

International Conference on Modern Roundabouts,
September 1998, Loveland, Colorado, USA



Roundabout Capacity and Performance

Rahmi Akcelik

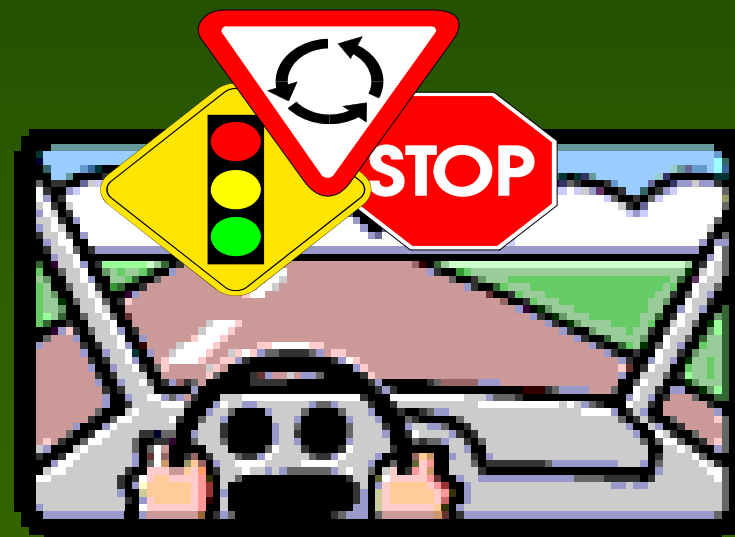
Note 30 Jul 2011: “aaSIDRA” software is
now called SIDRA INTERSECTION, and
website: www.sidrasolutions.com

Presentation schedule



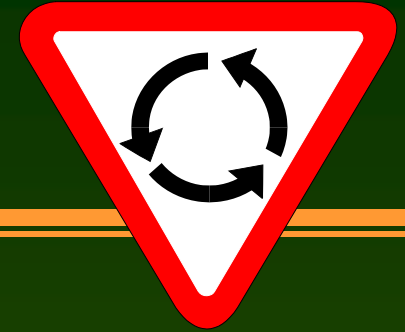
- Research Summary
- Roundabout Capacity and Performance Modeling:
 - ISSUES
 - DISCUSSION
- About Australia
- About aaSIDRA

Research Summary



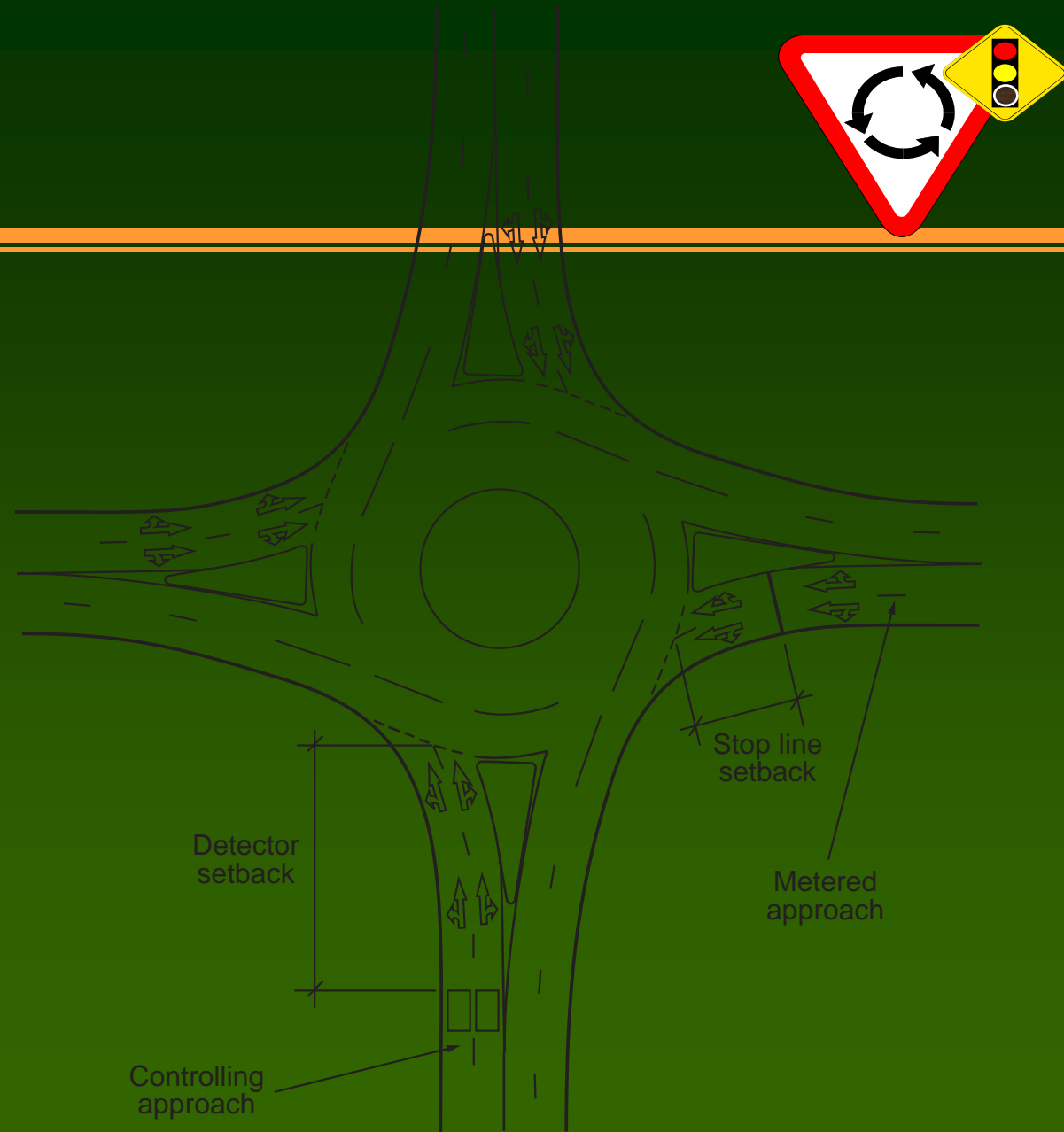
We know traffic

Roundabouts: capacity and performance



- Extensive research and development work
- Heavily directional (dominant) origin-destination movements (congestion)

Roundabout Metering Signals (current research)



