Optimisation of New Zealand’s Heavy Vehicle Fleet

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Aims

• Benchmark NZ vehicles against those from other countries
  – Pavement Wear
  – Bridge Wear
  – Road Space
  – Safety

• Identify opportunities for improvement
Scope - Geography

- Five Countries
  - Australia (Au)
  - Canada (Ca)
  - New Zealand (NZ)
  - Southeast Asia (SEA)
  - United Kingdom (UK)
Scope - Transport Tasks

- Six Transport Tasks
  - Passenger Coach (PC)
  - Bulk Liquids (BL)
  - Bulk Materials (BM)
  - 40 foot Intermodal Containers (IC)
  - Livestock (LS)
  - Refrigerated Goods (RG)
Vehicle Configurations

- Weights & Dimensions
  - Based on respective National Regulations
  - SEA Same as UK which is based on European.

- Payload Spaces
  - Elliptical Tanks – Liquids
  - Rectangular Cuboids
Vehicle Configurations

• Load Widths – 2.4m & 2.5m (Ca)
• Load Heights – Load Volume & Density
• Tyres & Axles
  – Trailer Axle Widths – 2.5m & 2.6m (Ca)
  – Trailer Tyres – Duals & Wide-Singles (UK)
<table>
<thead>
<tr>
<th>Task ID</th>
<th>Au</th>
<th>Ca</th>
<th>NZ</th>
<th>SEA</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>50p, 12.5m, 19.75t, 3-axle</td>
<td>55p, 14m, 21.68t, 3-axle</td>
<td>50p, 12.6m, 19.75t, 3-axle</td>
<td>44p, 12m, 17.62t, 2-axle</td>
<td>52p, 13.8m, 20.46t, 3-axle</td>
</tr>
<tr>
<td>BL</td>
<td>26m, 68t, 9-axle, B-double</td>
<td>19m, 46.5t, 5-axle, semi</td>
<td>20m, 44t, 8-axle, truck trailer</td>
<td>7.54m, 24t, 3-axle, truck</td>
<td>16.5m, 40t, 5-axle, semi</td>
</tr>
<tr>
<td>BM</td>
<td>19m, 42.5t, 6-axle, truck trailer</td>
<td>16.5m, 46.5t, 6-axle, semi</td>
<td>20m, 44t, 7-axle, truck trailer</td>
<td>6.84m, 24t, 3-axle, truck</td>
<td>16.5m, 40t, 5-axle, semi</td>
</tr>
<tr>
<td>IC</td>
<td>16m, 43.3t, 6-axle, semi</td>
<td>17m, 43.6t, 6-axle, semi</td>
<td>16m, 39t, 6-axle, semi</td>
<td>15m, 34t, 4-axle, semi</td>
<td>15.5m, 42.86t, 6-axle, semi</td>
</tr>
<tr>
<td>LS</td>
<td>26m, 68t, 9-axle, B-double</td>
<td>20m, 39.5t, 5-axle, semi</td>
<td>20m, 44t, 8-axle, truck trailer</td>
<td>7.54m, 21t, 3-axle, truck</td>
<td>16.5m, 40t, 5-axle, semi</td>
</tr>
<tr>
<td>RG</td>
<td>26m, 68t, 9-axle, B-double</td>
<td>20m, 39.5t, 5-axle, semi</td>
<td>18m, 44t, 8-axle, semi</td>
<td>7.54m, 22t, 3-axle, truck</td>
<td>16.5m, 40t, 5-axle, semi</td>
</tr>
</tbody>
</table>
Methodology

• Vehicles simulated using Yaw-Roll multi-body simulation software originally developed at UMTRI
• Performance measures were evaluated using the Australian PBS specifications
• Compound performance measures were developed to produce ratings for comparison
Pavement Wear Performance

• Derived from
  – Standard Axle Repetitions (SAR)
  – Payload (PLD)
  – Axle Group Weight (w)
  – Reference Axle Group Weight (W)
  – Number of Axle Groups (N)

\[
\text{Pavement Performance} = \frac{1}{\text{SAR}} \times \text{PLD}, \text{ where } \text{SAR} = \sum_{n=1}^{N} \left( \frac{W_{n}}{W_{n}} \right)^4
\]
Bridge Wear Performance

- Derived from
  - Peak Bending Moment (PBM)
  - Payload (PLD)
  - Reference Span of 12.5m
  - Simply-Supported Metal Girder
  - Axle Loads modelled as Point Loads

\[
Bridge \ Performance = \frac{1}{PBM^3} \times PLD
\]
Road Space Performance

• Derived from
  – Low-Speed Offtracking (LSO)
  – High-Speed Offtracking (HSO)
  – Payload (PLD)

\[
\text{Road Space Performance} = \frac{1}{(LSO \times HSO)^2} \times PLD
\]
Safety Performance

- Derived from
  - Rearward Amplification (RA)
  - High-Speed Transient Offtracking (HSTO)
  - Load Transfer Ratio (LTR)
  - Static Rollover Threshold (SRT)
  - Payload (PLD)

\[
\text{Safety Performance} = \frac{SRT^{3/2}}{(RA \times HSTO \times LTR)^{1/3}} \times PLD
\]
Relative crash rate v. SRT overlaid with the results of the reciprocal of the compound safety measure multiplied by PLD.
General Results

• With respect to pavement wear performance, NZ vehicles are the best, ... while SEA and UK vehicles are among the worst.

• With respect to bridge wear performance, NZ and Au vehicles are among the best, ... while SEA and UK vehicles are among the worst.
General Results

- With respect to road space performance, NZ and UK vehicles are among the best, ... while Ca and SEA vehicles are among the worst.
- With respect to safety performance, Ca vehicles are among the best, ... while SEA vehicles are the worst.
Optimising NZ Heavy Vehicles

- Most widely used combination is 4-axle truck towing 4-axle full trailer at 20m and 44t.
- For BL, for example, this vehicle ranks first for pavements, bridges and road space but only 4th for safety.
- Increasing weight to 50t and length to 23m improves safety while maintaining no 1 ranking for the other three aspects.
Conclusions

• The study has developed heuristic composite performance measures for comparing categories of performance.
• This enables a more general comparison of vehicle performance between jurisdictions.
• Generally NZ vehicles performed well compared to their international counterparts.
Conclusions

• The weakest comparative performance was in safety.
• The method facilitates developing more optimal configurations.
• However, it has not resolved the issue on how to handle tradeoffs between categories.
Acknowledgements

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The full report is available online at http://www.nzta.govt.nz/resources/research/reports/387/docs/387.pdf