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TRANSPORTATION RESEARCH BOARD

Benefitting from Weigh-in-Motion Data

October 21, 2020

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#TRBwebinar

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- TRB Standing Committee on Highway Traffic Monitoring (ACP70 - formerly ABJ35)
- Subcommittee on Weigh-In-Motion

https://sites.google.com/site/highwaytrafficmonitoring/home

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PDH Certification Information:

- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

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Learning Objectives

1. Identify uses of WIM data for highway programs and projects

2. Describe how other agencies use WIM data

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TRB Webinar

Many Uses and Benefits of Weigh-in-Motion Data

October 21, 2020

Use of Weigh-in-Motion Data for Improving Pavement, Bridge, Weight Enforcement, and Freight Logistics Practices

National Cooperative Highway Research Program (NCHRP)
Project 20-05, Synthesis Topic 50-03

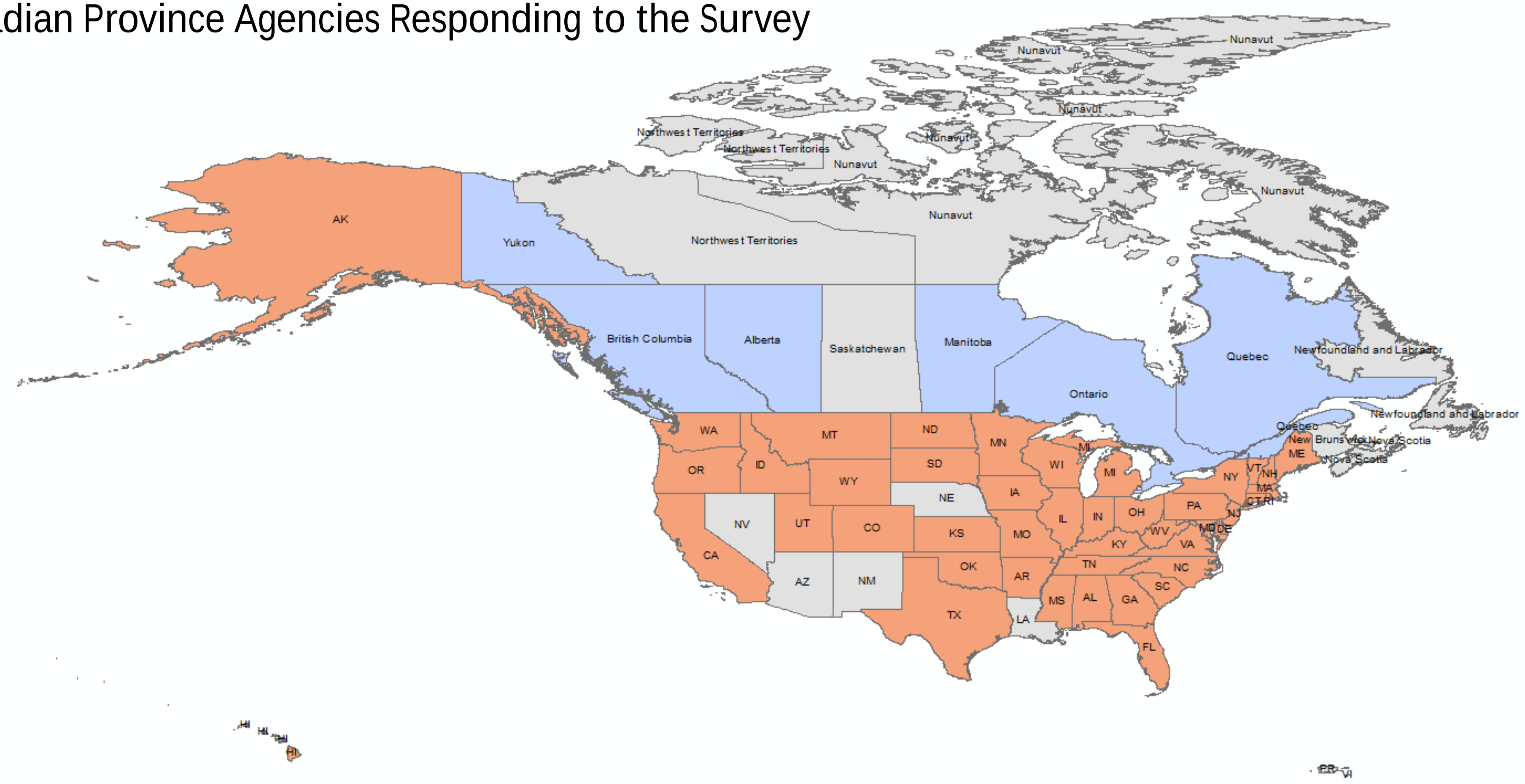
Darren Hazlett, Nan Jiang, and Lisa Loftus-Otway
The University of Texas at Austin – Center for Transportation Research

Methodology

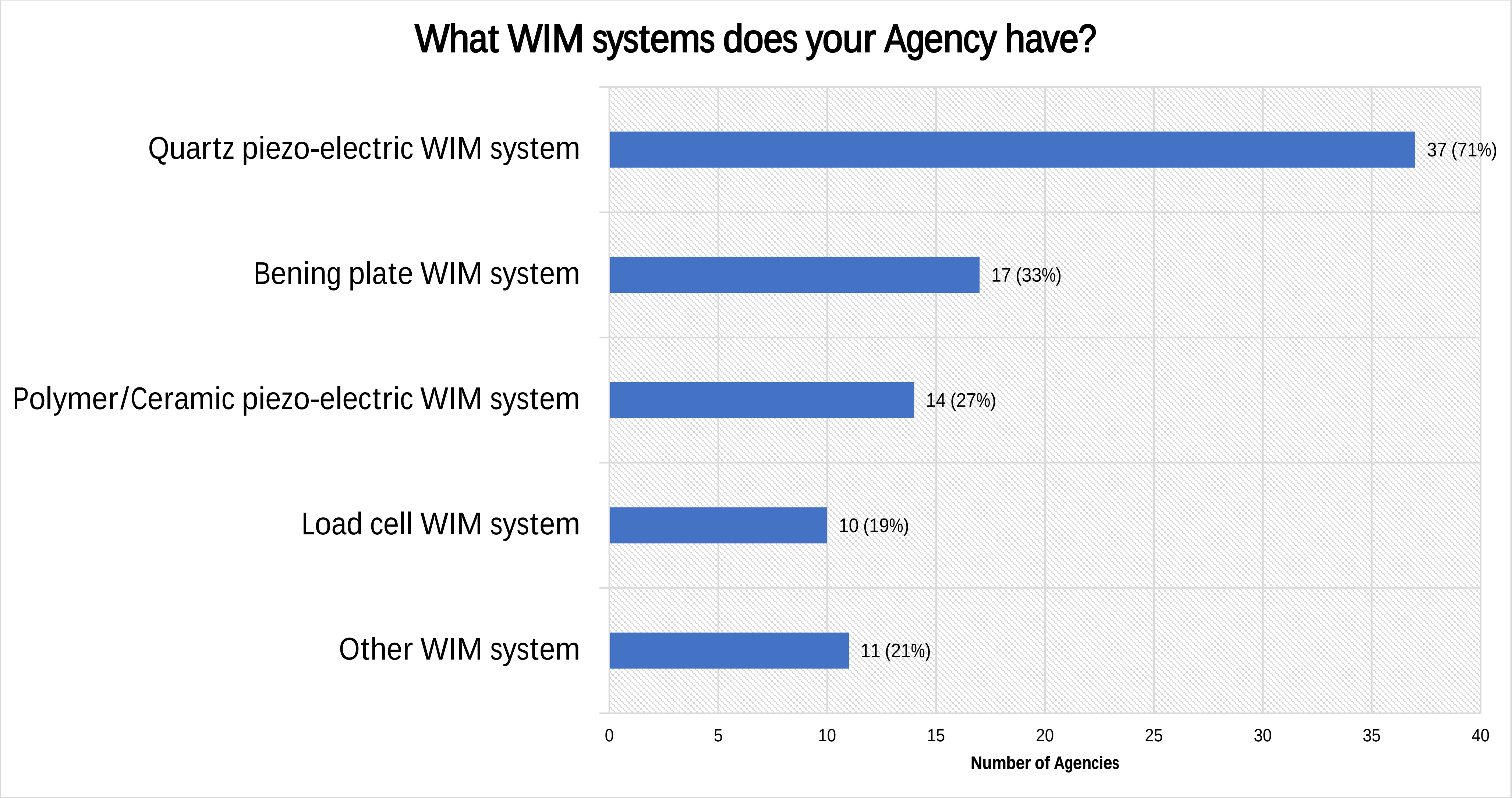
- Background
- Literature Review
- DOT Survey
- Case Studies (Interviews)
- Results and Conclusions

State of the Practice Survey

- US State Agencies Responding to the Survey
- Canadian Province Agencies Responding to the Survey