Research report

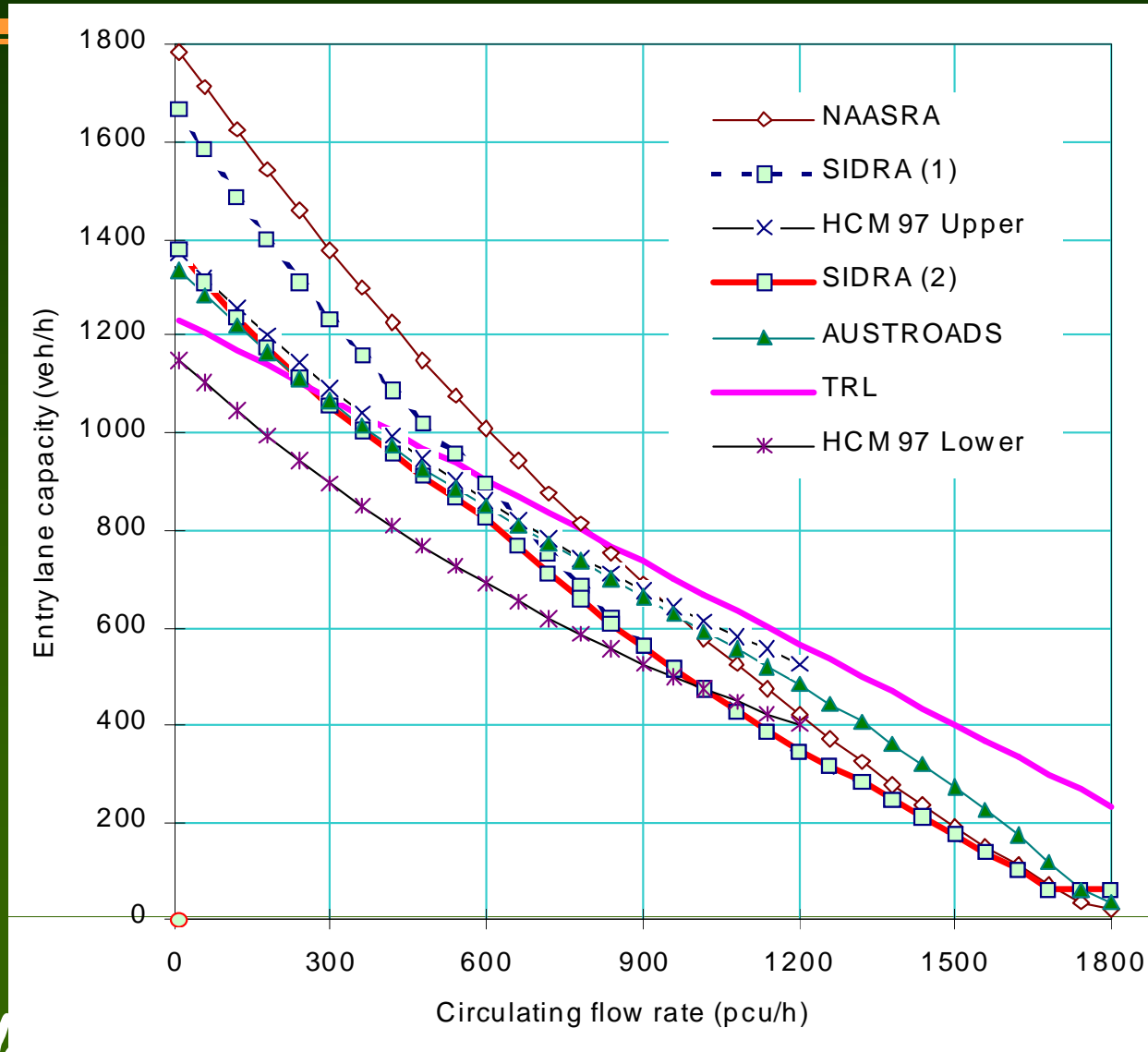
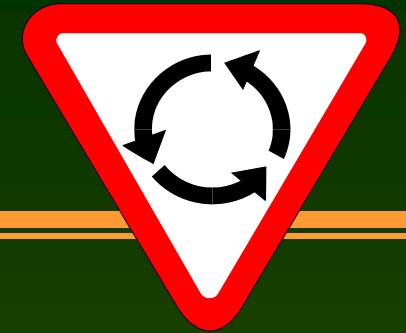


ARR 321

- Comparisons of the aaSIDRA, other Australian and the UK capacity and delay models:

Akçelik, R., Chung, E. and Besley, M. (1998). *Roundabouts: Capacity and Performance Analysis*. Research Report ARR No. 321. ARRB Transport Research Ltd, Vermont South, Australia (2nd Edition 1999).

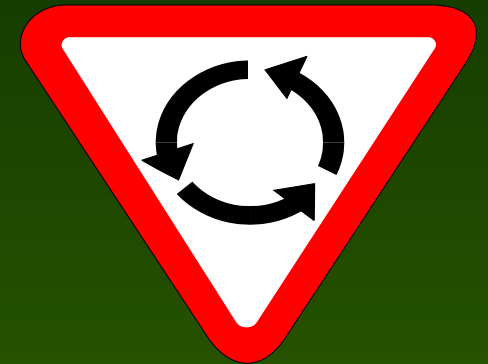
ARR 321



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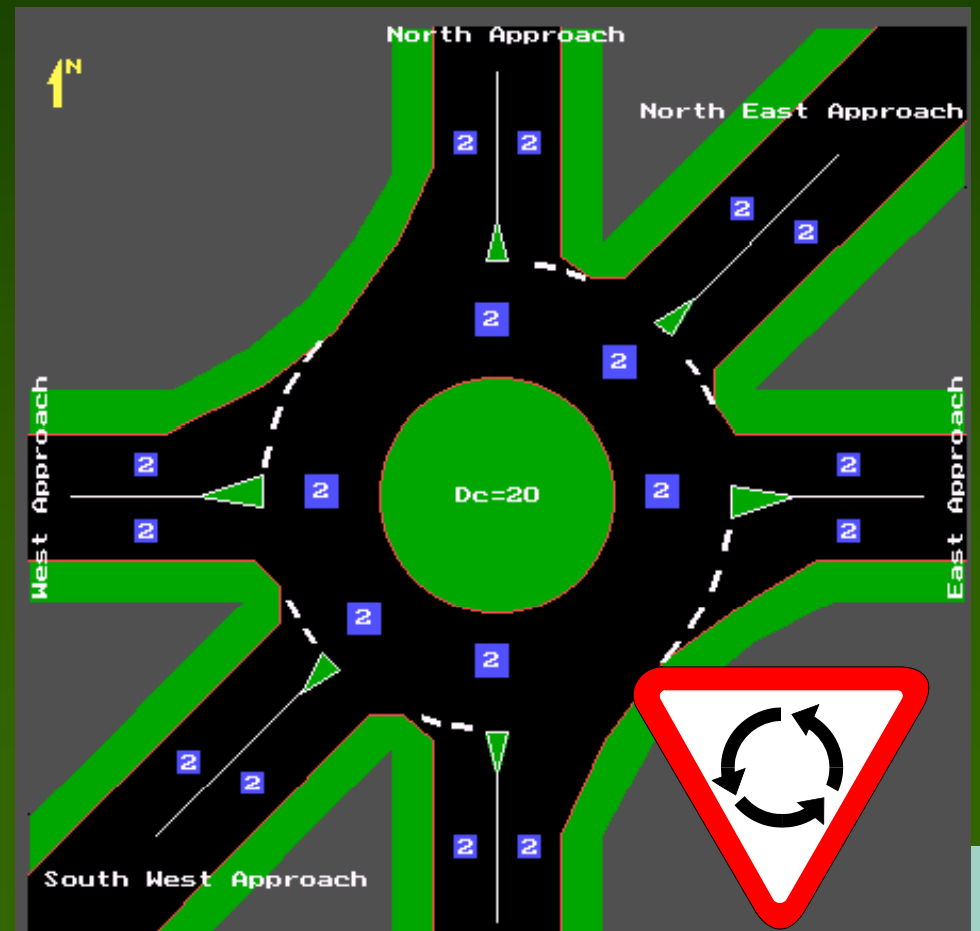
**International Conference on Modern Roundabouts,
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**Roundabout Capacity and
Performance Modeling:
ISSUES**



