2004 Technical & Maintenance Conference

A High Productivity Urban Rigid Truck Delivered Through Performance Based Standards (PBS)

Martin Leary

PhD Candidate

University Of Melbourne

Project Specification

Objective:

- maximise volume, either Unit Load Device (ULD) or palette

Constraints:

- meet Performance Based Standards (PBS),
  - see ARTSA, 2003; NRTC, 2003.
- 28T GVM
- ULD / palette geometry
- ADR 43/04 turning circle requirements
- other (e.g. cost, tyre wear, emissions, council regulations)

Design variables:

- axle morphology (location and number)
- drive wheels

Concept Generation

Concept i).
Twin steer front axles (11T)
Fixed rear drive axle (17T)

Concept ii).
Twin steer front axles (11T)
Passive rear steer, e.g. Trackaxle, www.trackaxle.com.au

Concept iii).
Twin steer front axles (11T)
Active rear steer (14T)

Concept Evaluation Requirements

Rapid evaluation of performance

- preferably analytic rather than numeric simulation

Appropriate accuracy level

- to compare concept performance
- identify unacceptable concepts
- gain a confidence in the optimal concept
- confirm with more sophisticated methods as required

Simplifications

- efficiency, e.g. ignore rolling resistance and drag
- ignore inertial effects

PBS Evaluation (1/5)

PBS evaluation categories

- power transmission
- static loading
- low speed tracking
- high speed handling

	Evaluation requirements			
Performance measures	**Power transmission**	**Static loading**	**Low speed manoeuvre**	**Transient handling**
1. Startability	?			
2. Gradability	?			
3. Acceleration	?			
4. Overtaking provision				?
5. TASP				?
6. Low speed offtracking			?	
7. Frontal swing			?	
8. Tail swing			?	
9. Steer tyre friction demand				
10. Static rollover threshold		?		
11. Rearward amplification				?
12. High -speed transient off tracking				?
13. Yaw damping				?
14. Pavement vertical loading		?		
15. Pavement horizontal loading		?		
16. Bridge loading		?		

PBS Evaluation (2/5)

Power transmission

Established solution

- mass
- driveline

Simplifications

- rolling resistance
- drag

	Evaluation requirements			
Performance measures	**Power transmission**	**Static loading**	**Low speed manoeuvre**	**Transient handling**
1. Startability	?			
2. Gradability	?			
3. Acceleration	?			
4. Overtaking provision				?
5. TASP				?
6. Low speed offtracking			?	
7. Frontal swing			?	
8. Tail swing			?	
9. Steer tyre friction demand				
10. Static rollover threshold		?		
11. Rearward amplification				?
12. High -speed transient off tracking				?
13. Yaw damping				?
14. Pavement vertical loading		?		
15. Pavement horizontal loading		?		
16. Bridge loading		?		

PBS Evaluation (3/5)

Static loading

Established solution

- mass
- geometry
- axle conditions

Simplifications

- tyre contact
- bridge load

	Evaluation requirements			
Performance measures	**Power transmission**	**Static loading**	**Low speed manoeuvre**	**Transient handling**
1. Startability	?			
2. Gradability	?			
3. Acceleration	?			
4. Overtaking provision				?
5. TASP				?
6. Low speed offtracking			?	
7. Frontal swing			?	
8. Tail swing			?	
9. Steer tyre friction demand				
10. Static rollover threshold		?		
11. Rearward amplification				?
12. High -speed transient off tracking				?
13. Yaw damping				?
14. Pavement vertical loading		?		
15. Pavement horizontal loading		?		
16. Bridge loading		?		

Static loading limits the allowable mass for a given axle configuration

PBS Evaluation (4/5)

Low speed tracking

Geometric solution

- geometry
- steer input
- axle position

19m max length →

Simplifications

- negligible inertia
- no tyre slip

	Evaluation requirements			
Performance measures	**Power transmission**	**Static loading**	**Low speed manoeuvre**	**Transient handling**
1. Startability	?			
2. Gradability	?			
3. Acceleration	?			
4. Overtaking provision				?
5. TASP				?
6. Low speed offtracking			?	
7. Frontal swing			?	
8. Tail swing			?	
9. Steer tyre friction demand				
10. Static rollover threshold		?		
11. Rearward amplification				?
12. High -speed transient off tracking				?
13. Yaw damping				?
14. Pavement vertical loading		?		
15. Pavement horizontal loading		?		
16. Bridge loading		?		