State of the Practice Survey



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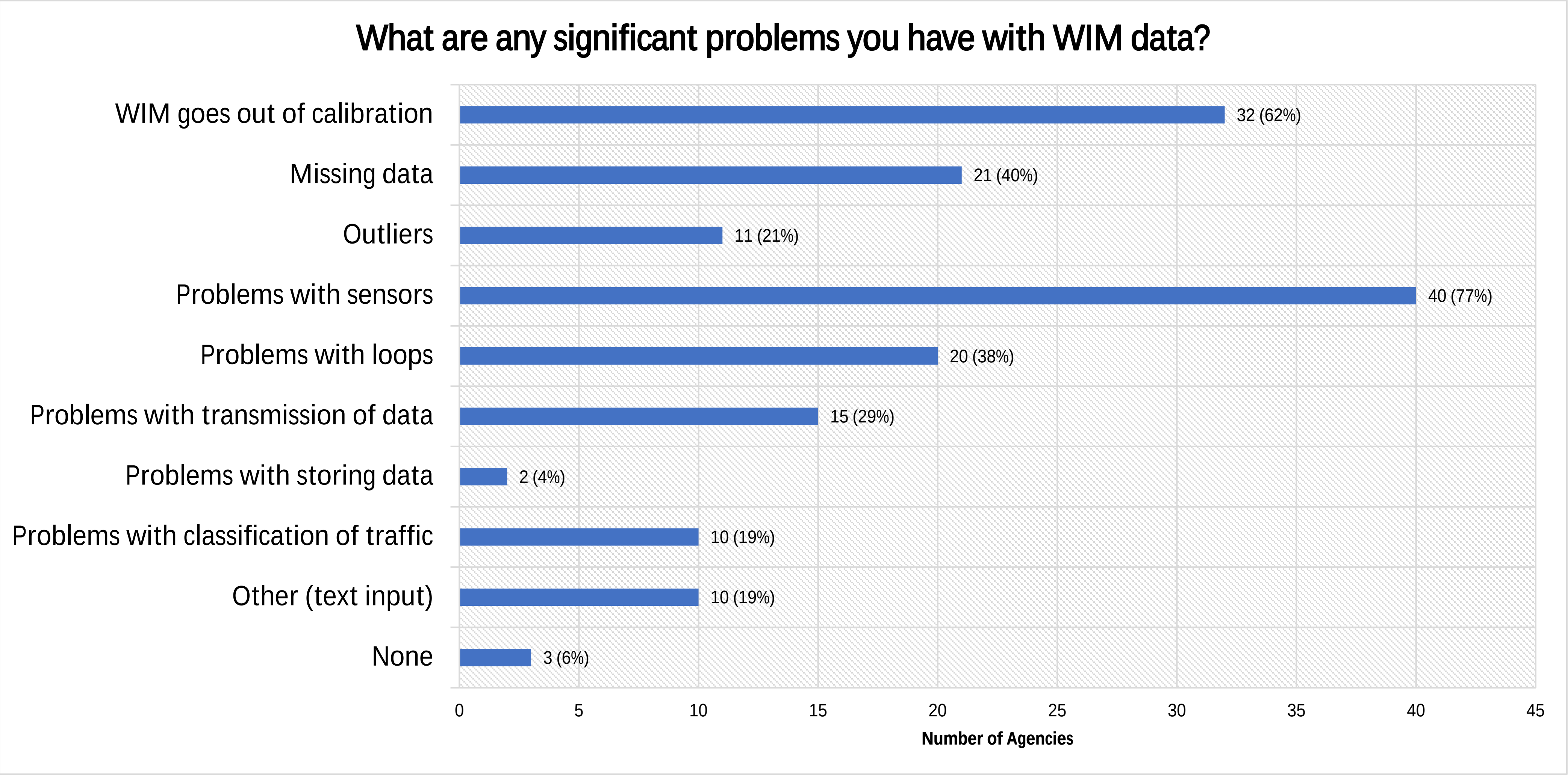

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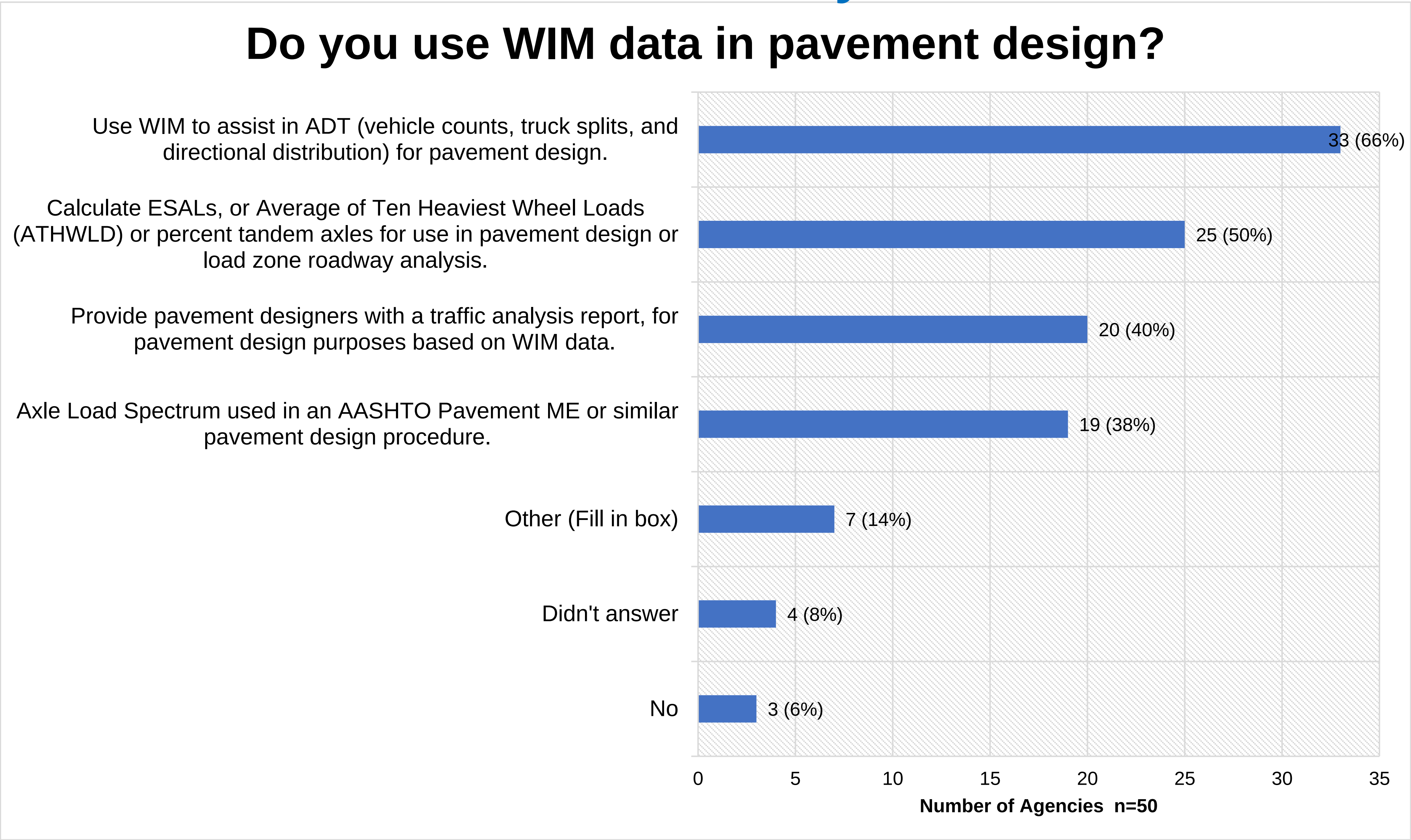

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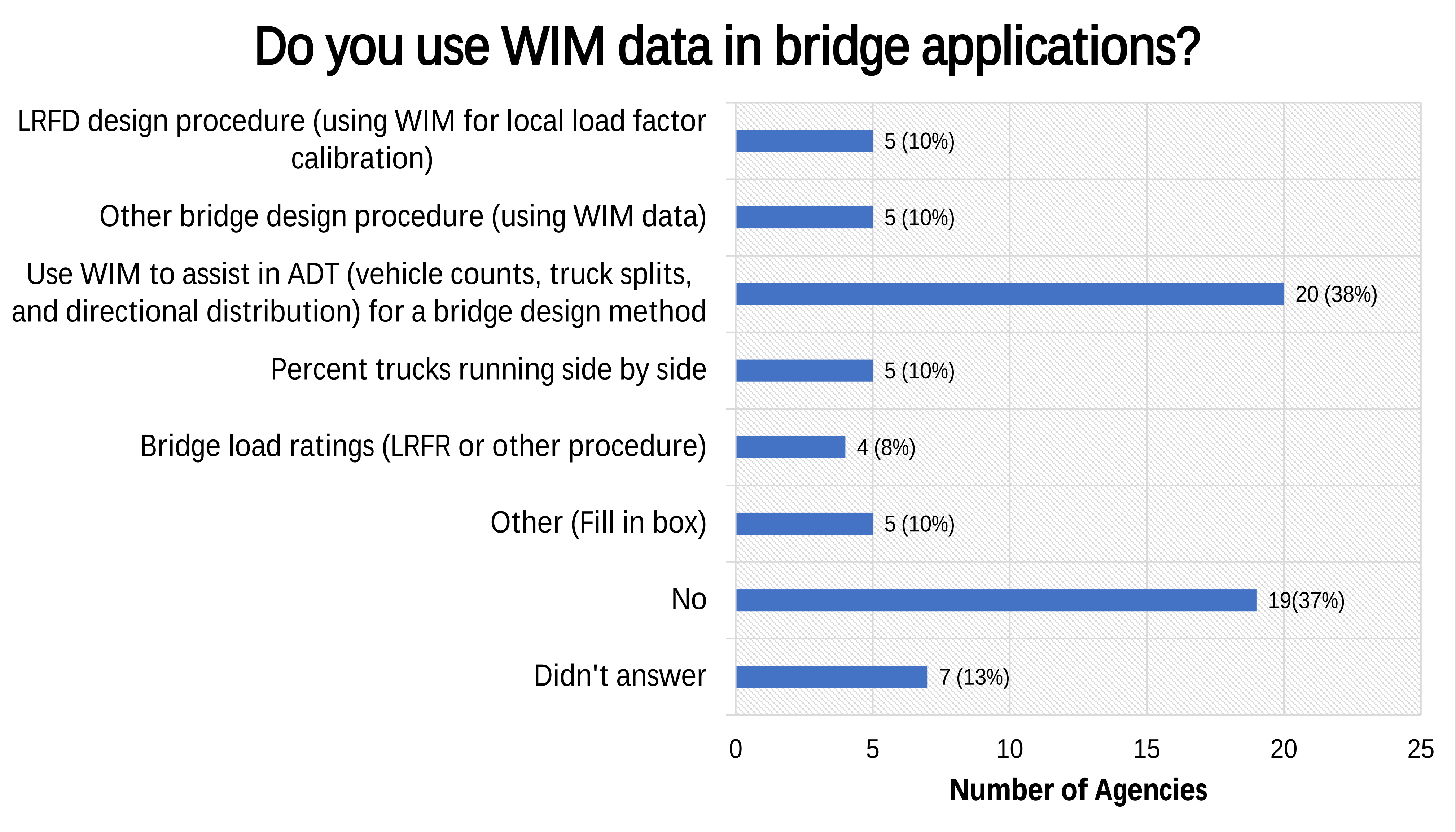