Estimating roundabout entry lane capacity and performance measures

- Analytical models (not simulation)



Capacity and performance models



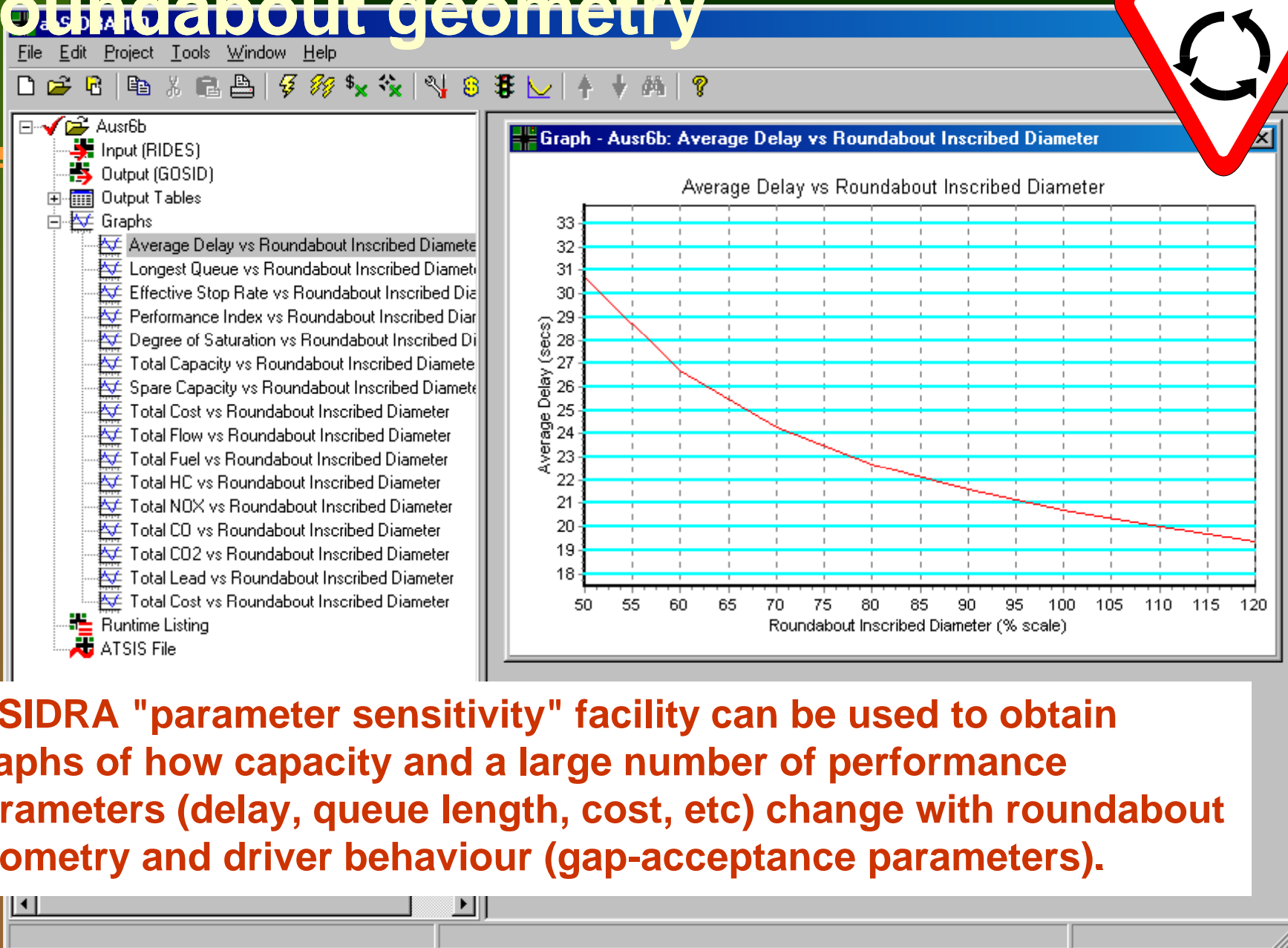
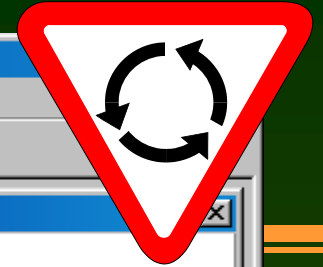
- A good method for predicting capacity and performance of modern roundabouts should model
 - DRIVER “YIELD” BEHAVIOUR and
 - ROUNDABOUT GEOMETRY.
- aaSIDRA model satisfies both criteria using a gap-acceptance based method to model driver yield behaviour, at the same time allowing for the effects of geometric variables. UK linear regression model used in the RODEL and ARCADY programs uses only the geometric variables.

Driver behaviour

- “Yield” means gap-acceptance !
(applicable to roundabouts, signals, sign control, freeway merge)
- Gap-acceptance model is **EMPIRICAL** in calibrating driver behaviour parameters:
 - entry stream characteristics
 - opposing / circulating stream characteristics

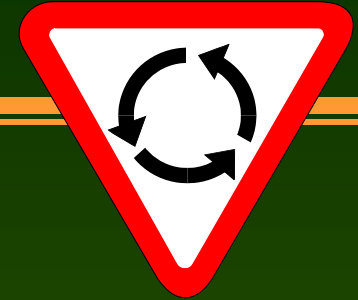


Roundabout geometry



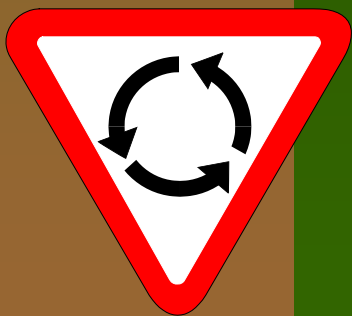
- aaSIDRA "parameter sensitivity" facility can be used to obtain graphs of how capacity and a large number of performance parameters (delay, queue length, cost, etc) change with roundabout geometry and driver behaviour (gap-acceptance parameters).