Critical to the feasibility of an over-dimension urban vehicle

PBS Evaluation (5/5)

High speed handling
high speed – inertia and slip

Simplifications

- rigid vehicle response is inherently more stable than articulated
- transient handling is evaluated at high speed (e.g. arterial and major routes), therefore rigid "competes" with larger, less stable vehicles

	Evaluation requirements			
Performance measures	**Power transmission**	**Static loading**	**Low speed manoeuvre**	**Transient handling**
1. Startability	?			
2. Gradability	?			
3. Acceleration	?			
4. Overtaking provision				?
5. TASP				?
6. Low speed offtracking			?	
7. Frontal swing			?	
8. Tail swing			?	
9. Steer tyre friction demand				
10. Static rollover threshold		?		
11. Rearward amplification				?
12. High -speed transient off tracking				?
13. Yaw damping				?
14. Pavement vertical loading		?		
15. Pavement horizontal loading		?		
16. Bridge loading		?		

Transient handling is complex, but will not govern rigid vehicle design

PBS Rigid Vehicle Design

- The design of a PBS vehicle is governed by (NRTC, 2003):
  - Low Speed Swept Path
  - Frontal Swing
  - Tail Swing

- Australian Vehicle Standards Rules (AVSR) must be met:
  - e.g. ADR 43/04 “must have a turning circle … not exceeding 25m”

Low Speed Swept Path

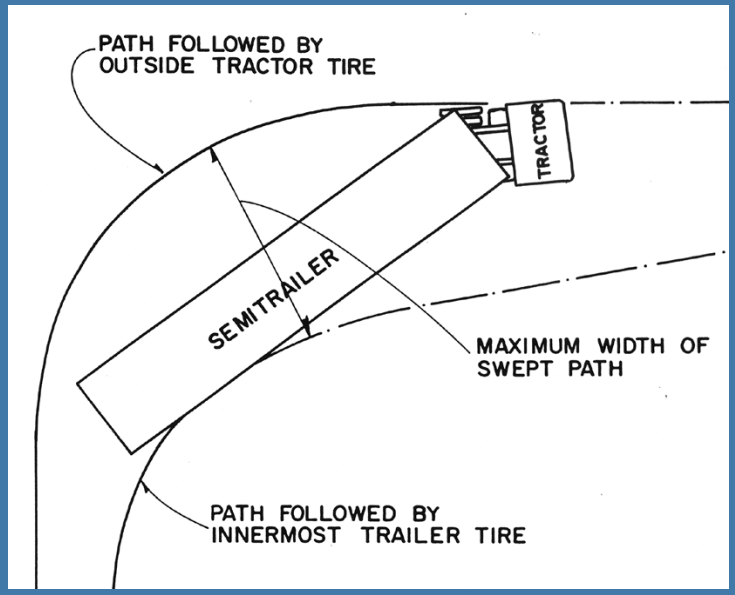
Low Speed Swept Path:

"Maximum distance that the rear axle tracks inside the path taken of the steering axle in an 11.25m, 90º turn at low speed".

Performance standard:

Maximum Swept Path:

Level 1:	7.4 m
Level 1:	8.7 m
Level 1:	10.1m
Level 1:	13.7m



Swept path in a 90° intersection turn (NRTC, 2003)