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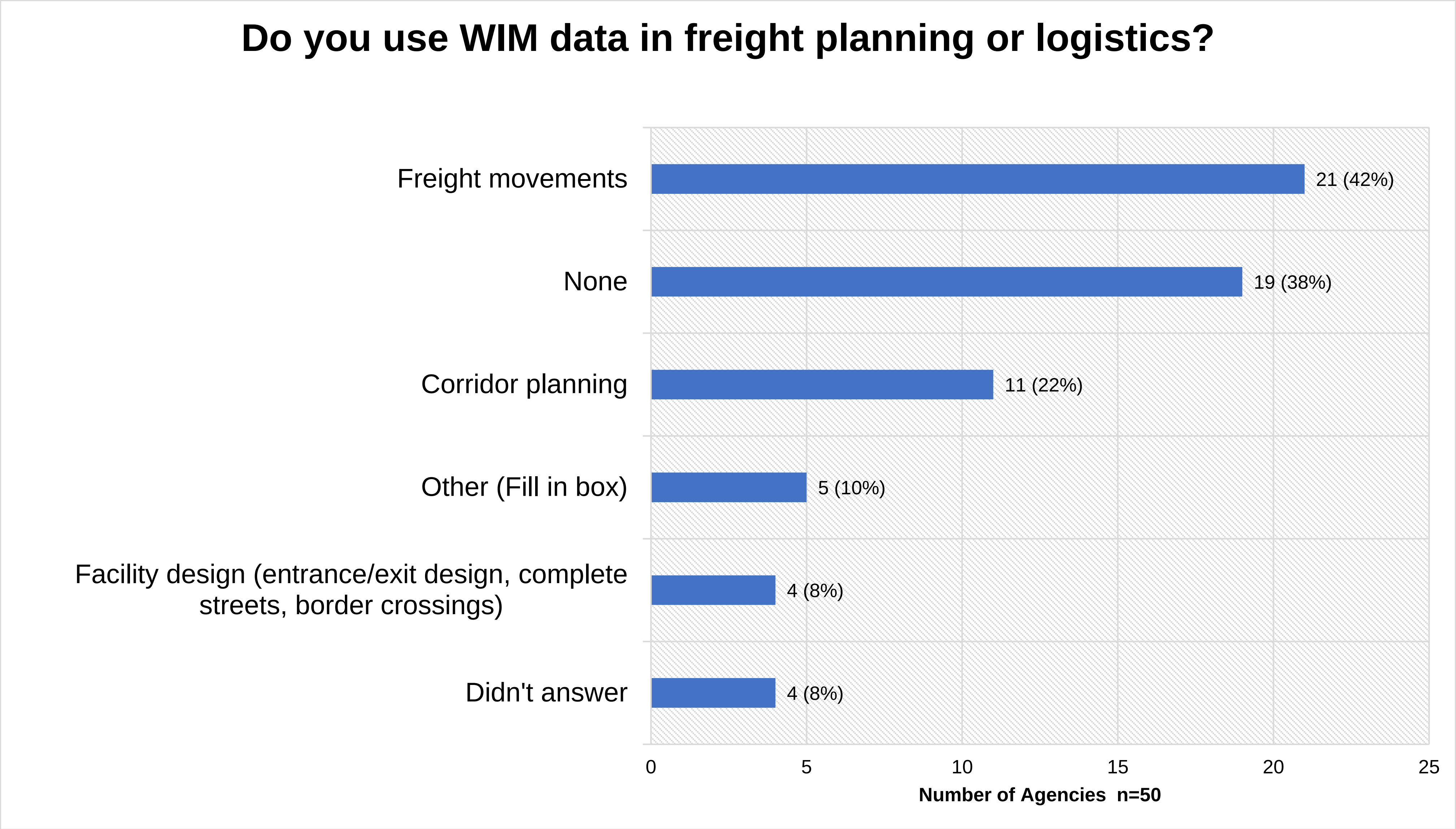


Survey

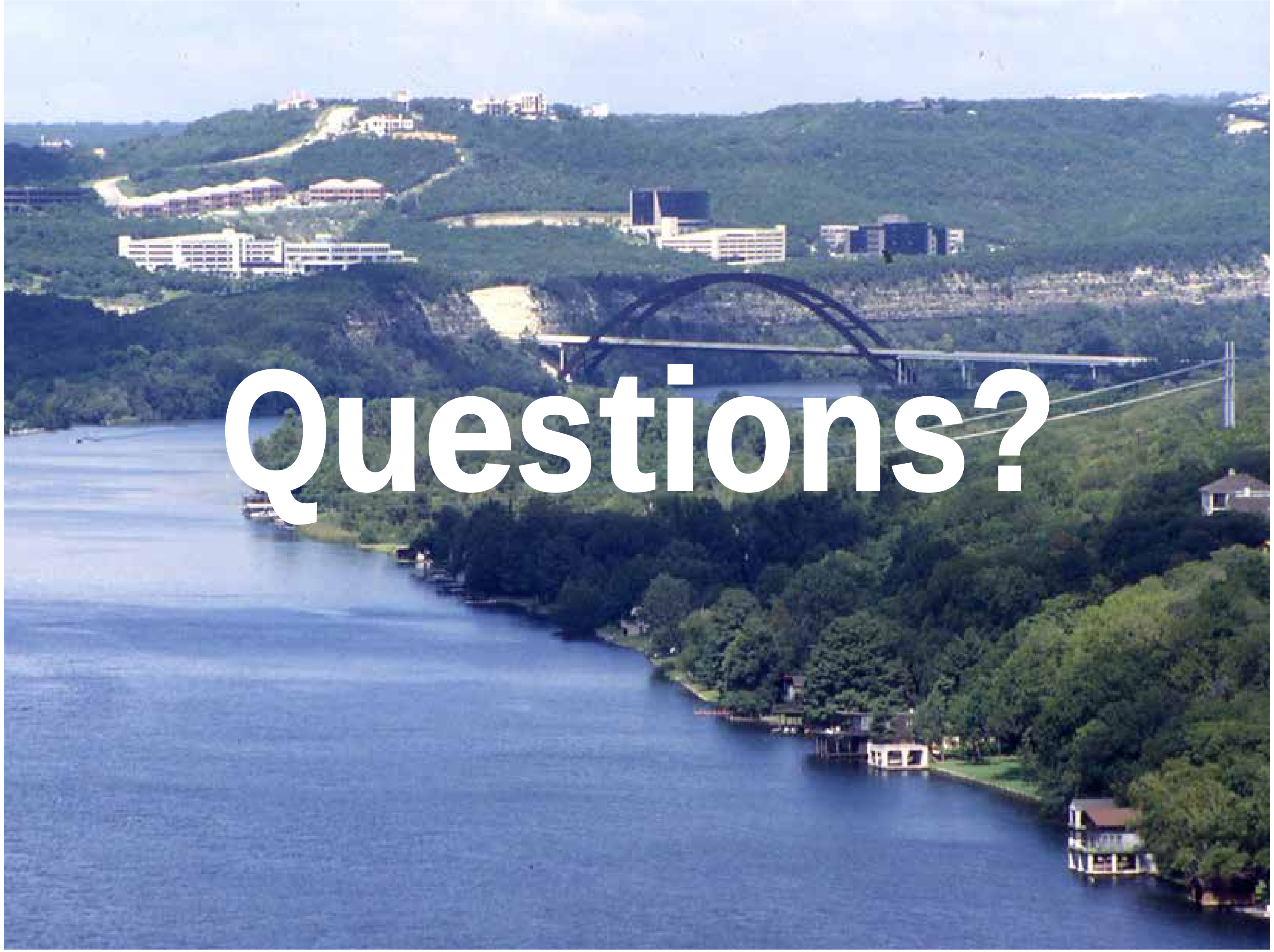
- Calibration is a concern
- One agency is actively using WIM data for freight planning, others are interested.
- May be opportunities to augment or even supplant WIM data with purchased freight and commodity data available from data aggregation and analytics (Big Data) companies.
- To obtain useful data, agencies need a sufficiently large WIM network, with enough stations.
- DOT staff collecting WIM data are sometimes unsure what is done with the data by others in the agency, and the DOT staff who could use the data do not know it is available or how it could help them.

Interviews - Caltrans, MnDOT, FDOT, Maryland DOT, and TDOT

- FDOT working with the U of F to use AI with WIM and image data to understand freight flows. This includes commodity type and load (empty, partial, and full trucks). This is an innovative use of the data that could benefit all DOTs.
- Caltrans is working on research with the University of California at Irvine to study whether more data can be collected using inductive loops to possibly study freight flows by truck type.

