Improving the safety of heavy vehicles in South Africa through a performance-based standards (PBS) approach to vehicle design

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CSIR Built Environment
CONTENTS

- PBS approach to vehicle design
- PBS pilot project in South Africa
- Pilot project monitoring results
Key Elements in Road Freight Transport

• Road infrastructure: roads, bridges, roadside furniture, signs, road markings, eToll gantries 😊

• Vehicles: design, maintenance & operation

• Drivers: skill, health, fatigue
PBS Pilot Project Objectives

Investigate the Performance-Based Standards approach to heavy vehicles design and operations as researched and implemented specifically in Australia, Canada and New Zealand with a view to improving heavy vehicles operations in South Africa through:

• Reduced road wear (per tonne.km)
• Reduced vehicle trips i.e.
  • Reduced congestion
  • Reduced safety exposure risk
• Improved safety performance
• Improved transport productivity
• Reduced emissions (per tonne.km)
Problem statement
Problem statement
Problem statement
Problem statement
Problem statement
### Performance-Based Standards vs. Prescriptive Standards

<table>
<thead>
<tr>
<th>Prescriptive Standards</th>
<th>Performance-Based Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What the vehicle looks like</strong></td>
<td><strong>What the vehicle can do</strong></td>
</tr>
<tr>
<td>Governs mass and dimensions</td>
<td>Governs actual on-road performance</td>
</tr>
<tr>
<td>Constrains productivity</td>
<td>Allows heavier and/or larger vehicles</td>
</tr>
<tr>
<td>Constrains innovation</td>
<td>Promotes innovation</td>
</tr>
</tbody>
</table>

*Images courtesy of the Australian National Transport Commission*
Smart Truck Pilot Project: Timeline

- **Phase 0 Preparation**
  - Go-ahead from DoT
  - Refining PBS framework for SA
  - Knowledge/skills development

- **Phase 1 Proof of concept**
  - Get more industries on-board
  - Get all provinces on-board
  - Monitoring data and research

- **Phase 2 Intensive monitoring**

- **Phase 3 Formalisation**
  - Implementation strategy
  - Promulgation
  - OR phase out

- **2004**
  - PBS committee established

- **2007**
  - 1st PBS vehicles
  - DoT support granted
  - 2 vehicles 1 province
  - Mars, 2009

- **2017**
  - 100 m km of data collected
  - MSc, 2012
  - PhD, 2013
  - PBS post-processor
  - Road wear toll, 2015
  - GeoTrack, 2016
  - MSc, 2017
  - Hyperformance, 2017

- **2020?**
  - Decision to implement
  - Decision not to implement
  - 245 vehicles 6 provinces

- **2025?**
  - Formal adoption
Performance-Based Standards Scheme
the Standards and Vehicle Assessment Rules
as at 10 November 2008 (incorporating all amendments consented to by the ATC up to the date)
# Performance-Based Standards: Safety

<table>
<thead>
<tr>
<th>Manoeuvre/Test</th>
<th>Performance Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-speed 90° turn (5 km/h)</td>
<td>Low-speed swept path</td>
</tr>
<tr>
<td></td>
<td>Tail swing</td>
</tr>
<tr>
<td></td>
<td>Frontal swing</td>
</tr>
<tr>
<td></td>
<td>Steer-tyre friction demand</td>
</tr>
<tr>
<td>High-speed lane-change (80 km/h)</td>
<td>Rearward amplification</td>
</tr>
<tr>
<td></td>
<td>High-speed transient offtracking</td>
</tr>
<tr>
<td>Rollover</td>
<td>Static rollover threshold</td>
</tr>
<tr>
<td>High-speed pulse steer (80 km/h)</td>
<td>Yaw damping coefficient</td>
</tr>
<tr>
<td>High-speed on uneven road (90 km/h)</td>
<td>Tracking ability on a straight path</td>
</tr>
<tr>
<td>Various (driveability standards)</td>
<td>Startability</td>
</tr>
<tr>
<td></td>
<td>Gradeability A</td>
</tr>
<tr>
<td></td>
<td>Gradeability B</td>
</tr>
<tr>
<td></td>
<td>Acceleration Capability</td>
</tr>
</tbody>
</table>
Low-Speed Offtracking
Low-Speed Offtracking

