MONASH University

Department of Transport
Trackless Tram Research – Shared Learning and Understanding
Thursday 7th April 2022

Do Trackless Trams need stronger roads? The “weight” of evidence

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PTRG PUBLIC TRANSPORT RESEARCH GROUP

GROUP OF EIGHT AUSTRALIA

MONASH INSTITUTE OF TRANSPORT STUDIES

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Agenda

Introduction

Research context

Pavement model

Results

Discussion and Conclusion

Trackless trams are a new mode developed in China. They provide the capacity and ride quality of Light Rail Transit (LRT), but travel on roads.

- Rubber wheeled
- Optically guided
- High passenger capacity:
  - 3 module vehicle: 250-300 people
  - 5 module vehicle: up to 500 people
- Rail bogie suspension provides high ride quality

3-module Trackless Tram in Zhuzhou, China

Source: Wikipedia, creative commons

Trackless Trams are stated to be much cheaper than LRT because there is no need for expensive and difficult track construction

- 2018 study tour to Zhuzhou, China
  (Newman, Hargroves et al. 2019)
  - Can be implemented in a weekend on existing roads
  - 9 tonnes per axle, similar to buses and heavy vehicles
  - Inertia Management Unit (IMU) minimizes sway that causes rutting
  - No rutting after 3 years of operation

LRT and Trackless Tram indicative cost comparison

	LRT	Trackless Tram
Vehicle and station costs	$15M/km	$6M/km
Total Costs	$49-$100M/km	$18M/km

Source: Newman, Mouritz et al. (2018) based on a consulting study for a project in Sydney, Australia

This paper explores topic: 1. puts Trackless Tram weight / size in context, 2. reports on a 2019 site visit, and 3. models pavement thickness requirements

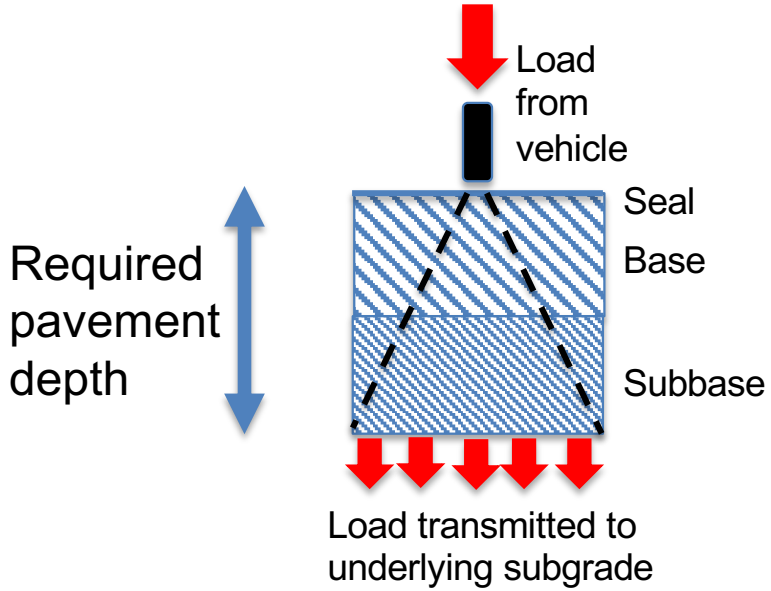
Articulated bus

Trackless Tram (3 modules)