Knowledge Gaps and Research Areas

- Calibration.
- Optimize data collection.
- Visualization techniques may help users connect data across an agency. More research is needed to show the various internal divisions within transportation agencies the data and how it fits together to inform better decisions.
- Can additional databases can be acquired and used in freight planning, as well as the application of data mining and AI analysis of current data from WIM and other data collection sensors in a DOT’s network.


Questions?

TRB ABJ70 Webinar:
Benefiting From Weigh in Motion Data

Office of Highway Policy Information

The Value of WIM Data for DOT Programs

STEVEN JESSBERGER
USDOT/Federal Highway Administration
Office of Highway Policy Information
Travel Monitoring and Surveys Division

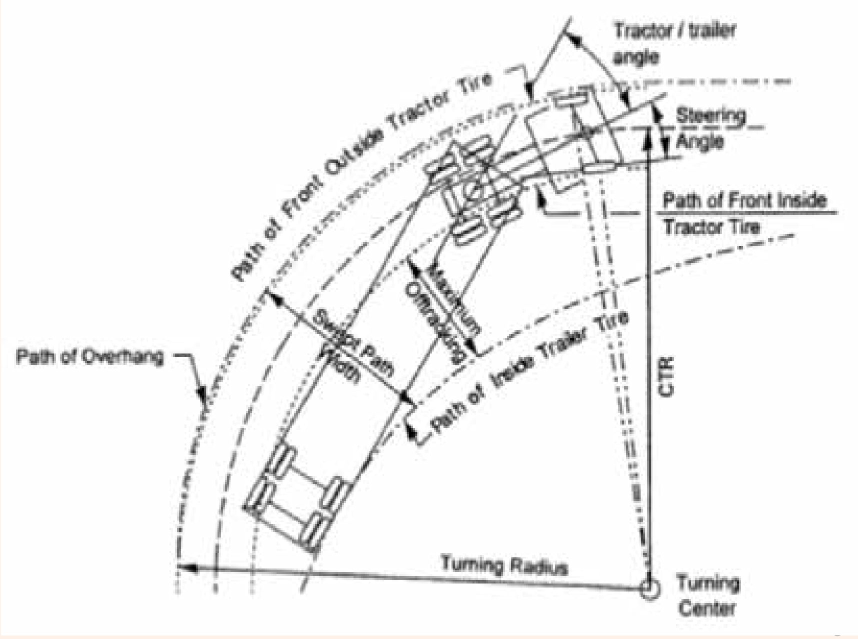
Benefits from WIM Data

- 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 with 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 4th 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

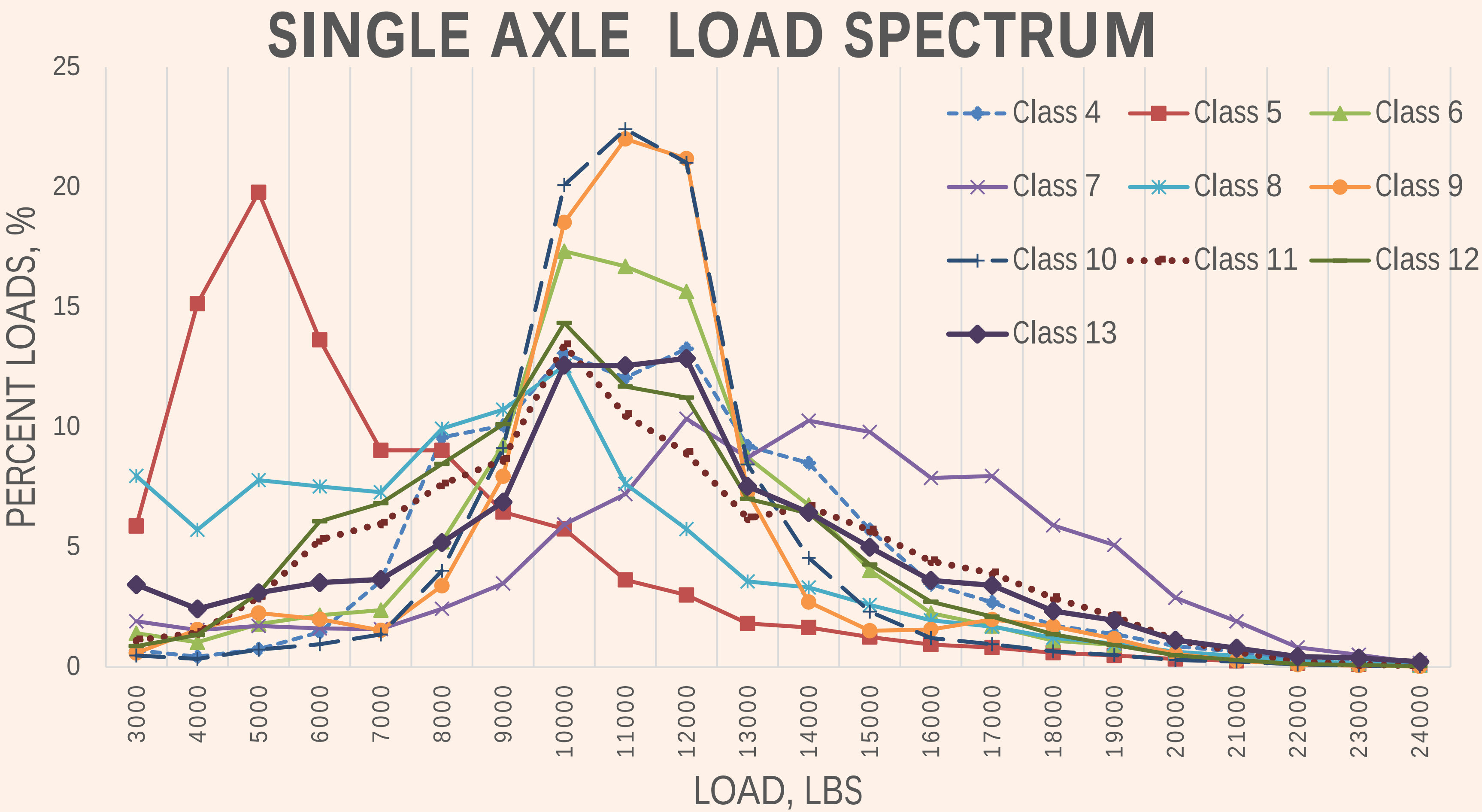
- Truck Volumes
  - Lane distribution
  - Directional distribution
  - Class distribution
  - By hour distribution
  - Growth factors by vehicle class
  - Tire width and tire wander

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

Office of Highway Policy Information



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

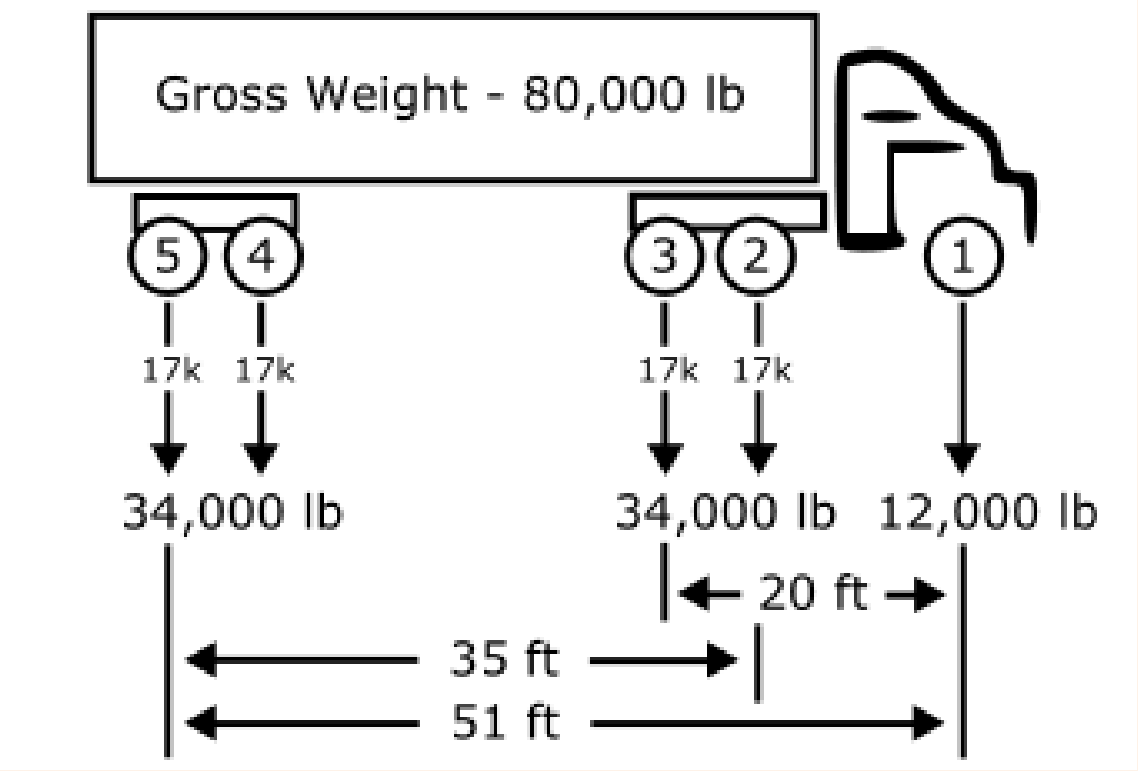
$$W = 500\left[\frac{LN}{N-1} + 12N + 36\right]$$