Modeling interactions amongst approach flows

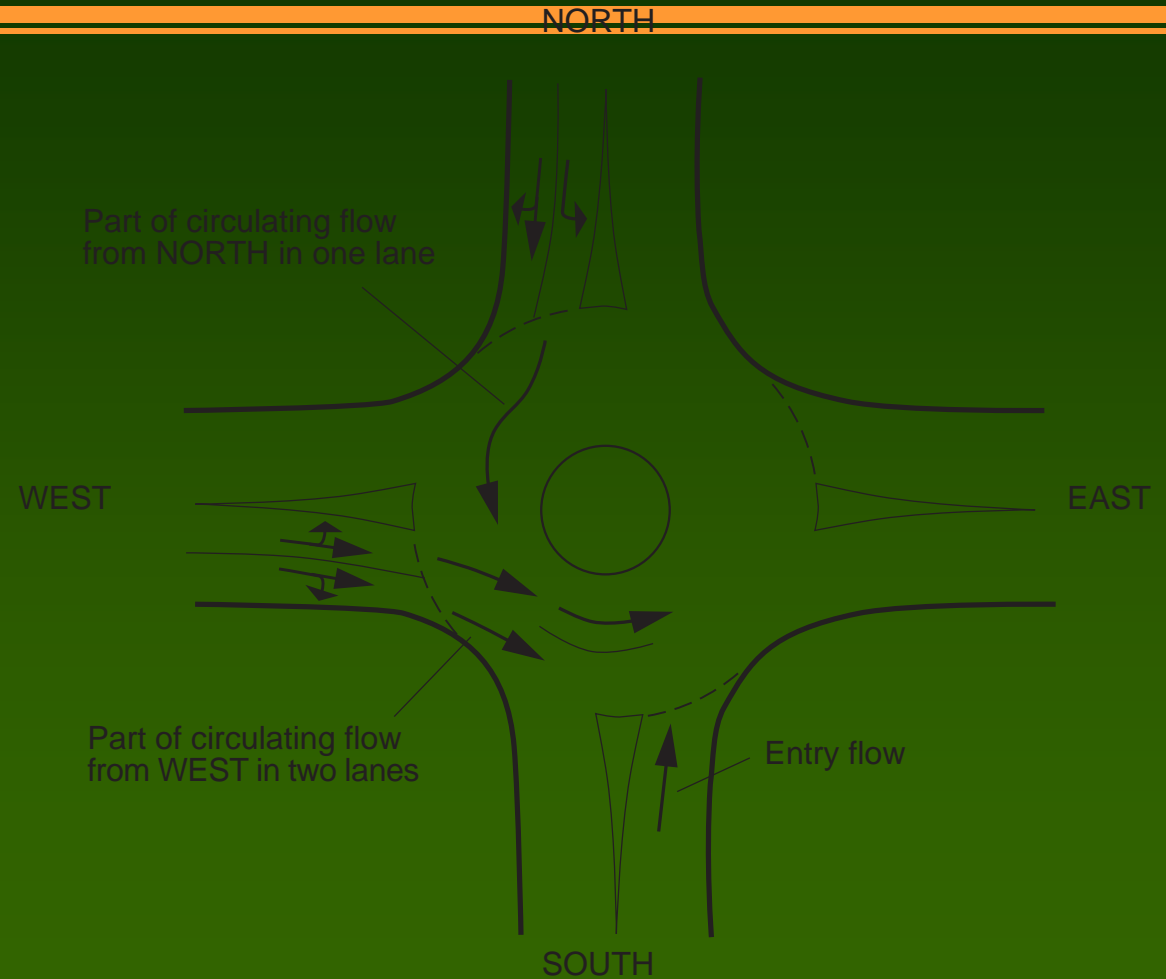


Modeling the roundabout AS A
SERIES OF T-JUNCTIONS is
inadequate
(heavy and unbalanced demand
flows require modeling of origin-
destination and queuing effects)

Approach lane use characteristics of the traffic streams that constitute the circulating flow

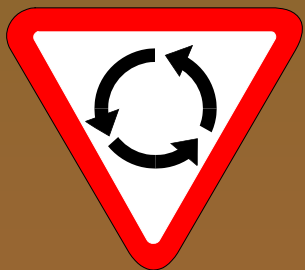
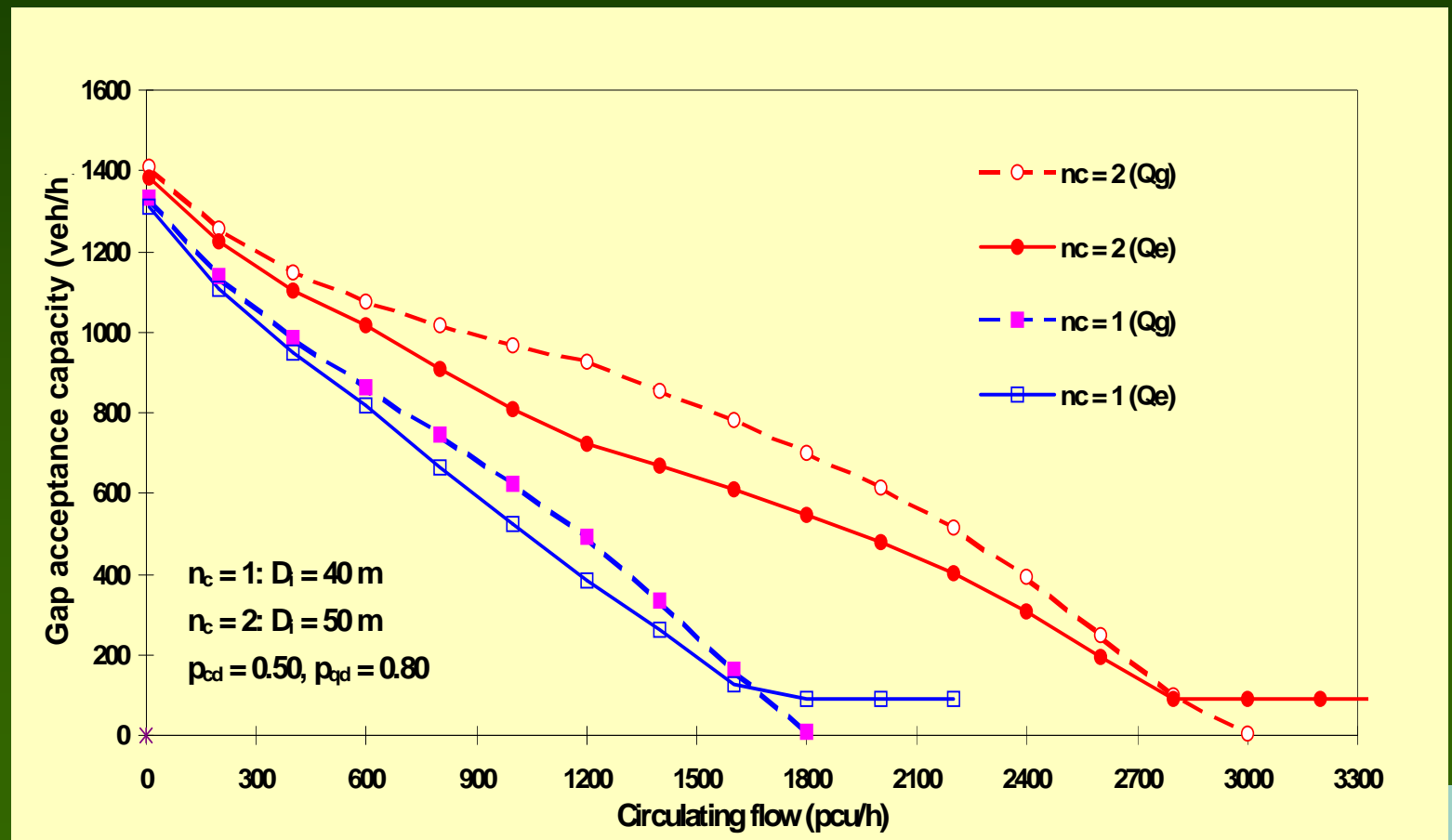


We know traffic



Approach lane use effect on circulating stream characteristics at a multilane roundabout

Ignoring approach flow interactions cause overestimation of capacity (underestimation of delays and queue lengths)



We know traffic

Issue: Analysis detail (level of aggregation)



*more detailed
model of
traffic stream*

Individual vehicles			<i>Microsimulation models</i>
Drive cycles			aaSIDRA
Traffic flows	<i>Most traffic analysis models</i>		
Speed-flow functions	<i>Most transport planning models</i>		
	Approaches	Lane groups	Individual LANES