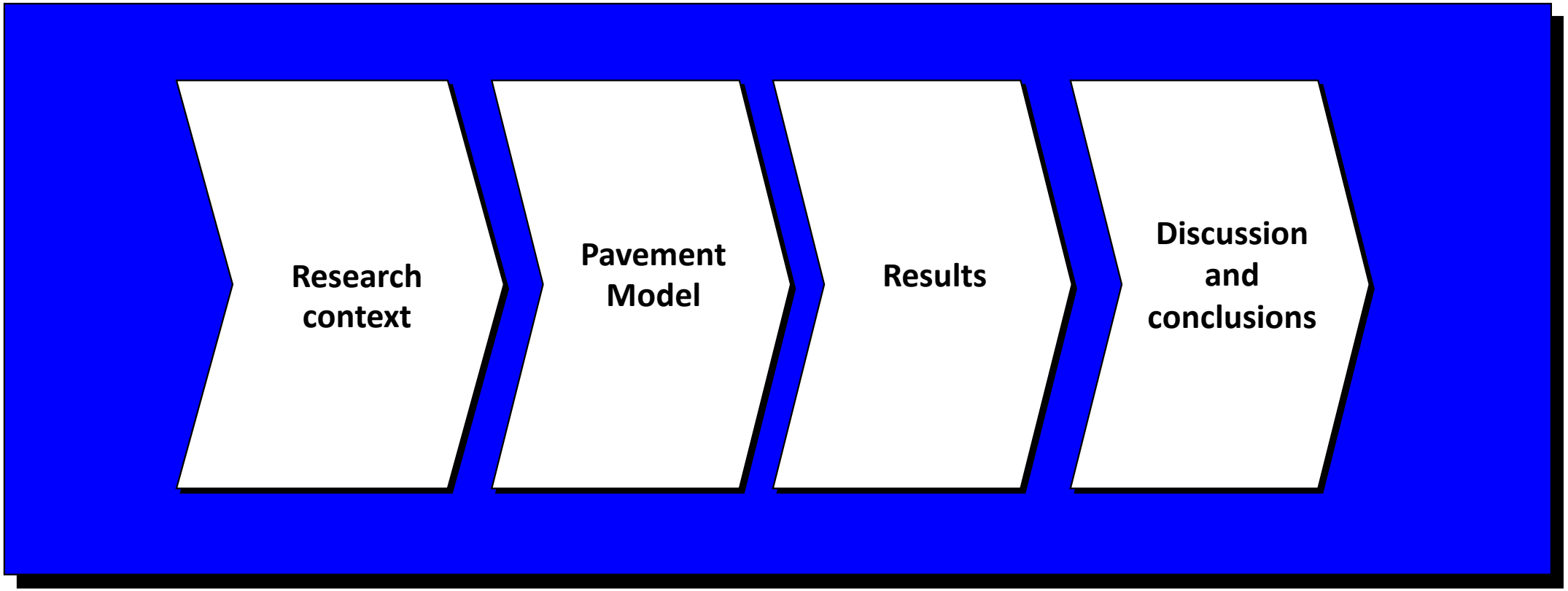
B-Double

Melbourne E class tram

Trackless Tram (5 modules)



The rest of this presentation is structured as follows:



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Advanced and guided bus designs are not new

Adelaide O-Bahn

Optically guided bus, Rouen

Equi.City 24

Sources: Wikipedia

The difference with the Trackless Tram is its size and mass

Articulated bus	26 tonnes (max)		max 18m
Equi.City	24 tonnes (empty) 33.5 tonnes approx. (full load)		23.8m
Semi-trailer	45.5 tonnes (max)		max 19m
Trackless Tram (3 modules)	32 tonnes (empty) **51 tonnes** (full load)		31.6m
B Double	57 tonnes (max)		max 26.0m
Melbourne E Class Tram	52 tonnes (empty) 67 tonnes (full load)		33.5m
Trackless Tram (5 modules)	50 tonnes (empty) **85 tonnes** (full load)		approx. 50m
A Double	90.5 tonnes (max)		max 36.5m

This is important because of the fourth power law for pavements:

2 times the axle load = 16 times the pavement damage

$$\text{Pavement damage}$$

$$\propto$$

$$(\text{Axle load})^4$$

2019 field visit by Monash University PTRG: Evidence of rutting

2019 field visit to Trackless Tram in Zhuzhou, China

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Developed scenarios comparing existing traffic to Trackless Tram operation. Considered poor and high quality soil conditions.

