Weigh in Motion (WiM) systems and their use in Queensland

WiM Forum  11-12 September 2017

Geoff Smith, Department of Transport and Main Roads
Our values, our diversity

Customers first

Unleash potential

Be courageous

Ideas into action

Empower people

diversity
inspire create innovate
Queensland Government’s objectives for the community

Creating jobs and a diverse economy
- Increasing workforce participation
- Ensuring safe, productive and fair workplaces
- Stimulating economic growth and innovation
- Delivering new infrastructure and investment

Delivering quality frontline services
- Achieving better education and training outcomes
- Strengthening our public health system
- Providing responsive and integrated government services
- Supporting disadvantaged Queenslanders

Protecting the environment
- Protecting the Great Barrier Reef
- Conserving nature and heritage
- Ensuring sustainable management of natural resources
- Enabling responsible development

Building safe, caring and connected communities
- Ensuring an accessible and effective justice system
- Providing an integrated and reliable transport network
- Encouraging safer and inclusive communities
- Building regions

Advance Queensland
Our strategic plan

Our vision
Creating a single integrated transport network accessible to everyone

Customer focus
Objective:
A customer-centric organisation that better meets the needs of our customers

Contemporary workforce
Objective:
A prepared and capable workforce that meets the future mobility needs of Queenslanders

Innovation
Objective:
An organisation that embraces change and adapts to external influences to minimise the impact of disruption

Liveable regions and active cities
Objective:
A network that connects communities and contributes to Queensland’s quality of life

Sustainable funding
Objective:
Responsive finance and investment arrangements that deliver value for money

Building prosperity
Objective:
A network that advances economic prosperity across our cities and regions
About us

Creating a single integrated transport network accessible to everyone

We manage:
- 33,343km state-controlled roads
- 3,029 bridges
- 20 ports

There were:
- 3.5m drivers licensed
- 5m vehicles registered
- 3,260 taxis licensed
- 256,151 recreational vessel registrations
- 997,289 boat licenses

Services provided:
- 180m trips taken annually on bus, rail, ferry and light rail in SEQ
- 12.1m trips outside SEQ
- 2.5m go cards in use
- Over 490,000 passengers travel on the south-east Queensland network on average each day

We serve:
- 3.63m customers served face-to-face at 59 Customer Service Centres
- Our customers conducted 6.68m online services

Statistics sourced from the Department of Transport and Main Roads Annual Report 2015-16
Overview

• The importance of WiM data
• WiM deployment strategy
• Business drivers for WiM
• WiM accuracy
• WiM technology
• Supporting technology and systems
• Data analytics and reporting.
What’s Weigh-in-Motion?

- Austroads (2000) defined Weigh-in-Motion (WiM) as a device that measures the dynamic axle mass of a moving vehicle to estimate the corresponding static axle mass.
Data provided by WiM

- Vehicle configuration
- Austroads vehicle class
- Speed
- Axle spacings
- Axle group mass
- Gross vehicle mass
Key technologies associated with WiM

Automatic number plate recognition (ANPR) camera

WiM

Weighbridge
Why do we need WiM data?

Asset management

• Heavy vehicle access
  ▪ Right vehicle, right road

• Freight management
  ▪ Utilisation of freight corridors
  ▪ Strategic investment on key routes
Why do we need WiM data? (cont.)

Asset preservation

• Compliance Intelligence
  ▪ Optimal use of resources (where and when)
  ▪ Engagement with industry
  ▪ Support Chain of Responsibility investigations

• On-road vehicle selection
  ▪ Identify overloaded vehicles from the traffic stream without impeding operators of legally loaded vehicles
Why do we need WiM data? (cont.)

Asset maintenance

• Capital and maintenance funding
  ▪ Secure investment

• Pavement and bridge design
  ▪ Appropriate design
Why do we need WiM data? (cont.)

Asset operations

• Traffic management and network operations (traffic data)
Why do we need WiM data? (cont.)

Road safety

• Reduced on-road activities by compliance officers

• Reduced incidence and severity of overloaded heavy vehicles

• Reduce potential for conflict by limiting the extraction of heavy vehicles from the traffic stream

• Fatigue management (when coupled with ANPR cameras)
Heavy vehicle access
Key freight routes
WiM site strategy

- Key freight routes
- Cordon lines around freight generators or hubs such as ports, freight depots and mines
- Entry/exits to adjacent state borders
- Supporting interception sites as a pre-selection tool
- Protection of susceptible pavements and bridges
- Sites delivered under major projects to inform a pavement maintenance contract.
Location of WiM sites
Heavy vehicle compliance
Cost of overloading

- An assessment of the impact of overloading on the road asset was estimated as an extra $30m-$45m per annum (in 1999 dollars). It was also noted that the estimated efficiency gains for new works for that year was $80m.

