Weigh-in-Motion (WIM) Systems

OM 1

Photo: Courtesy of Dr. Taek Kwon, University of Minnesota - Duluth

Description: State departments of transportation (DOTs) monitor the weights of commercial vehicles to ensure compliance and collect weight data essential to facility (particularly pavement) design, using tools such as weigh-in-motion (WIM) systems. Ensuring the weight of a commercial vehicle helps to address 1) crash risk and severity (e.g., truck rollovers, braking failure, loss of maneuverability, tire blow-outs), 2) damage to infrastructure (pavement deterioration), and 3) economic competitiveness (fair rules for rail, water, and road freight transportation). Traditionally, WIM sites have been challenged by high costs and truckers bypassing permanent sites; therefore, more recently, some portable, low-cost alternatives and virtual WIM applications have been proposed.

Rural Transportation Critical Needs

- ☐ Crash Countermeasures
- ☐ Emergency Services
- ☑ Operations & Maintenance
- ☐ Rural Transit & Mobility
- ☐ Surface Transportation & Weather
- ☐ Tourism & Travel Information
- ☑ Traffic Management

Issues Addressed

- ☐ Resource mapping & monitoring
- ☐ Central data storage
- ☐ Icing of roads
- ☐ Avalanches
- ☐ Maintaining cameras
- ☑ Commercial vehicles
- ☐ Prioritizing snow removal

Strategies Achieved

- ☑ Road User
- ☑ Road
- ☑ Vehicle
- ☐ Safety Culture
- ☑ Engineering
- ☐ Emergency Response
- ☑ Enforcement
- ☐ Education

Applicability

- Weigh-in-motion enforcement activities are very applicable to rural areas, as long-haul trucking operators will travel most of their distance on rural roads. Furthermore, trucks use rural roadways for agriculture and mining purposes. Weigh-in-motion systems are advantageous to both the trucker and a DOT, as they reduce delay, thereby encouraging compliance.

Partnerships

- Applications benefit from collaboration among numerous agencies, which may include:
  - Departments of transportation (local, state, federal)
  - Law enforcement
  - Trucking companies
  - Federal Motor Carrier Safety Administration (FMCSA)

Key Components

- Permanent weigh-in-motion (WIM)
  - In-pavement sensors and conduit
  - Shoulder-mounted pull boxes
  - Cabinet to house electronics
  - Electronic controller
  - Communication (wireless or hard line)
- Virtual WIM
  - Bending plate WIM scale
  - Vehicle detection system
  - Camera triggering system
- Low-cost WIM
  - Micro Tower PC, 8G RAM; Intel i-5, Win-7
  - 16bit ADC, 200 Samples/Sec
  - USB Thermocouple
  - 50-pin Screw Terminal
  - 50-Conductor Ribbon Cable
  - 2-Channel Charge Amplifier and Enclosure

Examples of Implementation

- **Indiana Department of Transportation's (INDOT) Virtual Weigh-in-Motion**

The INDOT has three virtual weigh-in-motion (WIM) sites. A study that evaluated them found them to be fifty-five times more efficient at citing overweights than that of traditional WIM.

- **New York Department of Transportation Thruway Authority**

The New York Department of Transportation Thruway Authority uses weigh-in-motion devices to assist with tracking unpermitted overweight vehicles, thereby allowing State Police to enforce violations.

- **Florida's Virtual Weigh Station**

Florida installed the Punta Gorda Virtual Weigh-in-Motion ByPass System. The system makes use of closed-circuit television to review drivers' license plates.

- **Arkansas, US 64, Virtual Weigh Station**

A virtual weigh-station was proposed on US 64 to discourage truckers from trying to bypass the permanent weigh-station installation on the interstate.

- **Caltrans' Virtual Weigh Station**

Caltrans installed a pilot virtual weigh station in Cordelia, California. The pilot results were promising; with anticipated benefits including reduced infrastructure damage. The system was functional in all but severe weather conditions and therefore Caltrans planned to install additional stations.

Implementation Considerations (Pro)

- Helps to reduce delay to commercial truck movement.
- Helps to ensure that compliant truckers are not penalized by delaying them (often non-compliant truckers are the ones who circumvent weigh stations).
- Addresses safety concerns with commercial vehicles on roadways.
- Collects unbiased (i.e. relative to weigh station bypass) and continuous data (i.e. 24/7) for use in infrastructure pavement design.

Implementation Considerations (Con)

- Permanent weigh-in-motion (WIM) stations are expensive.
- The accuracy of many high-speed WIM systems is a concern.
- Data on weather needs to be recorded to make use of low-cost WIM alternatives; weather changes can impact the accuracy of the measured weight.

Opportunities for Future Expansion

- As efforts for deploying connected vehicles advance, advanced truck load monitoring systems will be integrated on-board (a.k.a. on-board weigh-in-motion).

Additional Resources

- *Virtual Weigh-in-Motion Infrastructure Overview*, found here: https://purr.purdue.edu/publications/2340/1
- *Long-Term Bridge Performance (LTBP) Program's Literature Review on Weigh-in-Motion Systems*, found here: https://www.fhwa.dot.gov/publications/research/infrastructure/structures/ltbp/16024/16024.pdf
- Bernard, J. and V. Feypell-de La Beaumelle. (2010*). Improving truck safety: Potential of weigh-in-motion technology* – this paper presents a good discussion of the variety of weigh-in-motion systems over time and future technological improvements to weigh-in-motion systems, found here: http://www.sciencedirect.com/science/article/pii/S038611121000004X
- *International Society for Weigh-in-Motion*, found here: http://www.is-wim.org/index.php?nm=0&nsm=0&lg=en
- *Implementation and Evaluation of a Low-Cost Weigh-in-Motion System*, found here: http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=2512

Useful Tip

A research project through the University of Minnesota – Duluth developed a low-cost weigh-in-motion system around polymer piezoelectric film sensors (BL sensors), instead of the traditional crystalline-quartz piezoelectric sensors. The BL sensors, while more sensitive to temperature, were able to achieve the same level of accuracy in terms of the average weight measurement but not variance of the weight measurement.

Cost Range

(Cost/financial information, where noted, is based on 2016 dollars (unless otherwise specified). Cost/financial information is estimated, and will vary based on size and scope of project, number of units, etc. In general, capital costs include initial purchase costs of hardware, software, and other required equipment. Maintenance and operations costs include staff time to operate, monitor and maintain systems; data collection; system upgrades; evaluation; etc.)

Capital Costs: The total capital costs for this tool range from low ($0 to $50,000) to higher (above $250,000). A low-cost, portable WIM system was identified as costing $31,514. A two-lane and four-lane weigh-in-motion (WIM) configuration in Montana were identified as costing $55,000 to $89,200, respectively[1]. North Dakota installed a virtual WIM for $122,000 for a single lane and $145,000 for two lanes[2].

Operations Costs: The operations and maintenance costs for this tool are low ($0 to $50,000). Operating costs, which include labor, equipment, and travel, combined with supply costs, contracting costs and communication costs average out to about $5,800 per weigh-in-motion station in Montana[1]. In addition, maintenance and operations costs include staff time to operate, monitor and maintain systems, data collection, processing and dissemination, system upgrades, and evaluation of the system.

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