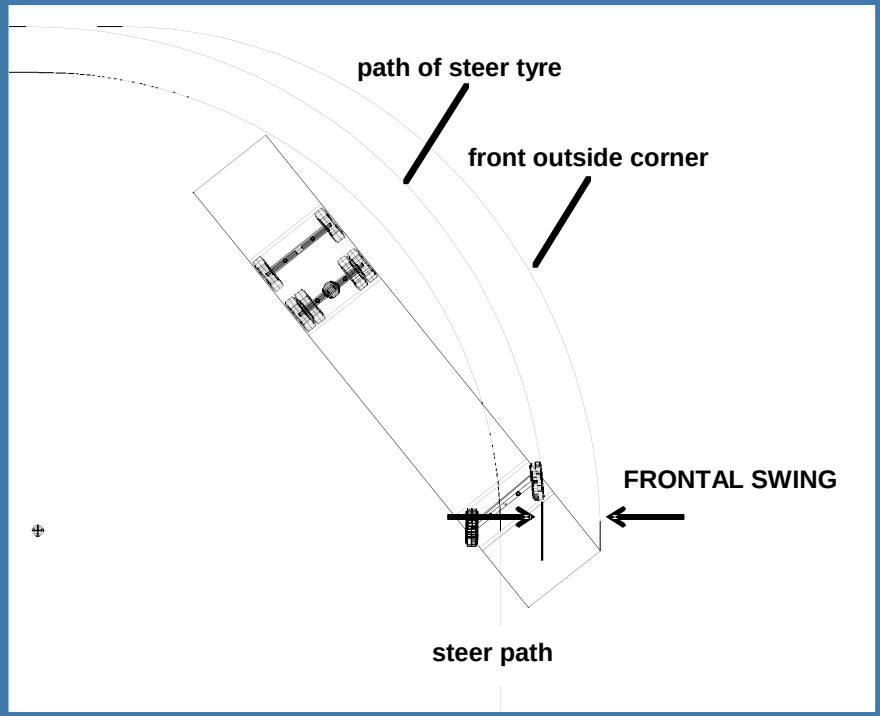
Frontal Swing

Frontal Swing:

"The maximum lateral displacement between the path of the front-outside steered wheel during an 11.25m, 90º turn at low speed."

Performance standard:

Maximum Frontal Swing:
Rigid trucks: 0.7m



Frontal swing in a 90° intersection turn (NRTC, 2003)

Tail Swing

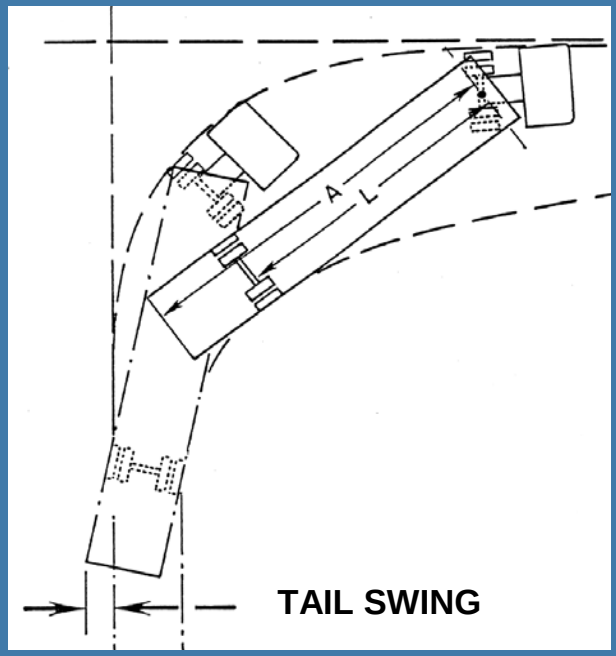
Tail swing:

"The maximum lateral distance that the outer rearmost point on a vehicle moves outwards, during an 11.25m, 90º turn at low speed"

Performance standard:

Maximum Tail Swing:

Level 1:	0.30 m
Level 2:	0.35 m
Level 3:	0.35 m
Level 4 :	0.50 m



Tail swing in a 90° intersection turn (NRTC, 2003)

ADR 43/04

ADR 43/04 :

“Every vehicle must have a turning circle in either direction, as determined by reference to the extreme outer edge of the tyre track at ground level, not exceeding 25 metres in diameter.”

Performance standard:

Limit on maximum steer angle of the forward-inside wheel for a given wheelbase.