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

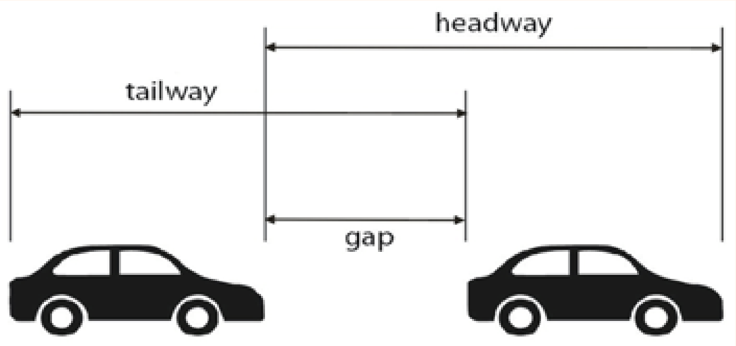


- Axles 1 to 5, W=500*(51*5/(5-1)+12*5+36)=80,000 lbs
- Axles 2 to 5, W=500*(35*4/(4-1)+12*4+36)=65,500 lbs

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)

  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

Contacts

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October 21, 2020

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TRB WIM Workshop
Benefitting from Weigh-in-Motion Data

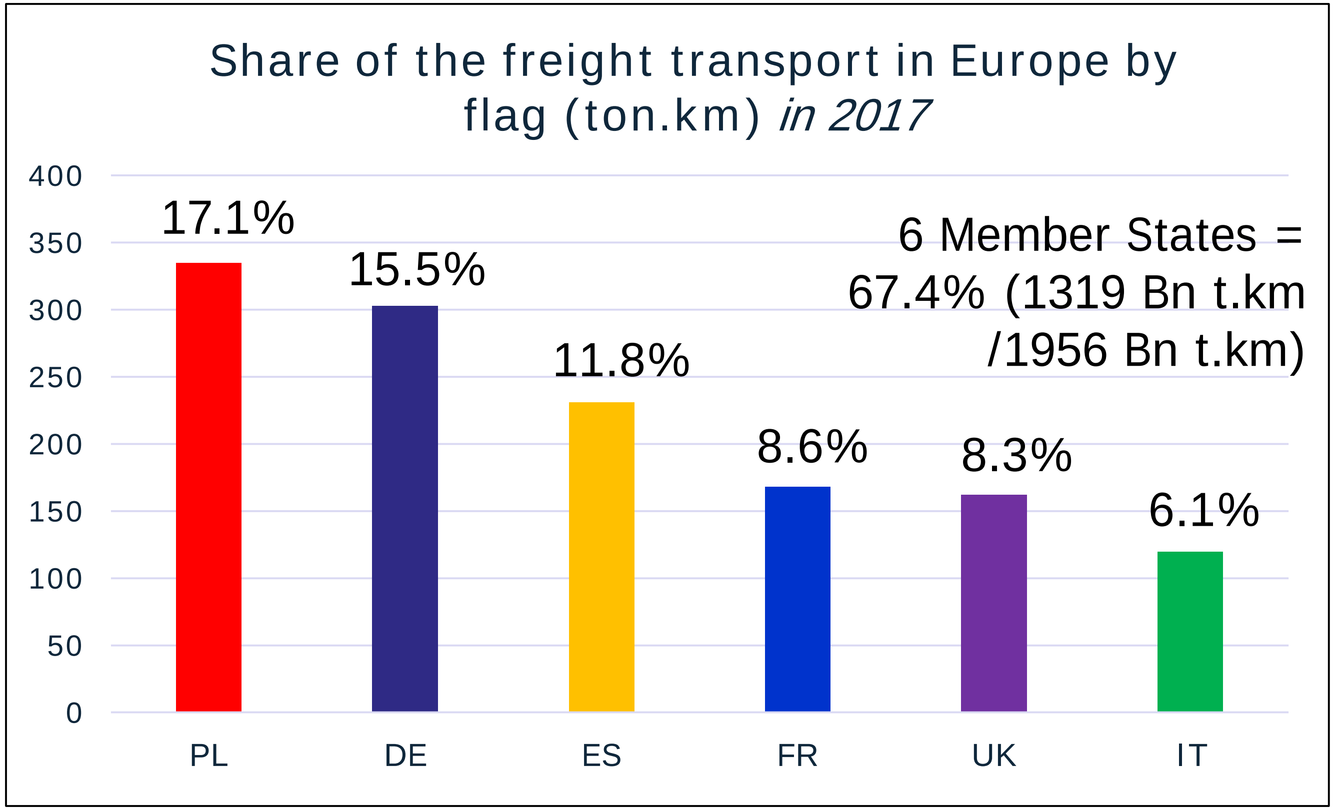
Highway Traffic Monitoring (ACP70)

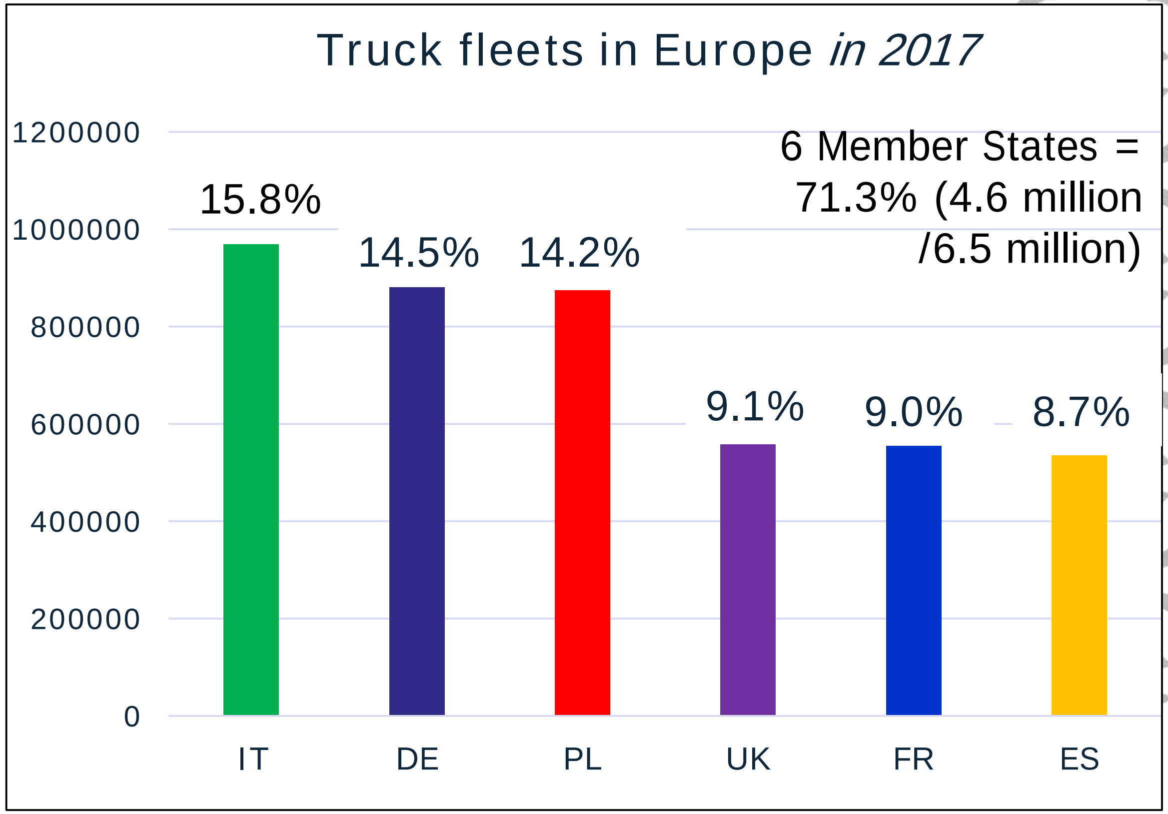
Use of WIM Data in Europe

Bernard Jacob
Vice-president Science, ISWIM
University Gustave Eiffel, France

Table of Content

Road Freight Transport in Europe (Facts and Figures)





- ❖ 77% of the in-land freight is carried by road
- ❖ 35% is made of International transport (t.km)
- ❖ 75% of t.km over medium/long distance (> 150 km)
- ❖ 85% of tonnage carried over < 150 km, 1% over > 1000 km

WIM Data Collection and Applications

- Data collection 24/24, 7/7 without staff required
- All vehicles in the equipped lanes are weighed
- Discrete and safe, quick installation, low intrusive
- Allows to assess infrastructure wear (e.g. fatigue) and to forecast maintenance works
- Allows to develop and (re)calibrate loading codes
- Allows monitoring the road freight transport activity and heavy traffic on a road network
- Helps to ensure a better compliance of weights and sizes of HGVs, thus to increase road safety, infrastructure durability and to guarantee a fair competition in freight transport

Accuracy of WIM Systems (COST323) by Application

- Heavy traffic monitoring, statistics on road freight movements, HGVs, etc.: low accuracy = C(15) to D(25), but no bias
- Infrastructure assessment (pavement, bridge, extreme loads and fatigue assessment): medium accuracy = B(10) to C(15), high scattering may lead to biased assessments (non-linearity in fatigue)
- Overloads screening: high accuracy = B+(7) or B(10), possible adjustment of the threshold of overload detection
- Direct enforcement: very high accuracy = A(5) + Legal metrology certification: OIML class 5 or 10, m.p.e. instead of statistical approach (100% of the data in the tolerances)

