Weigh-in-Motion for Enforcement in Europe

Authors:

Hans van Loo
Kalibra
hans.van.loo@kalibra.nl

Bernard Jacob
IFSTTAR
bernard.jacob@ifsttar.fr
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- Applications for Enforcement
- Examples in Europe (Fr, NL, CZ)
- Future Developments
What is Weigh-In-Motion

• Weighing in Motion:
  • process of estimating the gross weight of a moving vehicle, and the portion of that weight that is carried by each of its wheels or axles, by measurement and analysis of dynamic vehicle tyre forces

• WIM-System:
  • Sensors in or under the road, or attached to a bridge
  • Different sensing principles

• Additional Measurements:
  • Time, Speed, Axle Spacing, Vehicle Length, Vehicle Class
Developments in WIM <1990

- Focus on Sensor Development
  - Different sensing principles
  - More accurate sensors

- Focus on Infrastructure Applications
  - Pavement cracking and rutting
  - Effects on bridges

- National Projects
  - France, UK, Germany, Switzerland, Netherlands, ...
Developments in WIM 1990-2000

- Focus on Sensor & System Development
  - More reliable sensors
  - Accuracy test for WIM systems
  - Multiple sensor (MS-)WIM and B-WIM

- First Tests for Enforcement
  - Combination with video (VID-WIM in NL)

- First International Projects
  - COST323 (Co-operative action, COST Transport)
  - WAVE (4th Framework Program Project)
Developments in WIM >2000

- Focus on Applications
  - Pavement and bridge loading (advanced methods)
  - Enforcement of overloading
- Development of WIM Systems
  - Further analysis of MS-WIM (array design, algorithms)
  - Bridge-WIM: commercial system marketed
- International Projects
  - Top Trial, REMOVE, FiWi
  - Foundation of ISWIM
WIM in 2013, Status Quo

- WIM is proven Technology
  - Accurate and reliable measurements are possible
  - Good installation and maintenance are essential
  - WIM ≠ No plug and play forever

- Current WIM Systems
  - National WIM Networks
  - Local, individual systems

- Main users
  - Road maintenance, enforcement, toll roads
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Applications for Enforcement

• “Manual” Selection
Applications for Enforcement

- Manual Selection
- Statistics & Planning
Applications for Enforcement

- Manual Selection
- Statistics & Planning
- Screening & Pre-selection

WIM-System → Waiting Area → Sorting Point → Traffic

Static Weighing Area

communication

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Applications for Enforcement

- Manual Selection
- Statistics & Planning
- Screening & Pre-selection
- Preventive Actions
  - Company profiling
  - In company checks
Applications for Enforcement

- Manual Selection
- Statistics & Planning
- Screening & Pre-selection
- Preventive Actions
- Direct Enforcement

Measurement by WIM → Fine for Overloading

Certified Equipment → Measure Axes/Vehicle → Trigger Recording
                                 ↓                      ↓
               (In-)Accuracy     Measured Values         Digital Picture(s)
                                 ↓                      ↓
                    Subtract (in)accuracy  Corrected Values
                                 ↓                      ↓
                                     Determine Vehicle Class
                                           ↓
                                           Vehicle Classification

Limits / Categories → Calculate Overloading
                                 ↓
               Percentage Overloading
                                 ↓
                      Violation > Enf. Margin
                                 ↓
                                  Record of Violation
                                 ↓
                                    Delete Data
                                 ↓
                          Combine Data
                                 ↓
                               Record of Violation

Workshop WIM for Enforcement  Developments in Weigh-In-Motion
## Applications for Enforcement

<table>
<thead>
<tr>
<th>Direct Enforcement</th>
<th>Other Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of each <strong>individual</strong> measurement</td>
<td>Quality of <strong>average</strong> measurement</td>
</tr>
<tr>
<td>- Max. permissible error</td>
<td>- Mean error</td>
</tr>
<tr>
<td>- 100% of measurements (used)</td>
<td>- Standard deviation</td>
</tr>
<tr>
<td><strong>Evidence of vehicle identification</strong></td>
<td><strong>Indication of vehicle(s) involved</strong></td>
</tr>
<tr>
<td><strong>Performance certified by a notified body</strong></td>
<td><strong>Performance agreed between vendor &amp; buyer</strong></td>
</tr>
<tr>
<td>- Type approval + Initial verif.</td>
<td>- Acceptance test</td>
</tr>
</tbody>
</table>
Aspects of Overloading

- What is the overloading problem? (axle loads / gross vehicle weights)
- Which vehicles are overloaded? (Local / international / container / bulk materials / liquid tanks)
- Where does overloading occur? (highways / local roads)
- When are the peaks? (morning, evening, nights / week days or week-end)
- Who is responsible? (driver / transport company / shipper)
- Why is a truck overloaded? (by accident / structural)
- Etc...
Enforcement Mix

- Enforcement: Automatic
  - High Volume
  - General

- Overloading

- Transport: Local
  - Roads: Secondary

- Enforcement: Manual
  - Low Volume
  - Specific

- Transport: International
  - Roads: Highways

Workshop WIM for Enforcement

Developments in Weigh-In-Motion
# Applications of WIM

<table>
<thead>
<tr>
<th>Application</th>
<th>Pro’s</th>
<th>Con’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Selection</td>
<td>Flexibility for special situations</td>
<td>Low efficiency</td>
</tr>
<tr>
<td>Statistics &amp; Planning</td>
<td>More effective controls</td>
<td>No identification of violators</td>
</tr>
<tr>
<td>Screening &amp; Pre-selection</td>
<td>Efficient controls, Hit rate &gt; 95%</td>
<td>Only local effects, Evasion possible</td>
</tr>
<tr>
<td>Preventive Actions</td>
<td>Focus on compliance + Cheat companies</td>
<td>New way of working</td>
</tr>
<tr>
<td>Direct Enforcement</td>
<td>Highly efficient</td>
<td>Expensive systems, Not (yet) accepted</td>
</tr>
</tbody>
</table>
Enforcement Mix