Evaluating Performance

The performance measures of importance to rigid vehicle design can be evaluated from the vehicle Swept Path during two maneuvers:

Maneuver 1. PBS: prescribed 90 degree turn

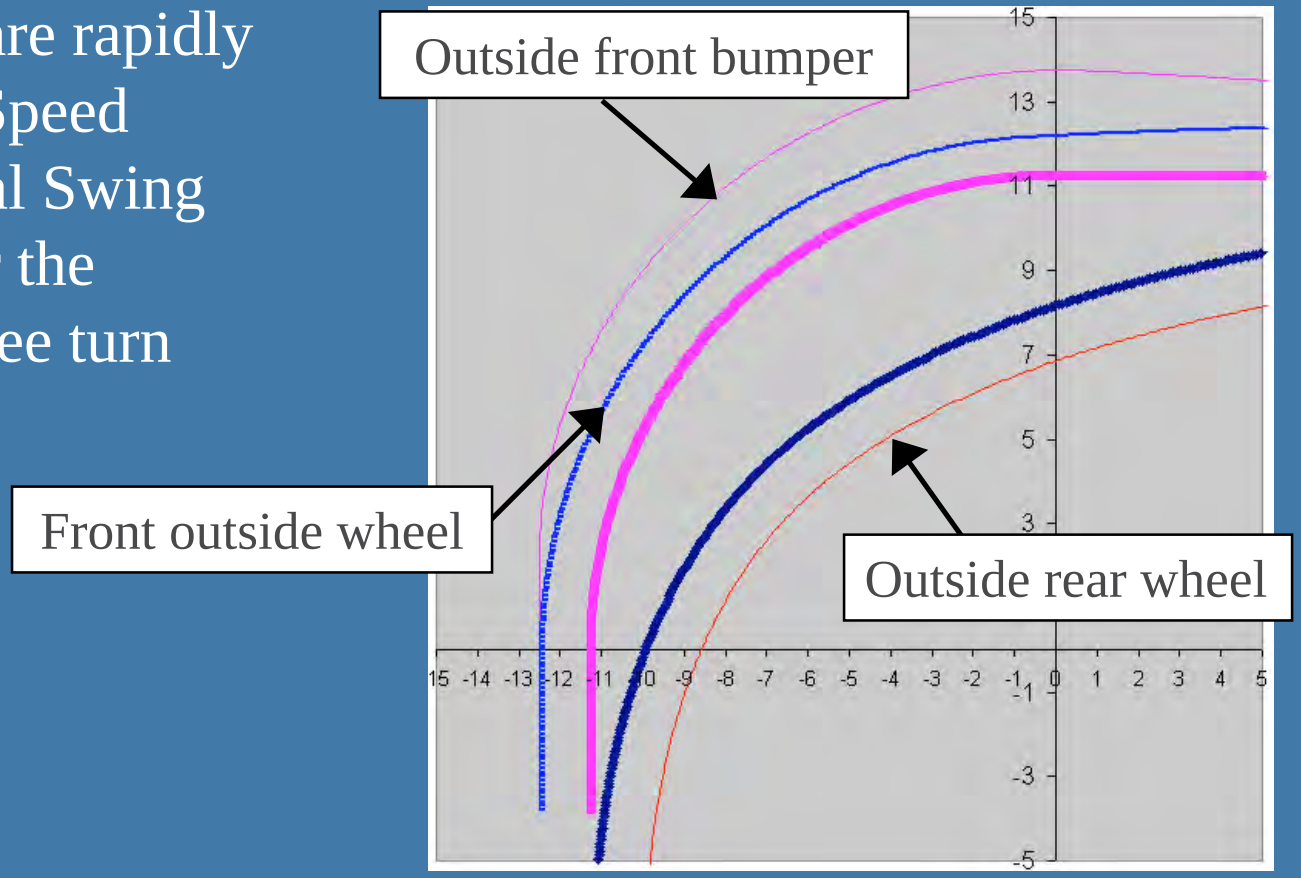
Maneuver 2. ADR: prescribed 25m diameter turn

Analytic software was developed to rapidly assess the Swept Path of a vehicle in these maneuvers.

