Vehicle Type Table. (classes 1, 2, 3, 4, 5-7 and 8-13)
- WIM site class data is the most accurate vehicle data you can collect (can use axle spacing, weights from vehicles and vehicle length to improve class data).

Other National and DOT Uses of WIM

- USDOT's Comprehensive Truck Size & Weight Limits Study completed in 2016 made wide use of WIM data in supporting various areas of technical analysis.
- Highway Cost Allocation utilized all weight and class data available from the Travel Monitoring Analysis System (TMAS).
- Freight Analysis Framework – utilizes freight data from both TMAS and HPMS.
- Highway Statistic Tables.
- FHWA Long-Term Pavement Performance (LTPP) and Long-Term Bridge Performance programs (LTBP)
- Environmental (noise and emission - DANA tool)

  Both weight and number of vehicles can greatly influence the noise and emissions for different roadway segments.

Studies Utilizing WIM Data

- AZ, CA, NM and TX are conducting a Pooled Fund Study entitled I-10 Connected Freight Corridor; the sharing of WIM data and other enforcement, over-size/over-weight permitting and truck parking information is included.
- FL study on pavements showed large savings in design cost when WIM data was used for local calibration of the design process vs. over designing with National values.
- MD, MN, PA, GA, MI, IN, NC, FL and many other states are using WIM data for MEPDG pavement design.
- LA DOTD TPF-5(242): Traffic Data Preparation for AASHTO MEPDG Analysis and Design done in 2017

https://www.pooledfund.org/Details/Study/470

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