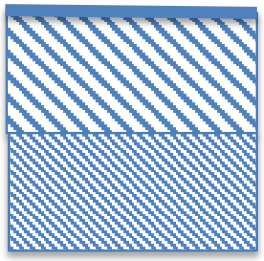
- Existing traffic (no Trackless Tram)
  - Local road 1 lane 2,500 vehicles per day
  - Secondary arterial 2 lanes 12,500 vehicles per day
  - Primary arterials 3 lanes 20,000 vehicles per day
- Trackless Tram in exclusive lane
  - 3-module or 5-module vehicle
  - Low and high frequency service pattern
  - Low and high average axle loading to reflect variable passenger loading
- Underlying soil conditions
  - Poor quality subgrade California Bearing Ratio (CBR) = 2
  - High quality subgrade California Bearing Ratio (CBR) = 18

Used AustRoads Guide to Pavement Technology to calculate traffic loading and required depths for flexible and rigid pavements

- Calculated traffic loading
  - Equivalent Standard Axle (ESA) – Single axle, dual tyres applying 80kN to the pavement
  - Convert traffic volumes and axle loadings into ESAs over a 30-year design life

- Calculated required pavement depth

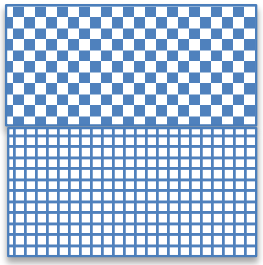
Required pavement depth



Flexible pavement

40mm flexible seal
Base pavement layer

Sub-base pavement layer



Rigid pavement

Concrete base layer

Concrete sub-base

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Agenda

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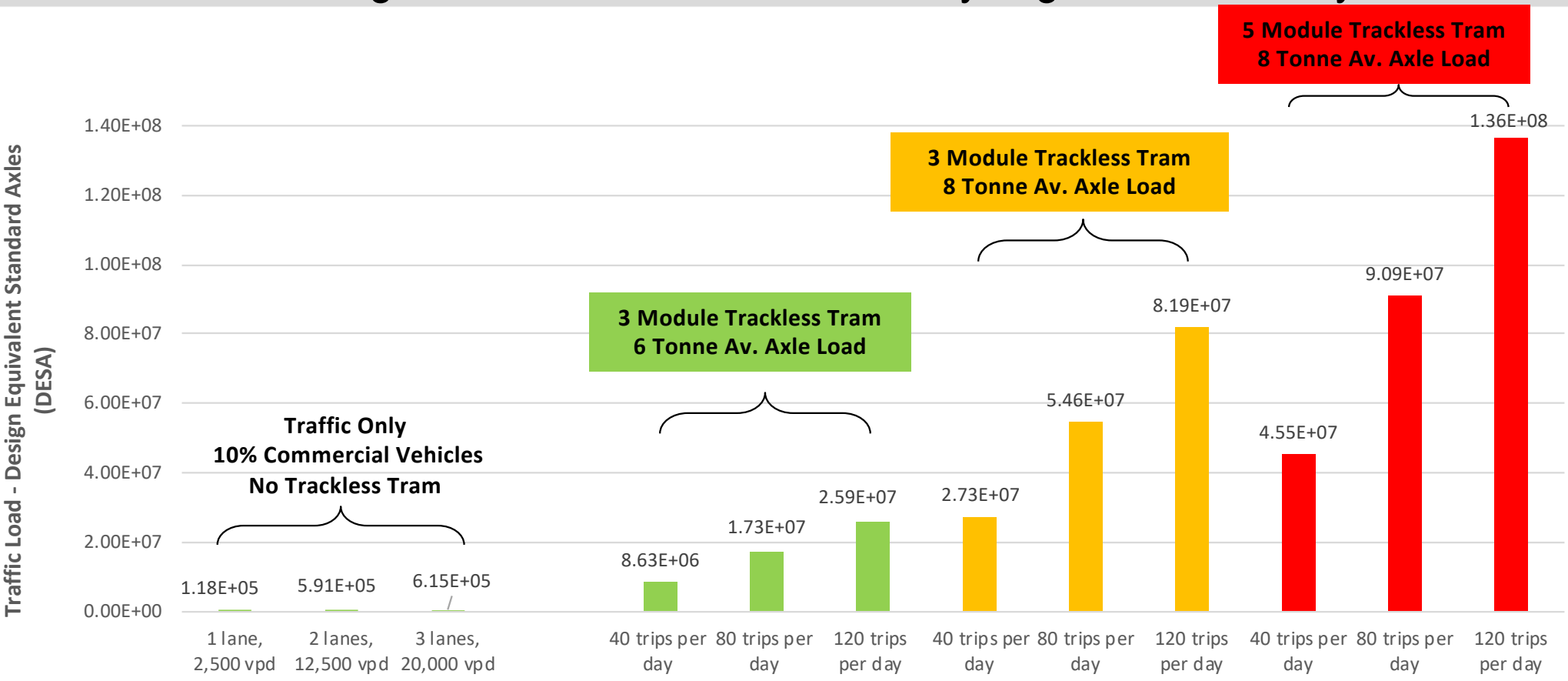
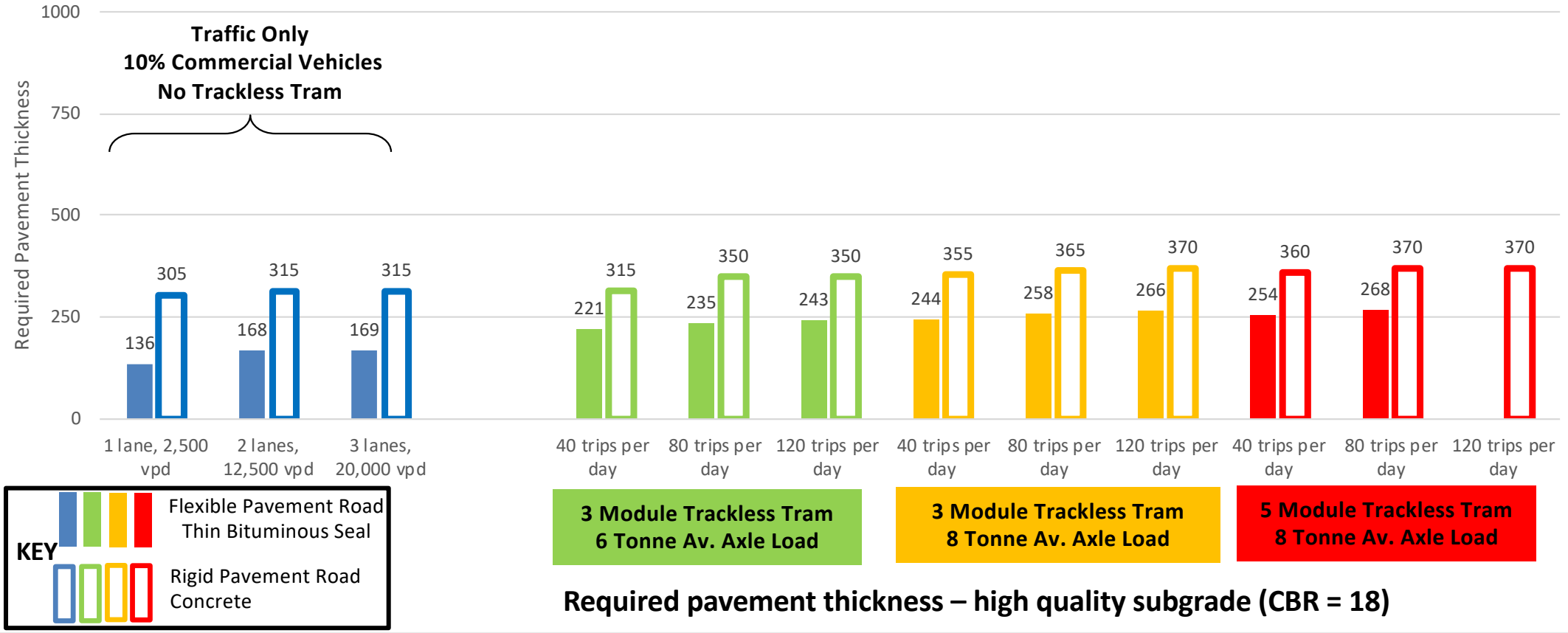
The traffic loading results suggest the design ESA for roads used by Trackless Trams will be much greater than for roads used by regular traffic only