PATH FOLLOWED BY OUTSIDE TRACTOR TIRE

SEMITRAILER

MAXIMUM WIDTH OF SWEPT PATH

PATH FOLLOWED BY INNERMOST TRAILER TIRE
Low-Speed Offtracking

Standard Semi-Trailer
High Speed Transient Offtracking

PBS Lane Change Manoeuvre (SAE J2179)

Course and test specifications:
- 2.5 second period
- 24.5 m/sec (55mph)
- 61 m (200 ft) maneuvering section
- 1.46 m (4.8 ft) lateral displacement
- 0.15 g peak lateral acceleration

Traffic cone pairs 4.58 m (15 ft) stripes placed 0.6 m (2 ft) apart*

Initial Straight section, 6.1 m (20 ft) spacing
"Maneuvering" section, 3 m (10 ft) spacing
Exit section, 6.1 m (20 ft) spacing

* not drawn to scale
High Speed Transient Offtracking

baseline

PBS

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Rollover stability: Baseline (legal) vs PBS
Performance-Based Standards: Infrastructure

Infrastructure

- Pavements
  - Pavement Vertical Loading
  - Pavement Horizontal Loading
  - Tyre Contact Pressure Distribution

- Bridges
  - Bridge Loading

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Road Wear Performance Standard

Pavement A: ES100

Pavement B: ES100

Pavement C: ES0.1

Pavement D: ES0.1

Pavement E: ES30/ES50

Pavement F: ES1.0

Pavement G: ES10

Pavement H: ES0.3

* Classification according to TRH 14 (CSRA, 1985)

* Classification according to Pavement Structures-1.ppt

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2 Span Bridge: Max Negative Bending Moment Load Ratio
(10% Baseline Overload)

- Timber Logistics Services Baseline Vehicle with 10% overload
- Worst Performing Single Tandem Trailer Vehicle 10%
- Worst Performing Single Tridem Trailer Vehicle 10%
- Worst Performing B-Double Vehicle 10%
- TLS PBS Vehicle
- NBC PBS Vehicle
- Unitrans Fuel Quad
- SAB PBS Vehicle
Structures Performance Standard
New technology not always appropriate in Africa ....
PBS in Africa ??? ....
PBS Pilot Project in South Africa

PBS VEHICLES IN OPERATION

× 282

136 073 256 km
TOTAL km TRAVELLED

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Access: Route assessments
Access: Route assessments
Access: Route assessments

SAB Prospecton Depot to SAB Springfield Depot:
Joyner Road onto N2 on-ramp

Legend:
- Tractor centre travel path
- PBS Combination Sn. 4 1 at 1
- Pavement
- Barrier
- Road marking
- Road marking
Access: Route compliance
Access: Speed compliance


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Forestry baseline and PBS vehicles

- 22.0 m, 56.0 tons
- 24.0 m, 64.1 tons
- 27.0 m, 67.5 tons
- 25.8 m, 67.5 tons
- 25.0 m, 70.0 tons
Buhle Betfu Rigid drawbar
Timber Logistics Services Rigid drawbar
Mining side-tipper
Unitrans BAB Quad
Unitrans B-Triple vs BAB Quad
Mining Road Train: Rearward Amplification
Barloworld Transport Sugar Bottom Dumper
SG Coal B-double
Unitrans Fuel Quad
Fuel Quad Case Study

PBS COMBINATION

- PAYLOAD GCM: 38t
- MASS DISTRIBUTION: 56t
- 68%

BASELINE COMBINATION

- PAYLOAD GCM: 32t
- MASS DISTRIBUTION: 55t
- 58%

**FUEL**

- 1.2
- L/Tonne Payload/100km
- 1.4
- 16.94% LESS FUEL CONSUMED BY THE PBS VEHICLE

**TRIPS**

- 27
- TOTAL RETURN TRIPS
- 31
- R 2 076 323 SAVING PER 1000 TONNE-Payload TRANSPORTED

**ROAD**

- 0.37
- Roadwear/Tonne Payload
- 0.41
- 9.5% LESS ROADWEAR/TONNE-Payload

**SAFETY**

- 1.37
- ACCIDENTS/MILLION KM
- 2.24
- 39% LOWER CRASH RATE FOR PBS VEHICLES
- R 261 000 ACCIDENT COST SAVING/MILLION KM

PBS COST SAVINGS PER 1000 TONNES

R 2 083 370
Beefmaster B-triple for cattle
SA Breweries PBS combination
## SA Breweries E. Cape PBS combinations: Efficiency improvements