Enforcement: Automatic
High Volume
General

Direct Enforcement

Preventive Actions

Screening & Pre-selection

Planning & Statistics

Manual Selection

Transport: Local
Roads: Secondary

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Transport: (Inter-) National
Roads: High Ways

Enforcement: Manual
Low Volume
Specific
LEGO Approach

- Manual Selection
- Statistics & Planning
- Pre-selection
- Problem Solving
- Direct Enforcement
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• Applications for Enforcement
• Enforcement Mix
• Examples in Europe (Fr, NL, CZ)
• Future Developments
WIM in France

- For pre-selection + company profiling
- **30 systems** installed
- motorways + highways
- balanced by region
- most > 2000 trucks/day
- accuracy ≥ C(15)
- 85 k€/system
WIM in France

- 22 silhouettes of trucks
- Axle loads and gross weights
- Speed (if implemented: mean speed)
- Axle distances + total length
- Pictures of vehicles + license plates (presumed violators only)
- All recorded data (statistical + violators’) → MoT (safe telecom network)
WIM in France

Main users

- Enforcement departments of DREALs
- Police, gendarmerie, customs
- Ministry of Transport: DGITM/DST/TR4
- Road and infrastructure
  - Inter-regional road directorates: DIR
  - Motorway concessionary
- Research and technical public organizations
  - IFSTTAR (ex LCPC)
  - CETE, SETRA
WIM in the Netherlands

WIM-NL Network

- 20 WIM systems
- Highways only
- National coverage
- Upgraded in 2012
- Registration of:
  - Loads + Weights
  - Vehicle Class
  - Licence Plates
WIM-NL System

Developments in Weigh-In-Motion

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## WIM in the Netherlands

<table>
<thead>
<tr>
<th>Users</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rijkswaterstaat (RWS)</td>
<td>Pavement Loading Design &amp; Maintenance</td>
</tr>
<tr>
<td>Transport Inspectorate (IL&amp;T)</td>
<td>Pre-Selection Company Profiling</td>
</tr>
<tr>
<td>Vehicle Authority (RDW)</td>
<td>Special Transports</td>
</tr>
<tr>
<td>Tax &amp; Customs Administration</td>
<td>International Transports</td>
</tr>
</tbody>
</table>
WIM in the Czech Republic

HS-WIM for Direct Enforcement

- 2011, Tested by Czech Metrology Institute
- Specification based on OIML, COST, ASTM, FiWi;
- e.g. Max. errors
  - Axle (group) Loads 11%
  - Total Vehicle Mass 5%
- Tests for EMC, Physical robustness and Environmental influences
- 2012, Type Approved according to CZ-law (MoT)
WIM in the Czech Republic

System Design

- 2 rows of Kistler Lineas WIM sensors;
- 2 Induction Loops;
- 3 Accelerometers;
- 2 Temperature sensors
- 1 Piezo sensor for detection of:
  - Wheel position
  - Twin Tyres
- Used for Validation of measurement
  - If validation number too low ⇒ rejection for enforcement
Registration of:

- Location
- Type and number of sensor
- Axle Loads, Axle Group Loads and Total Mass
  - Measured and Permitted values
- Number of Axles
- Speed
- Licence Plate
- Registration number
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Needs for the Future

- Overloading is a global issue
- Enforcement needs to be Regional/International (EU)
- Need for International data exchange (EU)
- International acceptance of WIM data
- Need for International harmonization
  - Specifications & Test procedures
  - Data format
  - Certification & Legal Acceptance
- Need for direct/automated enforcement?
Needs for the Future

• Benefits are global
• Research is time consuming and expensive
• Resources are limited
• Need for International cooperation
  • Coordination of research
  • Data exchange
  • Exchange of experience
  • International Standard
## Needs for the Future

<table>
<thead>
<tr>
<th>Issue</th>
<th>Advantage</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stronger, more robust Sensors</td>
<td>Longer life span</td>
<td>Sensor development</td>
</tr>
<tr>
<td>Guaranteed quality of WIM data</td>
<td>Allows International exchange of data</td>
<td>EU Standard in process</td>
</tr>
<tr>
<td>Multiple applications and users</td>
<td>Sharing of required investments</td>
<td>Cooperation between organisations</td>
</tr>
<tr>
<td>Preventive actions / Company profiling</td>
<td>Focus on compliance</td>
<td>Introduction of a new way of working</td>
</tr>
<tr>
<td>Direct enforcement</td>
<td>Highly efficient controls</td>
<td>EU Standard and procedures to be done</td>
</tr>
</tbody>
</table>
# Needs for the Future

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<tr>
<th>Issue</th>
<th>Challenge</th>
<th>Main Actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stronger, more robust sensors</td>
<td>Sensor development</td>
<td>WIM Industry</td>
</tr>
<tr>
<td>Guaranteed quality of WIM data</td>
<td>EU Standard and procedures</td>
<td>Certification bodies + Technical centers</td>
</tr>
<tr>
<td>Multiple applications and users</td>
<td>Cooperation between organisations</td>
<td>Users (Enforcement + road maintenance)</td>
</tr>
<tr>
<td>Preventive actions / Company profiling</td>
<td>Introduction of a new way of working</td>
<td>Governments, enforcement officers</td>
</tr>
<tr>
<td>Direct enforcement</td>
<td>EU Standard and procedure tbd</td>
<td>Certification bodies + Technical centers</td>
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