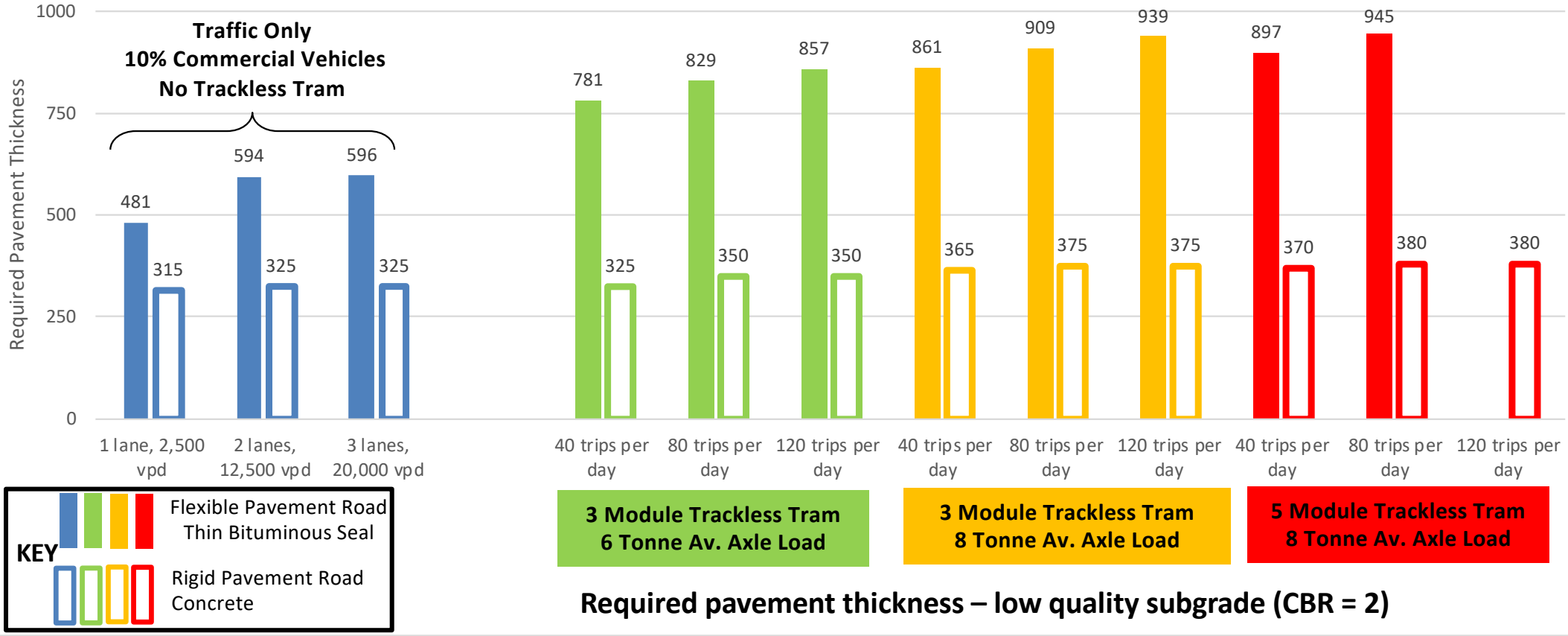


High quality subgrade: thickness increases to 220-270mm for flexible pavement and to 315-370mm for rigid pavements…



Required pavement thickness – high quality subgrade (CBR = 18)

…while for low quality subgrade required depths increase to 780-950mm for flexible pavements and 380mm for rigid pavements



Required pavement thickness – low quality subgrade (CBR = 2)

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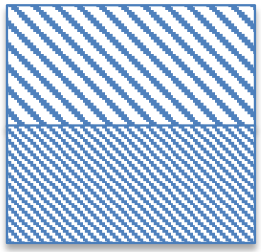
This paper is limited as it has only considered flexible and rigid pavement types…