UK "empirical model" falls in this category

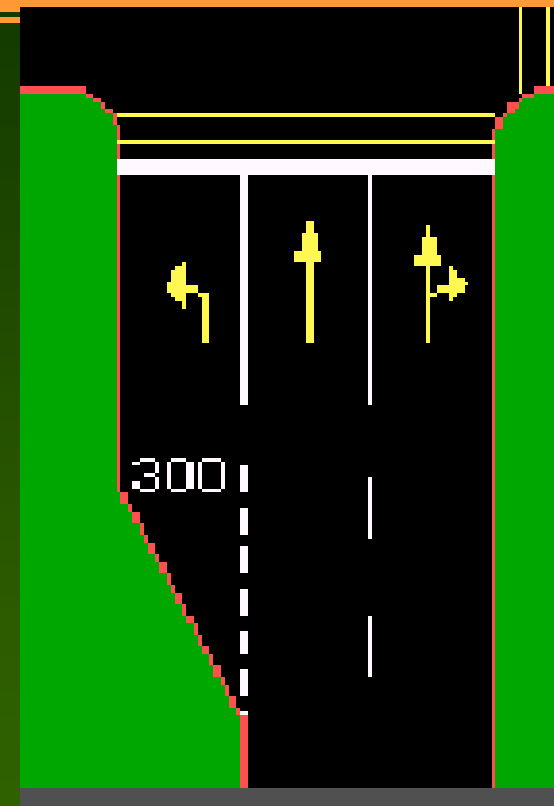
more detailed model of road geometry

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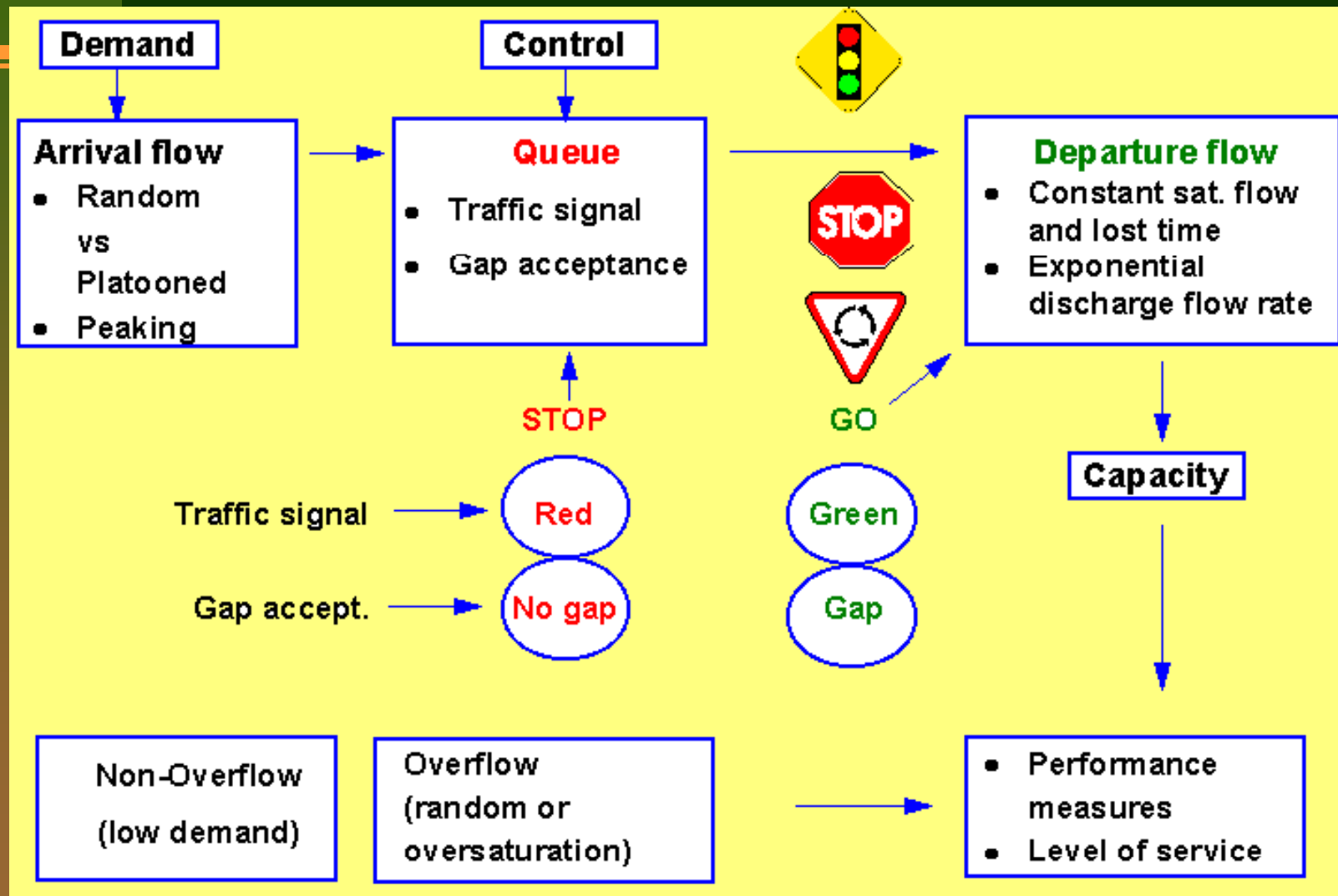
Lane-by-lane analysis

- aaSIDRA is the only widely-used analytical software that uses the lane-by-lane analysis including short lanes