<table>
<thead>
<tr>
<th></th>
<th>Kms Travelled</th>
<th>Kms Saved</th>
<th>Hours on the road</th>
<th>Hours Saved</th>
<th>Fuel Used (ℓ)</th>
<th>Fuel Saved (ℓ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec-16</td>
<td>33 250</td>
<td>13 253</td>
<td>621</td>
<td>248</td>
<td>23 940</td>
<td>3 962</td>
</tr>
<tr>
<td>Jan-17</td>
<td>74 642</td>
<td>29 720</td>
<td>1 477</td>
<td>588</td>
<td>55 059</td>
<td>7 558</td>
</tr>
<tr>
<td>Feb-17</td>
<td>63 854</td>
<td>25 519</td>
<td>1 245</td>
<td>497</td>
<td>46 564</td>
<td>7 060</td>
</tr>
<tr>
<td>Mar-17</td>
<td>82 108</td>
<td>32 349</td>
<td>1 614</td>
<td>636</td>
<td>60 497</td>
<td>8 117</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>253 854</strong></td>
<td><strong>100 841</strong></td>
<td><strong>4 957</strong></td>
<td><strong>1 969</strong></td>
<td><strong>186 060</strong></td>
<td><strong>26 697</strong></td>
</tr>
<tr>
<td>% Savings</td>
<td>28.4</td>
<td></td>
<td></td>
<td>28.4</td>
<td></td>
<td>12.5</td>
</tr>
</tbody>
</table>
ZZ2 B-triple for tomatoes
B-double Tautliner Case Study

**PBS COMBINATION**

- PAYLOAD: 48t
- GCM: 72t
- MASS DISTRIBUTION: 66%

**BASELINE COMBINATION**

- PAYLOAD: 34t
- GCM: 56t
- MASS DISTRIBUTION: 61%

**FUEL**

- L/100km: 67
- L/Tonne Payload/100km: 1.4
- Tonne-Km: 4,210,592
- 9.39% LESS FUEL CONSUMED BY THE PBS VEHICLE

**TRIPS**

- Total Return Trips: 22
- Fuel Cost Per Tonne-Km: R 0.15
- Fuel Cost % of Transportation Cost: 35%
- Total Cost Per Tonne-Km: R 0.44
- R 641,682 SAVING PER 1000 Tonne-Payload Transported

**ROAD**

- Roadwear/Tonne Payload: 0.159
- 7.5% LESS ROADWEAR/TONNE-PAYLOAD

**SAFETY**

- Accidents/Million Km: 1.37
- 39% LOWER CRASH RATE FOR PBS VEHICLES
- R 261,000 ACCIDENT COST SAVING/MILLION KM

**PBS COST SAVINGS PER 1000 TONNES**

- R 642,781

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Overtaking evaluation of baseline and longer PBS vehicles

**Comparison of Overtaking Times Taking Speeding into Account**

- **Baseline/22m PBS**
  - 0 km/h: 9.20 s
  - 100 km/h: 10.36 s
  - 110 km/h: 18.17 s

- **PBS - Timber**
  - 80 km/h: 9.68 s

- **PBS - Tautliner**
  - 80 km/h: 9.65 s

Reduction in overtaking time vs speeding baseline equivalent @ 100 km/h: 226 hours per PBS vehicle per year

Reduction in overtaking time vs speeding baseline equivalent @ 100 km/h: 262 hours per PBS vehicle per year
Overtaking evaluation of baseline and longer PBS vehicles

<table>
<thead>
<tr>
<th></th>
<th>Time to Overtake (s)</th>
<th>Increased Time for 1 vehicle pass</th>
<th>Pallets on truck</th>
<th>Weight per Pallet (KG)</th>
<th>Trips to Move 100 Pallets</th>
<th>Overtaking Time for 100 Pallets</th>
<th>Increase d Time for 100 Pallets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>9.2</td>
<td></td>
<td>28.3</td>
<td>1350</td>
<td>3.5</td>
<td>32.5</td>
<td>30.7%</td>
</tr>
<tr>
<td>PBS</td>
<td>9.95</td>
<td>8.2%</td>
<td>40</td>
<td>1350</td>
<td>2.5</td>
<td>24.9</td>
<td></td>
</tr>
<tr>
<td>Overspeeding baseline (100 km/hr)</td>
<td>10.96</td>
<td>19.1%</td>
<td>28.3</td>
<td>1350</td>
<td>3.5</td>
<td>38.7</td>
<td>55.7%</td>
</tr>
<tr>
<td>Overspeeding baseline (110 km/hr)</td>
<td>18.17</td>
<td>97.5%</td>
<td>28.3</td>
<td>1350</td>
<td>3.5</td>
<td>64.2</td>
<td>158.1%</td>
</tr>
</tbody>
</table>
PBS Bi-articulated Bus
PBS Bi-articulated Bus
Tail swing