Swept Path Analysis (PBS)

Maneuver 1. PBS: prescribed 90 degree turn

Swept Path Software rapidly assesses the Low Speed Swept Path, Frontal Swing and Tail Swing for the prescribed 90 degree turn



Tail swing in a 90° intersection turn (Leary and Burvill, 2003)

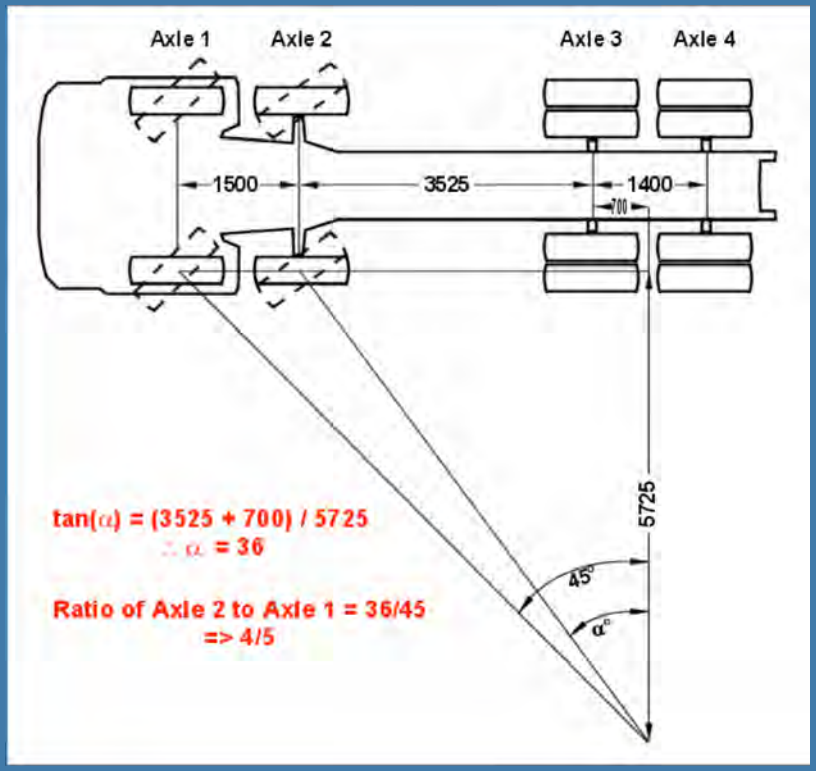
Swept Path Analysis (ADR)

Maneuver 2. ADR: prescribed 25m diameter turn

Steady state case:

Provides an initial estimate of the required steering angle based on steady state conditions:

Wheel Base (m)	Outside wheel (deg)	Inside wheel (deg)
4	19	23
6	29	35
8	40	48
10	53	63
12	74	85