SPATIAL MODEL rather than
LINKS or **LANE GROUPS**



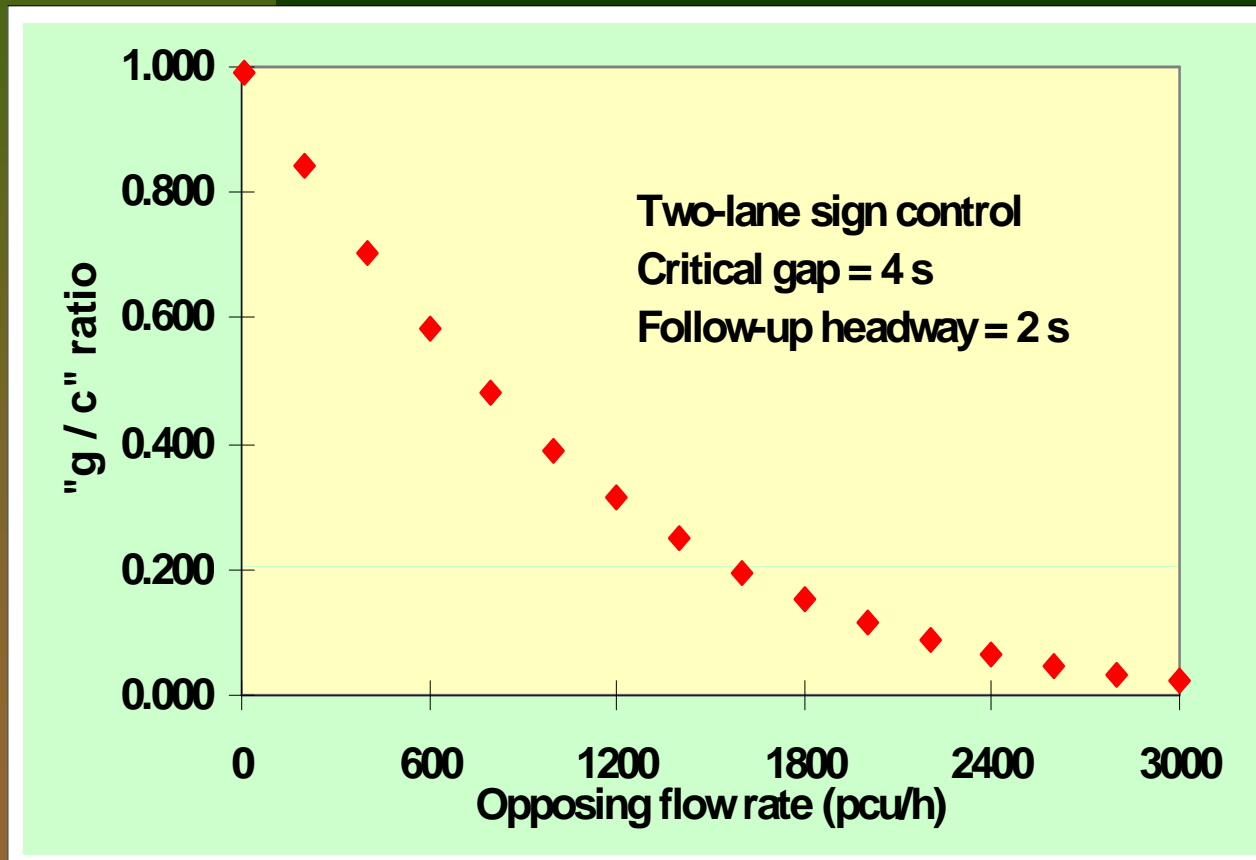
Basic concepts of traffic analysis



Issue: Capacity measurement method

- **By congestion (saturated conditions only)**
- **By total departures from queue (unsaturated conditions)**

"g / c" ratio



**Capacity =
s (g/c)**

where

$$s = 3600 / \beta$$

Issue: Linear regression (UK) vs Gap acceptance (US & Australia)

- “Empirical” misnomer (use “regression”)
- HCM 97 Chapter 10 on Roundabouts:
GAP-ACCEPTANCE METHOD
- UK method for 2-way stop-sign control is also a
REGRESSION MODEL (HCM and aaSIDRA use
GAP ACCEPTANCE)
!!! Same issues arise !!!

Issue: Linear regression (UK) vs Gap acceptance (US & Australia)

Roundabout Geometry:

Compared with the aaSIDRA model, the TRL regression model is **OVERSENSITIVE** to:

- inscribed diameter
- approach (lane) width
- and other geometric variables.

This is probably because the TRL database used in 1980s included a large number of sub-standard roundabout designs that existed in the UK historically. This makes the UK model not readily applicable to other countries where modern roundabouts are used.

Issue: Linear regression (UK) vs Gap acceptance (US & Australia)

Roundabout Geometry:

Modern roundabout designs are more uniform, and therefore, the more recent models based on them are less sensitive to the geometric variables (as in the case of the **Australian** roundabout model used in aaSIDRA).

German linear regression and gap-acceptance models were found to be sensitive only to the number of entry and circulating lanes!

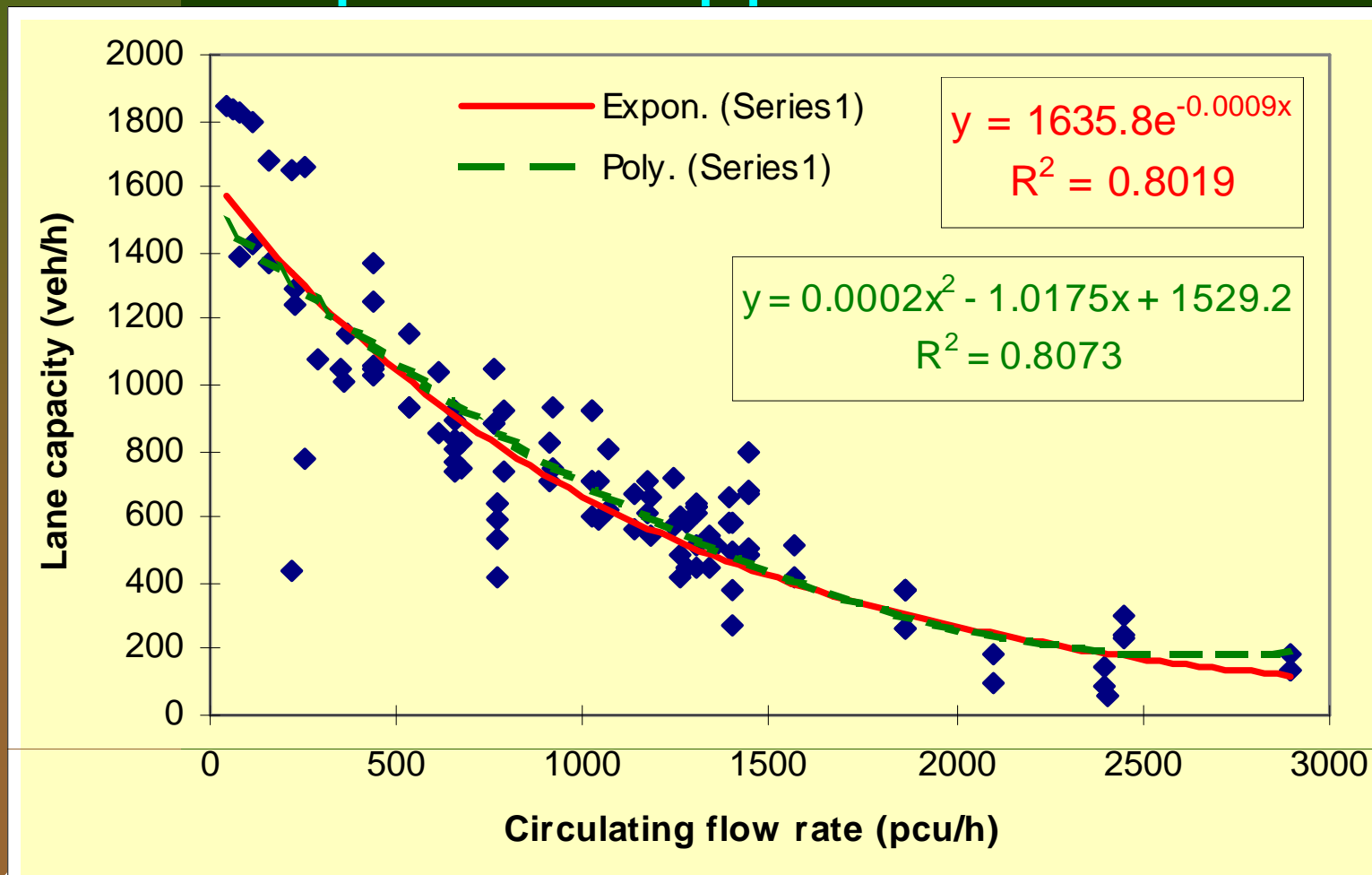
Issue: Linear regression (UK) vs Gap acceptance (US & Australia)

Linearity could be due to measurement method
(by approach rather than lane by lane)

A demonstration using aaSIDRA follows >>
(similar exercise using real-life & simulation data
recommended)

Capacity models: Linear or Non-linear?