- In effect half of the network efficiency gains were being lost to accelerated asset damage.
Cost of overloading (cont.)

• As a general rule, a one year reduction in pavement life (from a 20 year design life) can be expected for every 1% increase in overloading.

• Current industry design and load/damage calculations indicate that:
  • For unbound pavements – a 20% overload is 2 times more damaging than the legal load.
  • For asphalt pavements – a 20% overload is between 3–4 times more damaging than the legal load.
  • For cement pavements – a 20% overload is between 9–10 times more damaging than the legal load.
Typical remote WiM site
Typical remote WiM site
North West Queensland
WiM system components

• Pavement
• Mass sensor
• Vehicle/axle detectors
• Field processor
• Communications system
WiM accuracy – Contributing factors

- Pavement quality and smoothness – key component
- Sensor configuration and type
- Calibration procedure and frequency
- Condition of sensors
- Vehicle behaviour
Pavement condition

- Site considered unacceptable for WiM if any of the levels of pavement smoothness exceeded.
- Site assigned an accuracy class of "D" – binary WiM site.

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Excellent</th>
<th>Good</th>
<th>Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutting (3m straightedge)</td>
<td>≤ 4mm</td>
<td>≤ 7mm</td>
<td>≤ 10mm</td>
</tr>
<tr>
<td>Roughness (NRM)</td>
<td>0 – 33</td>
<td>33 – 68</td>
<td>68 – 105</td>
</tr>
</tbody>
</table>
# WiM accuracy classes

<table>
<thead>
<tr>
<th></th>
<th>A₁</th>
<th>B₂</th>
<th>C₃</th>
<th>D₄</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gross</strong></td>
<td>±6%</td>
<td>±10%</td>
<td>±15%</td>
<td>±25%</td>
</tr>
<tr>
<td><strong>Axle Group</strong></td>
<td>±10%</td>
<td>±15%</td>
<td>±20%</td>
<td></td>
</tr>
<tr>
<td><strong>Single Axle</strong></td>
<td>±15%</td>
<td>±20%</td>
<td>±30%</td>
<td></td>
</tr>
</tbody>
</table>

Tolerance for 95% Probability of Conformity

- 1 - equivalent of ASTM Type III (6%)
- 2 - equivalent of ASTM Type I (10%)
- 3 - equivalent of ASTM Type II (15%)
- 4 - equivalent of Euro Type D (25%)
WiM accuracy classes (cont.)

- **Class A**
  - For legal purposes such as enforcement of legal weight limits for example, IAP audit. None of the existing WiM sites in Queensland currently achieve this level of accuracy.

- **Class B**
  - For infrastructure design, pre-selection of overloaded vehicles.

- **Class C**
  - Detailed statistical analysis, infrastructure planning, freight planning and regulation and targeted enforcement.

- **Class D**
  - Binary level of accuracy that is, loaded or unloaded only - essentially an intelligent vehicle classifier. Suitable for traffic studies plus limited freight planning and regulation.
WiM site availability

- Goal is for WiM sites to be fully operational 24/7.
- Equipment malfunctions, telemetry outages and pavement failures will impact on availability and reliability of data.
- Realistic goal is 80% availability.

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;= 90%</td>
<td>&gt;= 80%</td>
<td>&lt; 90%</td>
<td>&lt; 80%</td>
</tr>
</tbody>
</table>
WiM sensor technology

- Strain gauge – Culway ✓
- Piezoelectric sensor ✓
- Kistler lineas sensor – Quartz piezo ✓
- Capacitive pad ✗
- Bending plate ✗

✓ Currently installed in Qld
Culway installation
Why piezo-based WiM?

• Absence of suitable culverts

• Lower sensor cost and the ease of installation

• The expense of concrete or deep lift asphalt pavement for plate solutions

• Superior multi-lane solution.
Queensland experience of piezo WiM

• First site installed in 1999

• Temperature compensation is essential
  - Without temperature correction, mass recorded in afternoon could more than double that recorded in the morning (same vehicle and load)

• Piezo sensors are not only very sensitive to temperature changes but also sensitive to the rate at which the temperature changes
Typical temperature compensation

Temperature Non-Linearity (TNL) curve

- orth 20th Nov 03.mdb
- TNL North Nov 03.mdb
Scatter of typical dual pad system
Scatter of typical piezo sensor system
ANPR camera – additional benefits

- Driver fatigue management
- Time over distance speed
- Traffic planning
  - Origin Destination (OD) Surveys
  - Travel Time Surveys.
Typical ANPR camera
ANPR and WiM – Motorway
ANPR and WiM – Rural environment
Heavy vehicle interception sites