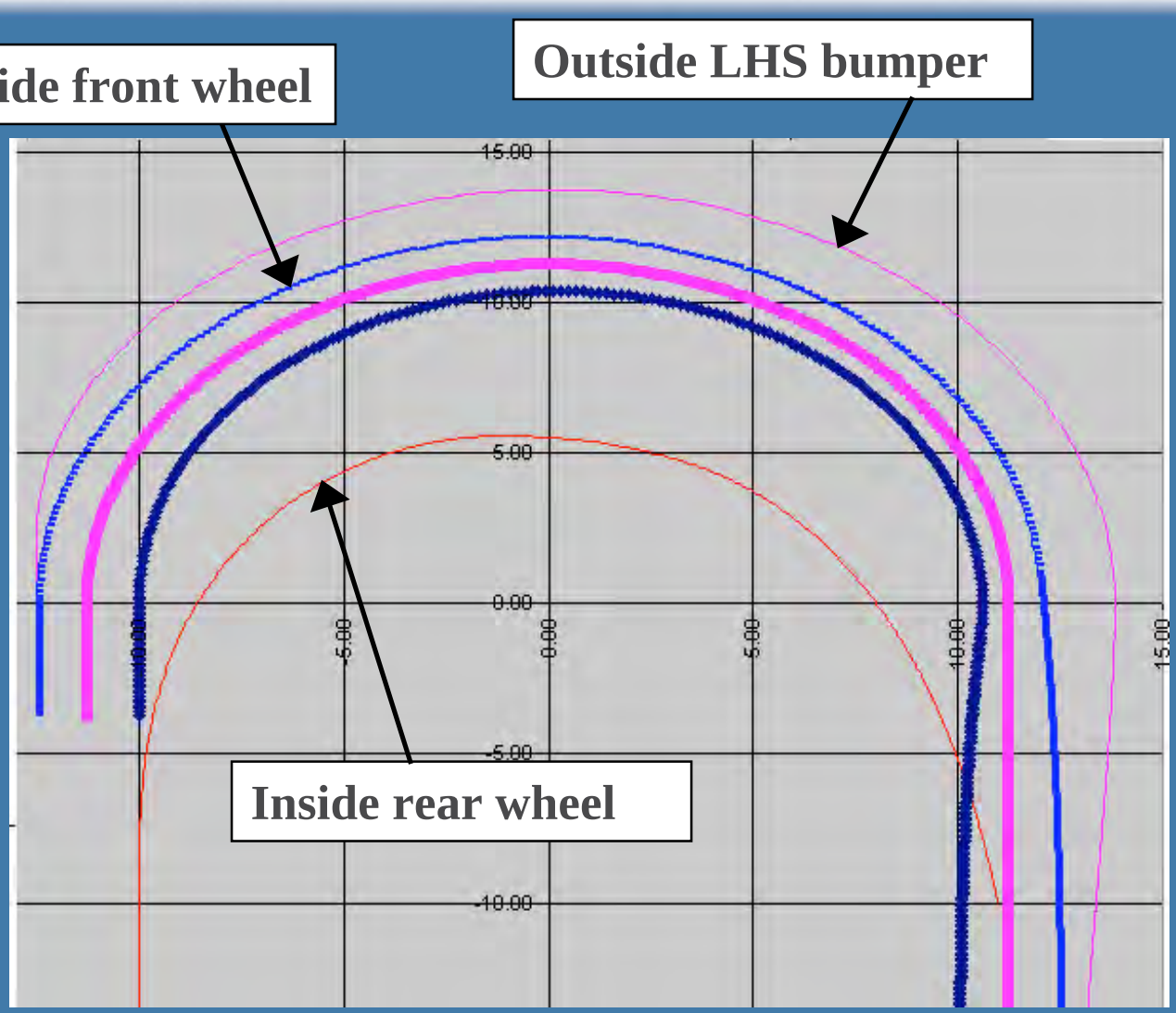
Steady state turn geometry for a twin steer rigid vehicle

Swept Path Analysis (ADR)

ADR 43/04:

Transient case:

Swept Path software provides an explicit ‘trace’ of all vehicle coordinates and steer angles at all points in time during the transient 25m diameter turn.



Swept Path analysis for a twin steer rigid vehicle with a turn diameter of 25m (Leary and Burvill, 2005).

Concept Generation

Concept i).
Twin steer front axles (11T)
Fixed rear drive axle (17T)

Concept i).
Viable for Level 2 network access
Conditionally viable for Level 1 network access

Concept ii).
Twin steer front axles (11T)
Passive rear steer
(e.g Trackaxle type)

Concept ii).
Viable for Level 1 network access
Reduced tyre wear
Increased rear overhang
Increased cost

Concept iii).
Twin steer front axles (11T)
Active rear steer (14T)

Concept iii).
Conditionally as for Concept ii).
Significantly increased cost

References

References:

• ARTSA (2003), PBS Explained: Performance Based Standards for Road Transport Vehicles, Issue 1 September 2003, Australian Road Transport Suppliers Association, Melbourne.
Available at www.artsa.com.au/PBS_Explained_Sept_03.pdf

• NRTC (2003), Performance-Based Standards Phase A – Standards and Measures Regulatory Impact Statement, National Road Transport Commission, December 2003, Australia.

• Leary and Burvill (2005), Performance Based Standards Assessment of a Rigid Urban Transport Vehicle, ICED, Melbourne.
Available at www.sweptpath.com

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