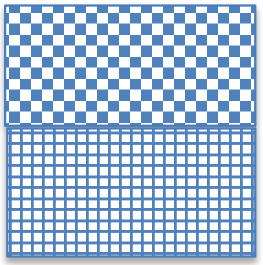
- This paper:



Flexible seal
Pavement layer

Sub-base pavement layer

Flexible pavement



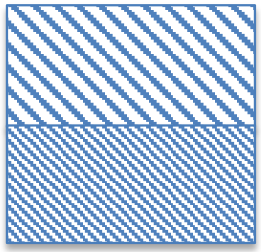
Concrete base layer

Concrete sub-base

Rigid pavement

…semi-flexible pavements have thicker asphalt layers providing structural strength. These are typical on arterials/freeways, but could not be modeled here

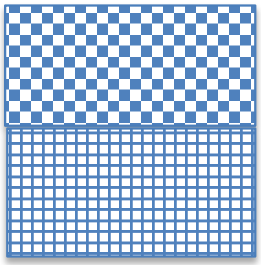
- This paper:



Flexible seal
Pavement layer

Sub-base pavement layer

Flexible pavement

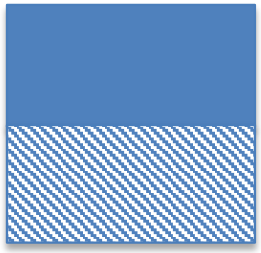


Concrete base layer

Concrete sub-base

Rigid pavement

- Semi-flexible pavements NOT modelled in this paper

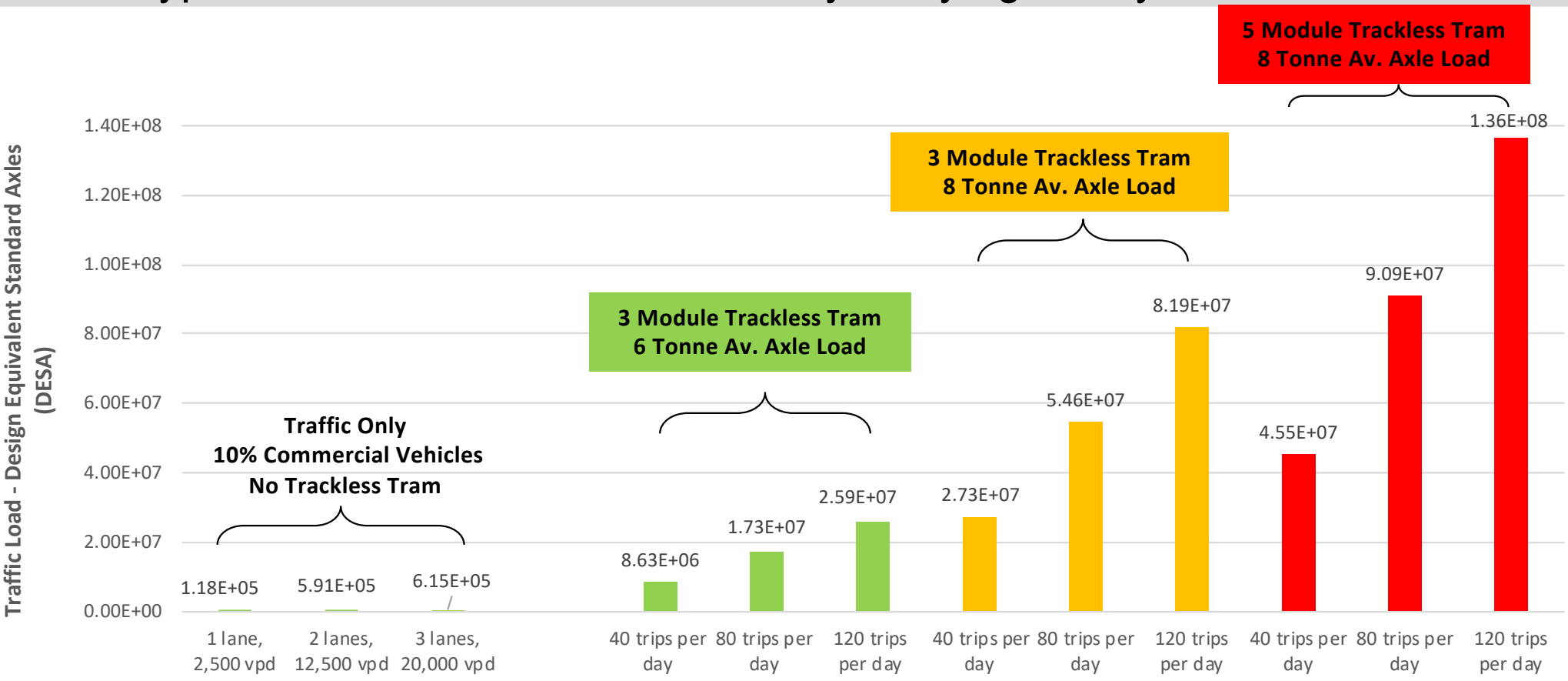


Thick layer(s) of asphalt providing structural strength

Sub-base pavement layer

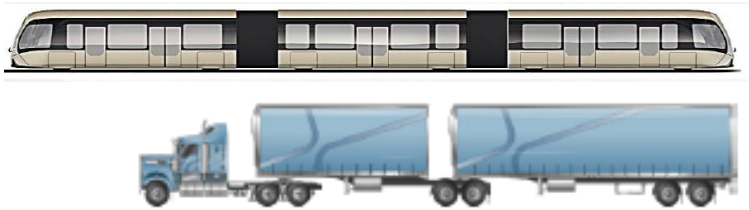
Full depth asphalt

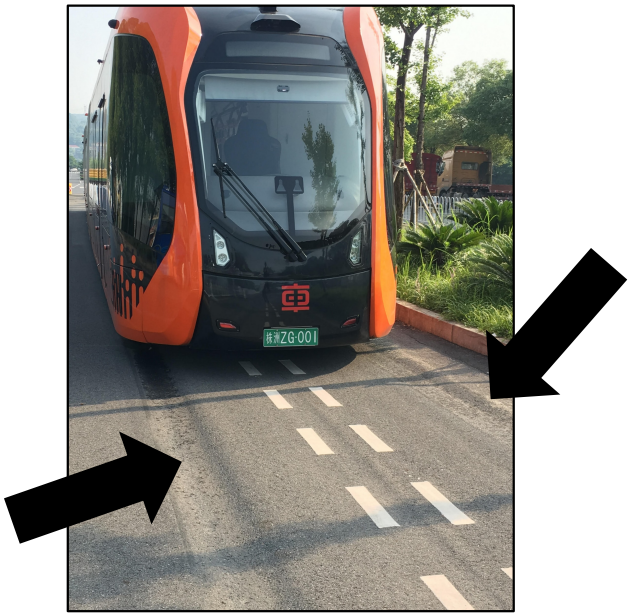
Modelling suggests that the Trackless Tram will impose much greater loadings than are typical on urban routes not already carrying heavy vehicles



Similar size to heavy vehicles. Evidence of rutting suggests pavement works may be required. Rapid implementation may not be possible on all roads.

Trackless Tram (3 modules)	32 tonnes (empty) **51 tonnes** (full load)	31.6m
B-Double	57 tonnes (max)	max 26.0m





However, if pavement works are needed, still likely much cheaper than LRT.

LRT and Trackless Tram indicative cost comparison

	Light Rail	Trackless Tram
Vehicle and station costs	$15M/km	$6M/km
Total Costs	$49-$100M/km	$18M/km

Source: Newman, Mouritz et al. (2018)

+ Pavement rebuild / construction

- Federal government *Road construction cost and infrastructure procurement benchmarking: 2017 update*
  - $6.3 million per lane kilometer for urban arterials, which implies $12 million per route kilometre
  - BUT, highly dependent on site conditions!

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