- Pull over – where enforcement officers pull over a suspect vehicle or driver encountered during their journey

- Short duration – where enforcement officers spend less than two hours at a time

- Long duration – where enforcement officers spend more than two hours at a time

- Long duration including weighing facilities – these are located on motorways or other high speed divided roads.
Typical motorway site layout

- Automatic Number Plate Recognition (ANPR) and Weigh-in-Motion (WiM)
- Changeable Message Sign (CMS)
**Eastbound HVIS**

- **Entry** from Motorway off-ramp
- **Exit** onto Motorway on-ramp
  - allows sufficient acceleration length before re-entering motorway
  - causes inspected local traffic to ‘go around’
HVIS operations
Monitoring heavy vehicles
Data flow diagram

- Weigh-in-Motion
- ANPR
- Database and analytics tool
- Traffic counter classifiers
- Web-based reporting tool
# Database reporting

## State-Wide Ranked Overloading Report

**Traffic Class Codes:** 2C, 2D, 2E, 2F, 2G, 2H, 2J, 2K, 2L  
**Date Range:** Friday 01-Mar-2013 - Sunday 31-Mar-2013

### Ranked by Percentage of Vehicles with Overloading Severity 0% - 10%

<table>
<thead>
<tr>
<th>Rank</th>
<th>Area</th>
<th>Site</th>
<th>WIM Site Name</th>
<th>All Vehicles</th>
<th>Overloaded 0% - 10%</th>
<th>Overloaded 10% - 20%</th>
<th>Overloaded 20% - 60%</th>
<th>Overloaded 60% - 100%</th>
<th>Overloaded 100% +</th>
<th>All Overloaded Vehicles</th>
<th>All Overloaded Vehicles %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>409</td>
<td>100069</td>
<td>WIM Site Callio Creek</td>
<td>163</td>
<td>15.96%</td>
<td>15.34%</td>
<td>7.98%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>64</td>
<td>39.26%</td>
</tr>
<tr>
<td>2</td>
<td>402</td>
<td>32559</td>
<td>WIM Site Oakley</td>
<td>3,617</td>
<td>14.80%</td>
<td>5.97%</td>
<td>3.62%</td>
<td>0.10%</td>
<td>0.00%</td>
<td>553</td>
<td>24.55%</td>
</tr>
<tr>
<td>3</td>
<td>403</td>
<td>90041</td>
<td>WIM Site Cardwell</td>
<td>8,336</td>
<td>12.56%</td>
<td>8.99%</td>
<td>14.74%</td>
<td>0.61%</td>
<td>0.11%</td>
<td>3,069</td>
<td>36.81%</td>
</tr>
<tr>
<td>4</td>
<td>402</td>
<td>30041</td>
<td>WIM Site Gatton Trd S7.2km</td>
<td>8,182</td>
<td>12.30%</td>
<td>7.00%</td>
<td>6.10%</td>
<td>0.40%</td>
<td>0.10%</td>
<td>2,112</td>
<td>25.81%</td>
</tr>
<tr>
<td>5</td>
<td>405</td>
<td>83159</td>
<td>WIM Site Elan</td>
<td>12,546</td>
<td>8.87%</td>
<td>3.73%</td>
<td>4.00%</td>
<td>0.35%</td>
<td>0.00%</td>
<td>2,112</td>
<td>16.71%</td>
</tr>
<tr>
<td>6</td>
<td>403</td>
<td>111609</td>
<td>WIM Site Millaa Millaa</td>
<td>499</td>
<td>8.82%</td>
<td>6.01%</td>
<td>3.61%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>91</td>
<td>18.24%</td>
</tr>
<tr>
<td>7</td>
<td>406</td>
<td>91701</td>
<td>WIM Site Loyshon</td>
<td>1,436</td>
<td>8.43%</td>
<td>7.31%</td>
<td>12.74%</td>
<td>1.53%</td>
<td>0.21%</td>
<td>454</td>
<td>30.22%</td>
</tr>
<tr>
<td>8</td>
<td>406</td>
<td>131830</td>
<td>WIM Site Nudgee</td>
<td>185,753</td>
<td>0.84%</td>
<td>2.35%</td>
<td>1.07%</td>
<td>0.04%</td>