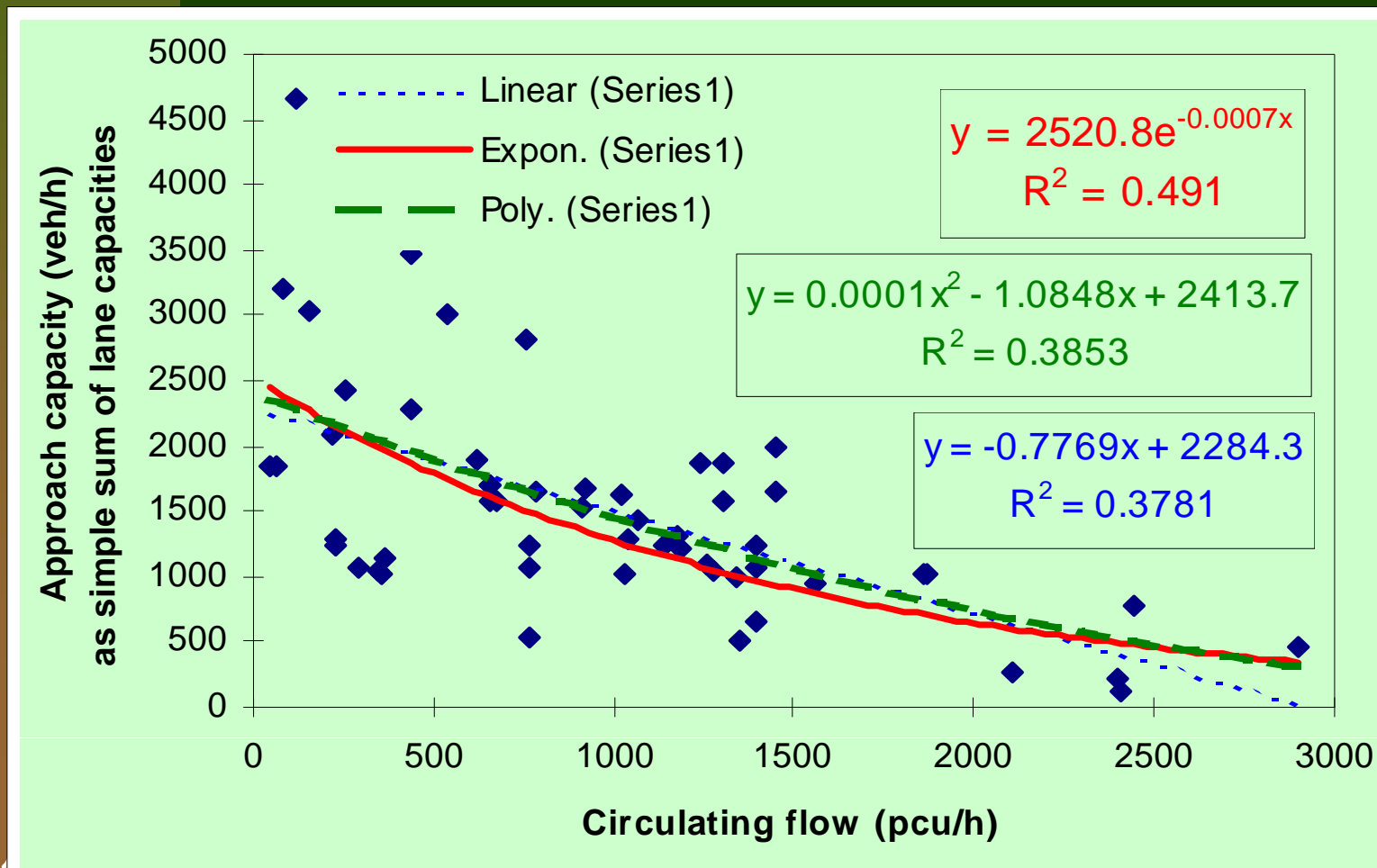
LANE capacities appear non-linear



Capacity models: Linear or Non-linear?