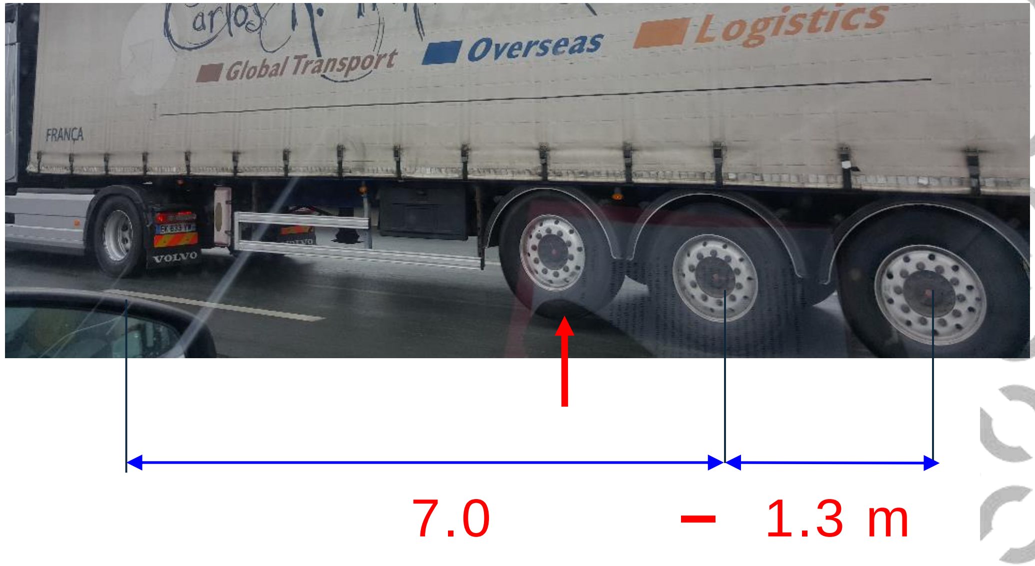
Road Safety: Truck Spacing Monitoring on a Motorway (A63, Atlandes, France)

Direction	Dist	Day	Night
North > South	25-50m	7.1%	3.1%
	5 à 25m	1.9%	0.8%
	Link	0.1%	0.2%
	>= 50m	90.8%	95.9%
South > North	25-50m	7.5%	4.8%
	5 à 25m	2.1%	1.4%
	Link	0.2%	0.2%
	>= 50m	90.1%	93.6%

- Flow > 4,400 trucks/day/direction
- Route: France ↔ Spain

- Truck spacing (free traffic)
- *Wild platooning*, without automation nor connectivity
- ⇒ Safety risk

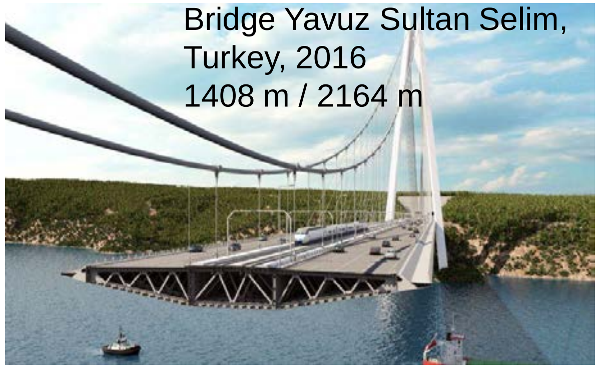
Traffic Monitoring: Lifted Axles Counting



- ❖ Deviation from the mean spacing may reveal a lifted axle (low std dev. of the axle spacing)
- ❖ Robustness depends on the silhouette (high for T2S3)

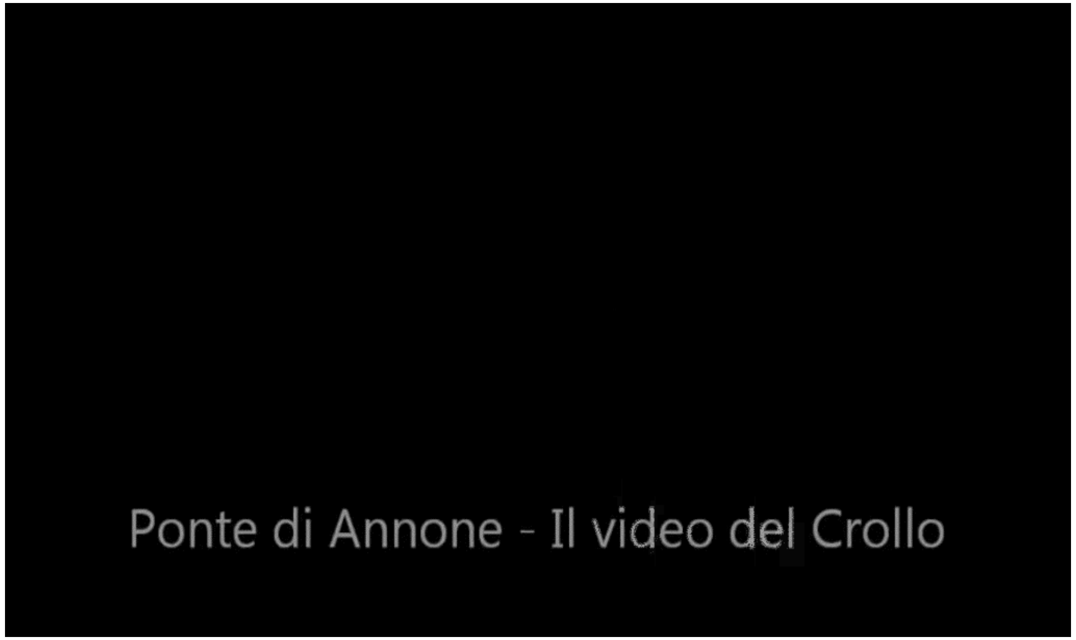
Bridge Issues - Evolution

- Bridges are lighter with high performant materials, more accurate design, economy of material and energy, while traffic loads continuously increase
  $\Rightarrow$ increase of the ratio: LIVE LOAD/DEAD LOAD
- Long span bridges are sensitive to the accumulation of heavy vehicles, shorter ones to single trucks
- Fatigue can affect steel and composite bridges
- Not all the bridge collapses result from overload, but overloads increase risks
- Traffic loads are not fully known (time history, load pattern)
- The bridge safety factors are progressively and implicitly decreasing (material aging + load increase)



Bridge Collapses under Overloads

Mirepoix, 2019



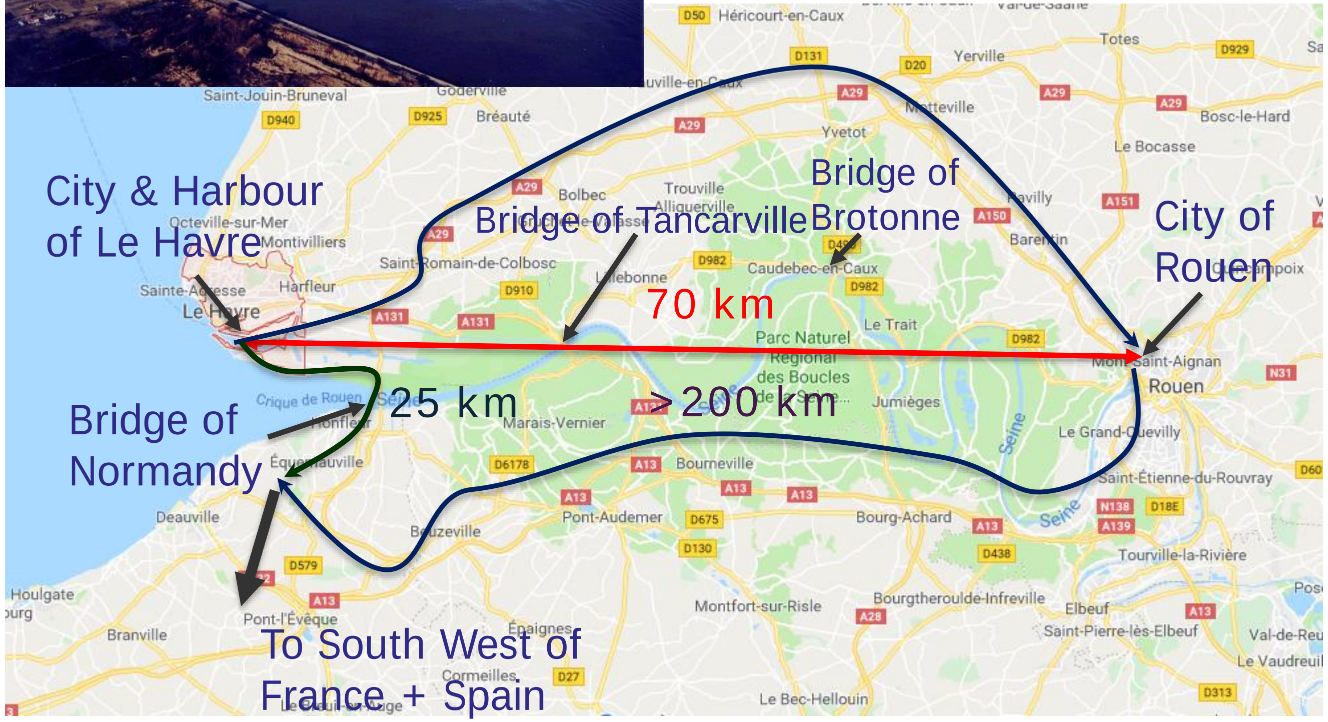
- Some bridges are aging, with limited load capacity
- Overload may cause bridge collapses:
  - Sully s/Loire (France, 1986)
  - Mirepoix (France 2019)
  - Annone (Italy, 2018)
  - Aulla (Italy, 2020)