Low-speed swept path

Rear overhang

Tail swing

Frontal swing

LSSP

DoM

MoD

FS

TS

12.5 m

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Tail swing

• Existing car-carriers were shown to exhibit poor tail swing performance due to excessive rear overhangs.
• Tail swing of up to 710 mm was calculated (limit = 300 mm).
• This was shown to be a result of lenient rear overhang legislation.

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Rear Overhang</th>
<th>Tail Swing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid truck</td>
<td>3.7 m</td>
<td>5.01 m</td>
</tr>
<tr>
<td>Semitrailer</td>
<td>3.7 m</td>
<td>6.32 m</td>
</tr>
<tr>
<td>Tag-trailer</td>
<td>3.7 m</td>
<td>7.00 m</td>
</tr>
</tbody>
</table>

Smart Truck Pilot Project: Impact

- **Total trips saved per year**: 85,923 trips (22%)
- **Total fuel saved per year**: 2.24 M litres = $2.21 M (12%)
- **Total km saved per year**: 14,207,336 km (22%)
- **Greenhouse gas emission**: 5,896 tons CO2/year (12%)
- **Roadwear reduction**: $2,000 per vehicle/year (13%)
- **Crashes per million km**: 1.25 vs 2.10 for baseline vehicles (41%)

*Note: Statistics are reported as at June 2018*

*Fuel at R14.19 per litre*
Smart Truck Pilot Project: Baseline vs PBS vehicles

PBS

- Level 1: 80%
- Level 2: 12%
- Level 3: 2%

Baseline

- Fail: 56%
- Level 1: 28%
- Level 2: 13%
- Level 3: 3%
Smart Truck Pilot Project: Baseline vehicles

Number of PBS Failures

- 1 Failure: 73%
- 2 Failures: 18%
- 3 Failures: 9%

Percentage of Baseline Vehicles Failing PBS assessment

- Static Rollover Threshold: 40%
- Rearward Amplification: 20%
- Yaw Damping Coefficient: 15%

Performance Standards
Estimated Savings in Road Wear for 2017 (PBS vs Baseline):

- Total: R 4.7 to R 6.4 million (R 0.3 to R 0.4 LEF/tonne.km)
- 13% reduction
- Average R 24 450 per vehicle
- Average R 0.34 per laden km travelled
Smart Truck monitoring: Crash rates

Smart Truck Pilot Project: Cumulative Crash Rates for Trucks

Crash rate ratio:
Smart Truck : Baseline 1:1.68
# Smart Truck monitoring: Cost of crashes

<table>
<thead>
<tr>
<th></th>
<th>Km (million)</th>
<th>Crash Rate (per million km)</th>
<th>Cost/crash</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Trucks</td>
<td>136.07</td>
<td>1.25</td>
<td>R 300 000</td>
<td>R 170 088 000</td>
</tr>
<tr>
<td>Legal Trucks</td>
<td>166.01</td>
<td>2.10</td>
<td>R 300 000</td>
<td>R 348 611 000</td>
</tr>
<tr>
<td>Cost savings</td>
<td></td>
<td></td>
<td></td>
<td>R 178 524 000</td>
</tr>
</tbody>
</table>

Cost savings: R 178 524 000
Smart Trucks: Potential Gains

- Reduced vehicle trips i.e.
  - Reduced congestion
  - Reduced safety exposure risk
- Improved safety performance
- Improved transport productivity
- Reduced road wear (per ton.km)
- Reduced emissions (per ton.km)
- Improved performance of the SA heavy vehicle fleet
Smart Trucks: Way forward

• Phase 2
  • Intensive monitoring
  • Increase sample size
  • Involvement of all 9 provinces in the pilot
  • Decision whether to implement or not

• Phase 3
  • Formalise policies and procedures
  • Update legislation
  • Smart Truck portal: administration, monitoring, evaluation
  OR
  • Exit strategy

• Formal adoption
Thank you