<td>0.01%</td>
<td>17,311</td>
<td>9.32%</td>
</tr>
<tr>
<td>9</td>
<td>405</td>
<td>90042</td>
<td>WIM Site Githabringa</td>
<td>2,623</td>
<td>5.30%</td>
<td>2.05%</td>
<td>0.76%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>213</td>
<td>8.12%</td>
</tr>
<tr>
<td>10</td>
<td>408</td>
<td>91699</td>
<td>WIM Site Greenacres</td>
<td>4,565</td>
<td>5.19%</td>
<td>3.73%</td>
<td>5.40%</td>
<td>0.28%</td>
<td>0.00%</td>
<td>672</td>
<td>14.72%</td>
</tr>
<tr>
<td>11</td>
<td>406</td>
<td>136161</td>
<td>WIM Site Belmont (North)</td>
<td>155,636</td>
<td>4.95%</td>
<td>1.46%</td>
<td>6.02%</td>
<td>0.00%</td>
<td>0.02%</td>
<td>14,252</td>
<td>7.16%</td>
</tr>
<tr>
<td>12</td>
<td>404</td>
<td>159529</td>
<td>WIM Site Freds Gully</td>
<td>4,942</td>
<td>4.84%</td>
<td>1.21%</td>
<td>0.63%</td>
<td>0.04%</td>
<td>0.00%</td>
<td>302</td>
<td>6.72%</td>
</tr>
<tr>
<td>13</td>
<td>403</td>
<td>111611</td>
<td>WIM Site Palmer River</td>
<td>405</td>
<td>4.65%</td>
<td>1.98%</td>
<td>0.25%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>28</td>
<td>6.91%</td>
</tr>
<tr>
<td>14</td>
<td>407</td>
<td>20739</td>
<td>WIM Site Yandina Bypass</td>
<td>47,765</td>
<td>3.56%</td>
<td>2.48%</td>
<td>3.88%</td>
<td>0.35%</td>
<td>0.01%</td>
<td>4,910</td>
<td>10.20%</td>
</tr>
<tr>
<td>15</td>
<td>406</td>
<td>130000</td>
<td>WIM Site Belmont (South)</td>
<td>183,656</td>
<td>2.36%</td>
<td>0.57%</td>
<td>0.41%</td>
<td>0.12%</td>
<td>0.01%</td>
<td>6,368</td>
<td>3.47%</td>
</tr>
<tr>
<td>16</td>
<td>404</td>
<td>159532</td>
<td>WIM Site Bore Creek</td>
<td>7,951</td>
<td>1.60%</td>
<td>0.11%</td>
<td>0.16%</td>
<td>0.06%</td>
<td>0.01%</td>
<td>155</td>
<td>1.95%</td>
</tr>
<tr>
<td>17</td>
<td>402</td>
<td>40047</td>
<td>WIM Site Miles 3.4km East of Int 26C</td>
<td>34,326</td>
<td>1.34%</td>
<td>0.41%</td>
<td>0.27%</td>
<td>0.11%</td>
<td>0.00%</td>
<td>732</td>
<td>2.13%</td>
</tr>
<tr>
<td>18</td>
<td>410</td>
<td>10029</td>
<td>WIM Site Cyrus Creek</td>
<td>8,698</td>
<td>1.07%</td>
<td>0.25%</td>
<td>0.25%</td>
<td>0.09%</td>
<td>0.01%</td>
<td>145</td>
<td>1.71%</td>
</tr>
<tr>
<td>19</td>
<td>410</td>
<td>10036</td>
<td>WIM Site 500m nth Holbrook Cr Southbound</td>
<td>43,053</td>
<td>1.56%</td>
<td>0.21%</td>
<td>0.20%</td>
<td>0.15%</td>
<td>0.00%</td>
<td>741</td>
<td>1.72%</td>
</tr>
<tr>
<td>20</td>
<td>406</td>
<td>91332</td>
<td>WIM Site Leichhardt Creek</td>
<td>6,562</td>
<td>0.96%</td>
<td>0.24%</td>
<td>0.05%</td>
<td>0.03%</td>
<td>0.00%</td>
<td>67</td>
<td>1.33%</td>
</tr>
<tr>
<td>21</td>
<td>402</td>
<td>30042</td>
<td>WIM Site Southbrook</td>
<td>14,437</td>
<td>0.51%</td>
<td>0.11%</td>
<td>0.05%</td>
<td>0.01%</td>
<td>0.00%</td>
<td>97</td>
<td>0.67%</td>
</tr>
<tr>
<td>22</td>
<td>403</td>
<td>111605</td>
<td>WIM Site 40 Mile Scrub</td>
<td>689</td>
<td>0.25%</td>
<td>0.15%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3</td>
<td>0.44%</td>
</tr>
</tbody>
</table>
Thank you and stay connected

Twitter @TMRQld
Facebook @TMRQld
LinkedIn Department of Transport and Main Roads
Blog blog.tmr.qld.gov.au