Sully s/Loire, 1986

Aulla, 2020

Abnormal Loads on a long Span Cable-stayed Bridge (Normandy) - Challenge

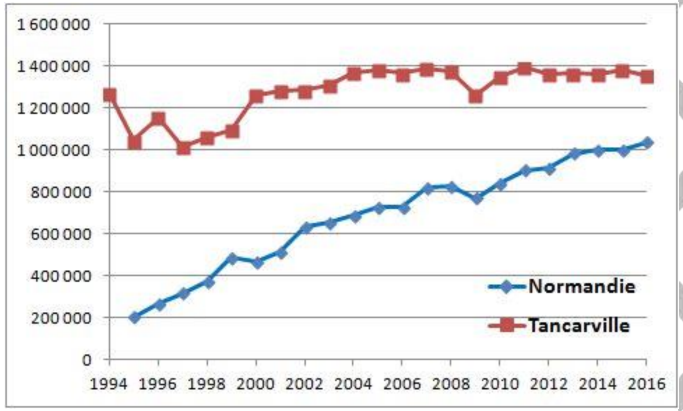
- Bridge of Normandy: opened in 1995 over the Seine river, cable-stayed 856 m (main span), total length 2.1 km, orthotropic steel deck sensitive to fatigue
- Maximum allowed GVW: 44 t, toll bridge

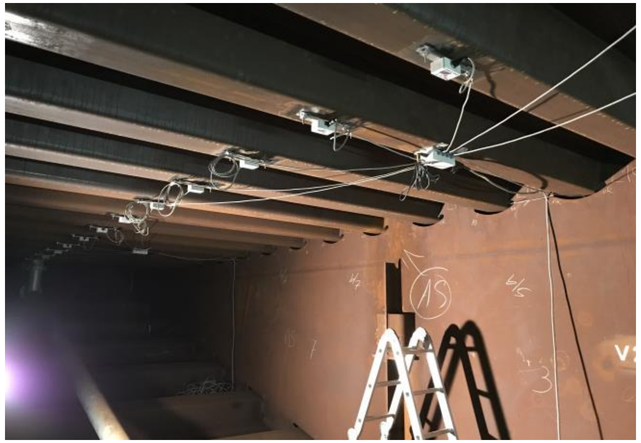


- 2018: requirement to study the feasibility to open the bridge to abnormal loads up to 120 t
- to shorten the route from/to the harbor of Le Havre by 90% avoiding to cross the city of Rouen
- Question mark of the concessionary (Chamber of Commerce of Le Havre)

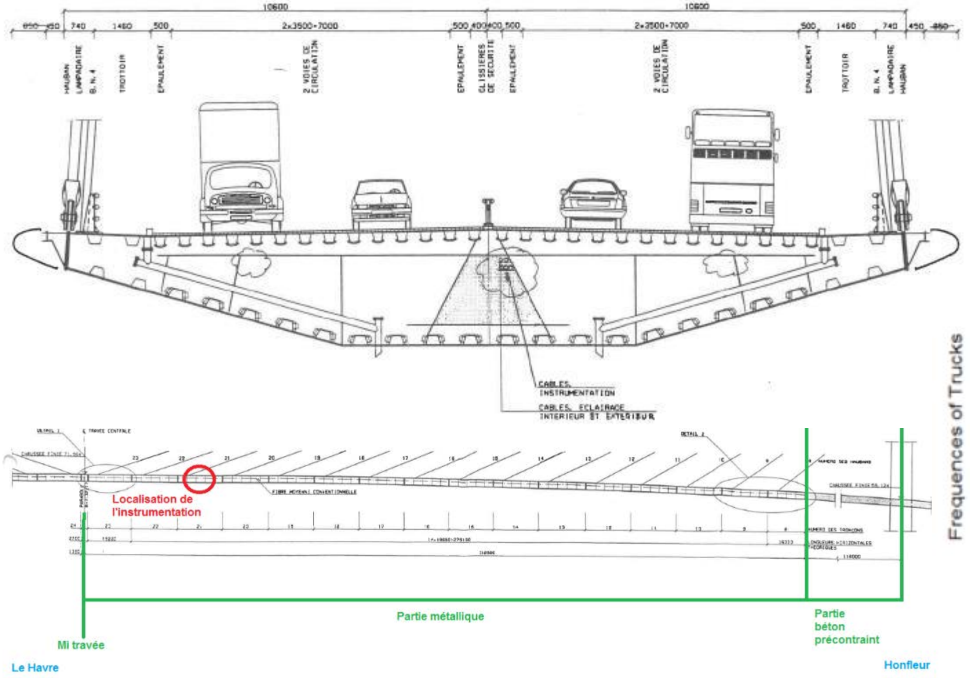
Instrumentation and WIM Data Collection

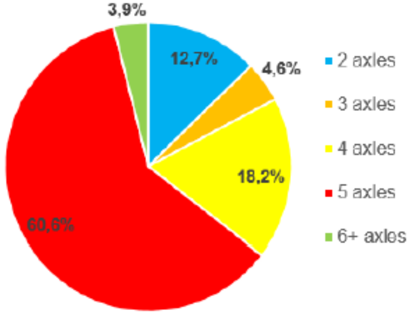
- ❖ Loading assessment: traffic flow increased
- ❖ Use of B-WIM to assess the current traffic loads
- ❖ Calibration, accuracy assessment and WIM data collection over 6 months:
  - ➢ Rather low accuracy COST323 D(25)
  - ➢ Sufficient for fatigue assessment

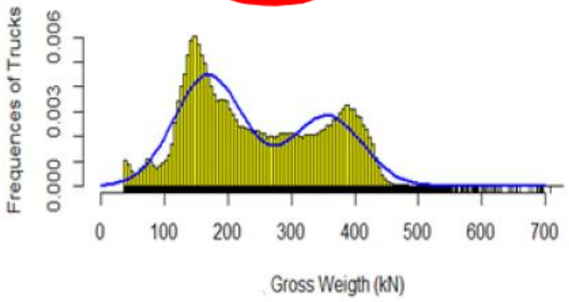




B-WIM (SiWIM) installed in July 2017







Application of different Loadings

- 4 traffics considered (recorded WIM data), with various aggressiveness

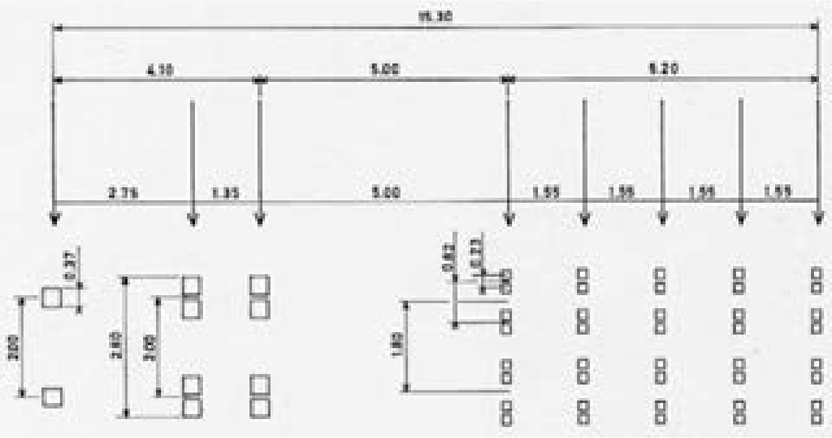
measured over 6-12 months

Site	Dates	Nb days	Nb trucks	Mean flow trucks/day	Proportion . 2^{nd} mode	Median 2^{nd} mode (kN)	St. Dev. 2^{nd} mode (kN)
Normandy (A29)	7/17-1/18	189	224354	1187	40%	350	50
Massay (A20)	2015	362	498269	1376	20%	384	27
Maulan (RN4)	2015	353	755757	2141	28%	383	30
Fabrègues (A9)	1-6/2015	189	901231	4768	40%	371	26

- 4 abnormal loads: 2 cranes + 2 conventional abnormal load models


Crane 1: 96 t

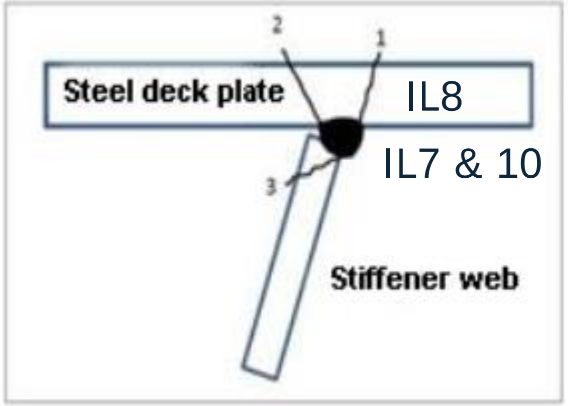

Crane 2: 108 t

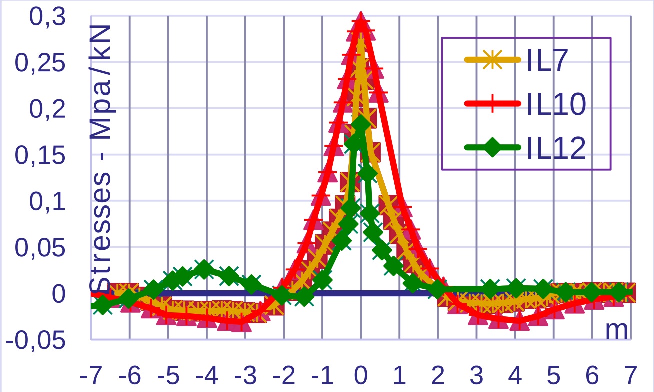


Models:
94 t – 120 t
8 axles
6-12-12.8 t
7-12.75-17.5 t

Fatigue: Impact of Abnormal Loads on Lifetime

- ❖ Details analyzed: weld between the deck plate and the stiffener web
- ❖ Influence lines of the most critical details (stiffeners) analyzed
- ❖ Lifetime calculations using Miner law (class 71) for each traffic flow…
  - ❖ … for the abnormal loads (2 runs per day/direction) of each
  - ❖ Assessment of the lifetime reduction (in %)





Infl. line	Crane 1 (96 t)	Crane 2 (108 t)	C1 (94 t)	C2 (120 t)
IL7	9.778 (1.53%)	9.530 (1.57%)	13.754 (1.10%)	4.124 (3.56%)
IL10	4.349 (0.78%)	4.348 (0.78%)	5.354 (0.63%)	2.140 (1.57%)
IL8	13.238 (2.59%)	13.140 (2.61%)	19.976 (1.73%)	6.280 (5.30%)

Traffic	A29	A20	RN4	A9
IL7	254	296	274	75
IL10	57	40	33	10
IL8	586	588	573	113

	A29	4 AL	Final	red.
IL7	254	3190	235	7.37%
IL10	57	1496	55	3.67%
IL8	586	4618	520	11.3%

The Netherlands/Rotterdam
Van Brienenoord Bridge

Determination of ULS & fatigue spectrum as an input for recalculation and determination of the rest life of the bridge and the design of reinforcement operations

Both bridges instrumented with OSMOS Optical Strands
Eastern bridge : 51 strands
Western bridge : 12 strands

Mitigation of Overloads on Bridges

- Most of overloaded vehicles cross bridges illegally periodically above all on secondary roads
  - thus, monitoring continuously bridge crossings will allow to detect the first overloads, identify the vehicles (camera…) and take preventive measures (e.g. company warnings)…
  - … or to take measures afterwards, but before the bridge collapse

- Identification of illegal crossings can allow targeted checks nearby the bridge

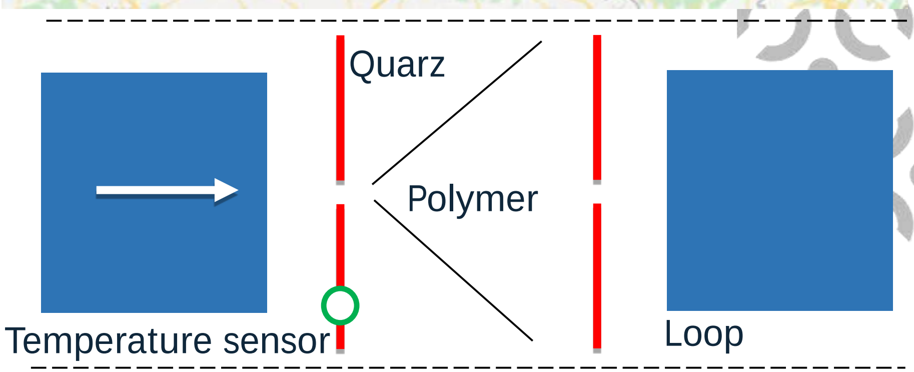
- On main highways/motorways, most bridges are well designed even against overloads (partial safety factors). However, direct enforcement can dissuade overloading.

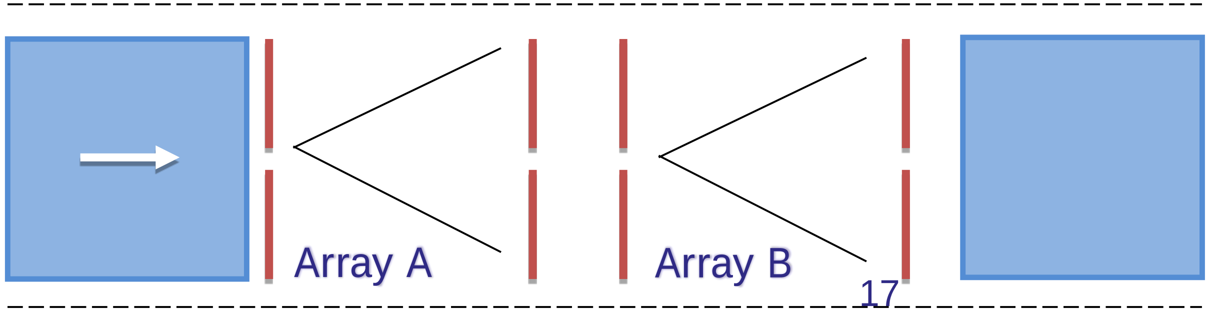
WIM for Direct Enforcement

- Two EU Member States already implemented HS-WIM for direct enforcement: Czech Republic (since 2011-13) and Hungary (2017). However, the type approval procedure does not fully meet the OIML R-134 requirements (95% of measurements within the tolerances)
- Three more EU Member States are engaged in the process:
  - Belgium: research works & tests since 2016, SPW, on-going process of type approval on an open motorway with one system/2 lanes, Sterela
  - France: National research project (2014-...), DoT (DGITM) + IFSTTAR/Univ Gustave Eiffel + Cerema, phase 1 (feasibility, tests of sensors and systems – Kapsch + Sterela - done, phase 2 in progress (type approval procedure)
  - Germany: BAST is managing R&D works with Univ. Aachen and Neurosoft to develop a methodology and a type approval process

Belgium - SPW (1)

- ❖ 5 WIM systems installed since 2015 for pre-selection
  - ➢ ~ 9 millions trucks and light commercial vehicles (vans) weighed per year
  - ➢ Overload rates: van (max 3.5t) : ~31%
    5-axles articulated (GVW 44 t, axle 12 t) : ~10%
  - ➢ > 95% of selected vehicles are penalized (but special permits and doubtful measurements)
- ❖ Royal decree: approval, verification and installation of measuring instruments used to monitor enforcement of the law relating to road traffic
- ❖ Deliver a type approval HS-WIM system for direct enforcement (OIML R-134)
- ❖ Validation method using a second WIM array (Array B)





Belgium - SPW (2)

❖ Results of 6-month test on a motorway

Start Period	End period	Calibration	Conditions
September 2019	February 2020	Yes	II-R2**

Type of vehicles	Validated vehicles (out of)	Mean	Std. dev.	Accuracy	Confidence level	Out of tolerance
		%	%	%	%	
T2S3	182 (404)	0.33	1.49	5	99.999	0
U2	186 (188)	-4.61	2.83	10	99.977	0

Accuracy according to the COST323. Test conditions: full environmental reproducibility conditions Confidence level from a statistical Gaussian distribution.

❖ Type approval tests are in progress since May 2020, according to Specs by Sterela + METAS, to be approved by the Walloon Legal Metrology from Belgium

❖ OIML class 5 for 5-axle trucks, class 10 for vans

❖ Objective: direct enforcement implemented in 2021

France – Direct Enforcement by WIM

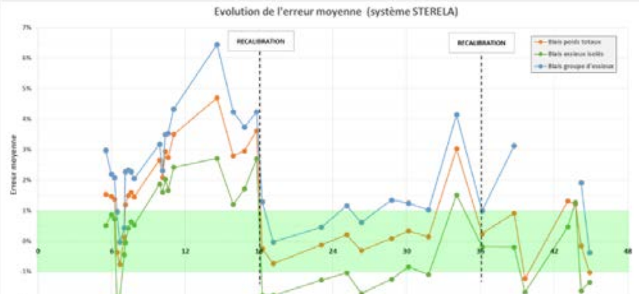
- 2014-16: lab and Accelerated Pavement Testing (APT) tests (Nantes) of several WIM sensors (piezoquarz, piezoceramic and piezopolymer)

	Quarz	Ceramic	Polymer
Lab: bending / Transv. location	0,04 % / 1.7%	1-5 % / no test	1-3 % / noise 3%
APT: speed / temp. / transv loc Total	1 / 3-4 / 5 % 10 %	2 / 1 / 11 % 17%	10 / 25 / 16 % 35%

⇒ only the piezoquarz are eligible for direct enforcement

- 2015-2019: on-road tests on motorway (A4, Saint-Avold) in eastern France:
  - 2 manufactured WIM systems by Kapsch and Sterela tested
  - 1585 vehicles weighed in motion and in static on approved scales, 68% T2S3, 18.5% vans
  - In 2018-19: both systems in class A(5) COST323 for 4+ axle trucks, A(10) for vans tolerances of the OIML class 5E met for 97-98% of the vehicles

System entity	Tolerance class OIML 5E	Kapsch		Sterela	
		Number	Out of tolerance	Number	Out of tolerance
Gross weight	±5%	522	18 (3.45 %)	236	5 (2.12 %)
Group of axles	±8%	531	5 (0.94 %)	240	3 (1.25 %)
Single axle	±8%	1031	16 (1.55 %)	462	9 (1.95 %)



Mean bias over time – 2 recalibrations

- 2019-2020: development of a type approval procedure

Conclusions and Perspectives

- Interest of WIM data for traffic monitoring and road safety by operators
- Bridge damage/collapse mitigation by WIM (overload ban)
  - Main concerns about bridge safety under overloaded trucks
  - Aging bridge stock in Europe, budget cuts for maintenance and repair
  - More flexibility for abnormal loads, permanent permits
  - Several bridge collapses or major damages and closure since 10-15 years

  ⇒ Use of WIM systems to identify overloads on weak bridges + company warning/profiling + adapted penalties (up to loss of reputation)
- Direct enforcement by WIM
  - On-going revision of the OIML R-134: ISWIM and several EU countries involved
  - Main challenge for the near future
  - Several issues still to be discussed: tolerances for type approval tests and initial verification, on-road tests vs dedicated test site, types of vehicles in the scope (e.g. vans?), range of approval (overloaded vehicles only?), etc.
  - ISWIM involved as an organization in liaison with the TC9/SC2/p11

Thank you for your attention

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