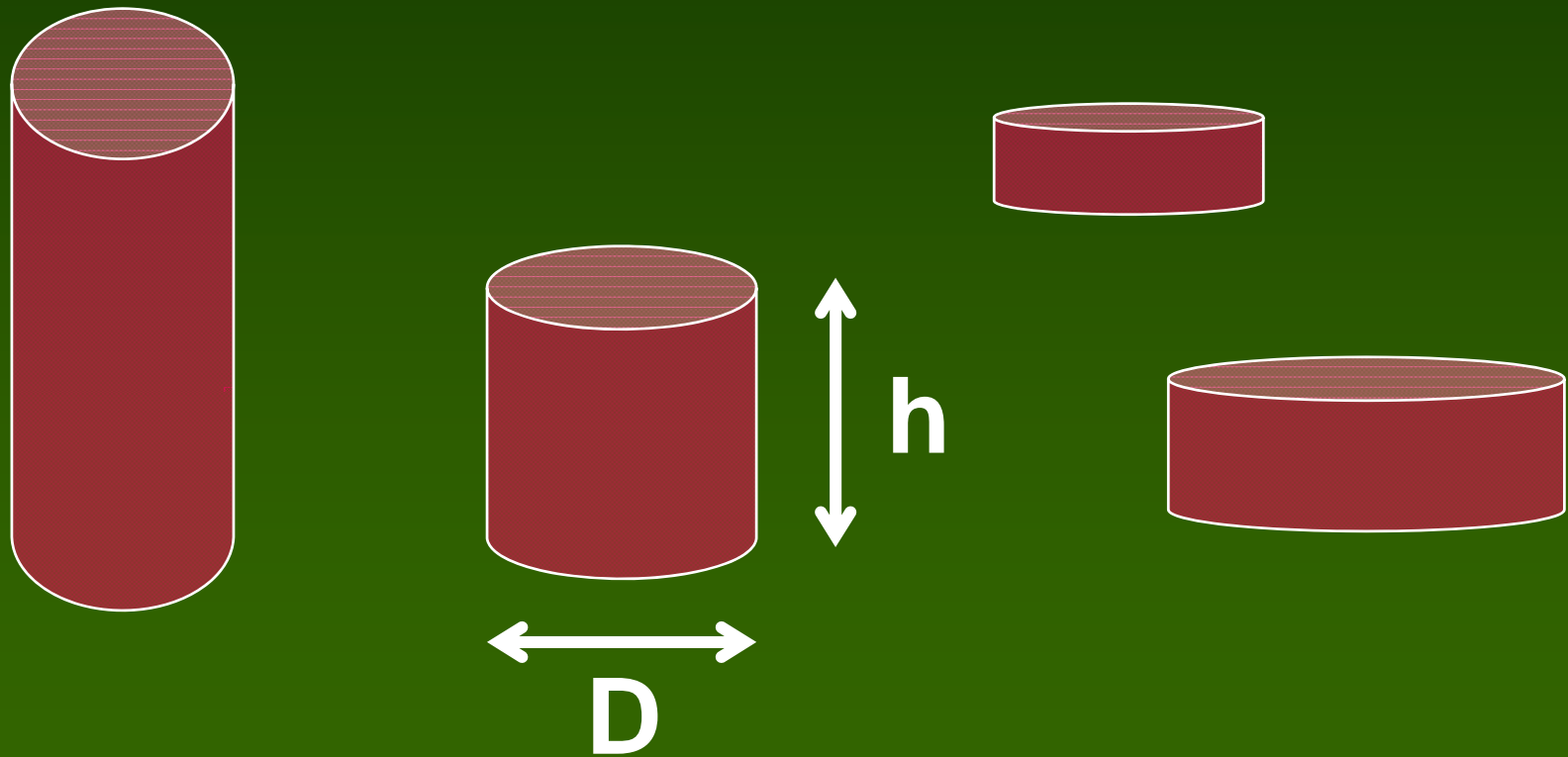
APPROACH capacities appear linear

but exponential (non-linear) appears to be better

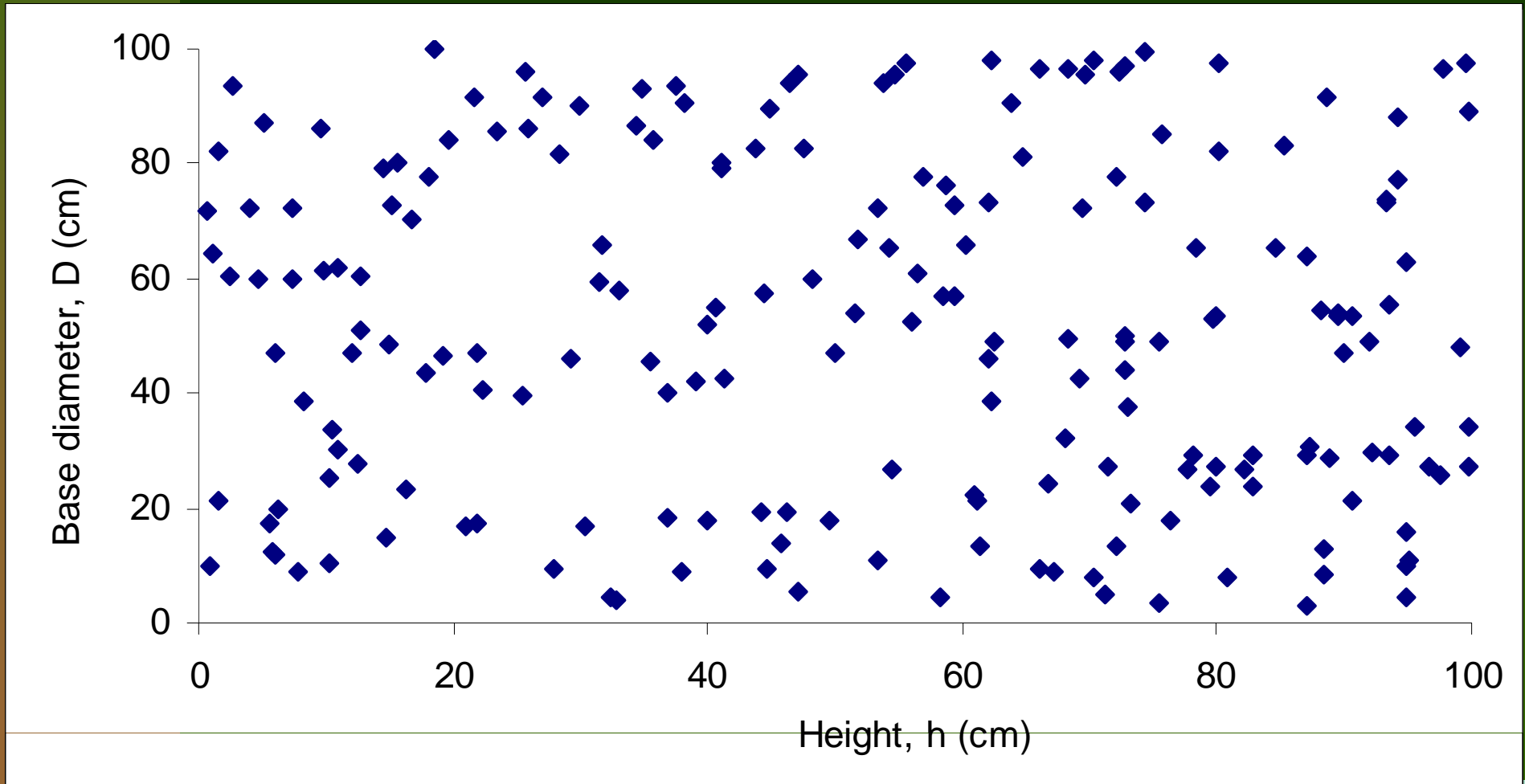


A demonstration of regression vs mathematical model:

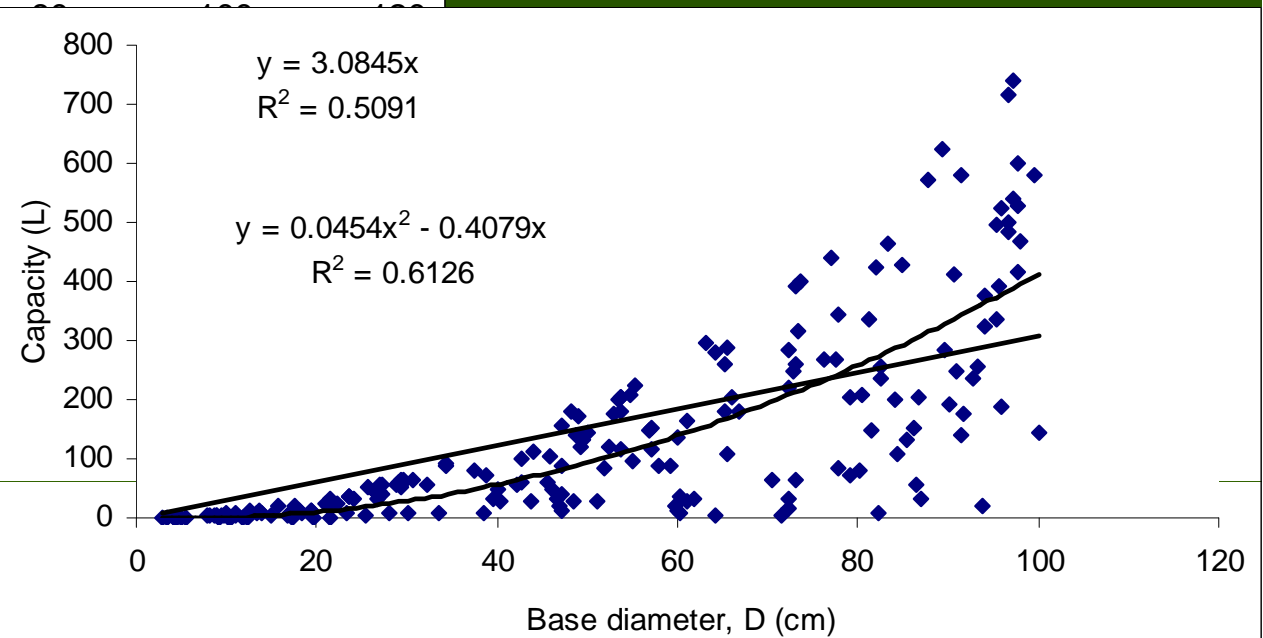
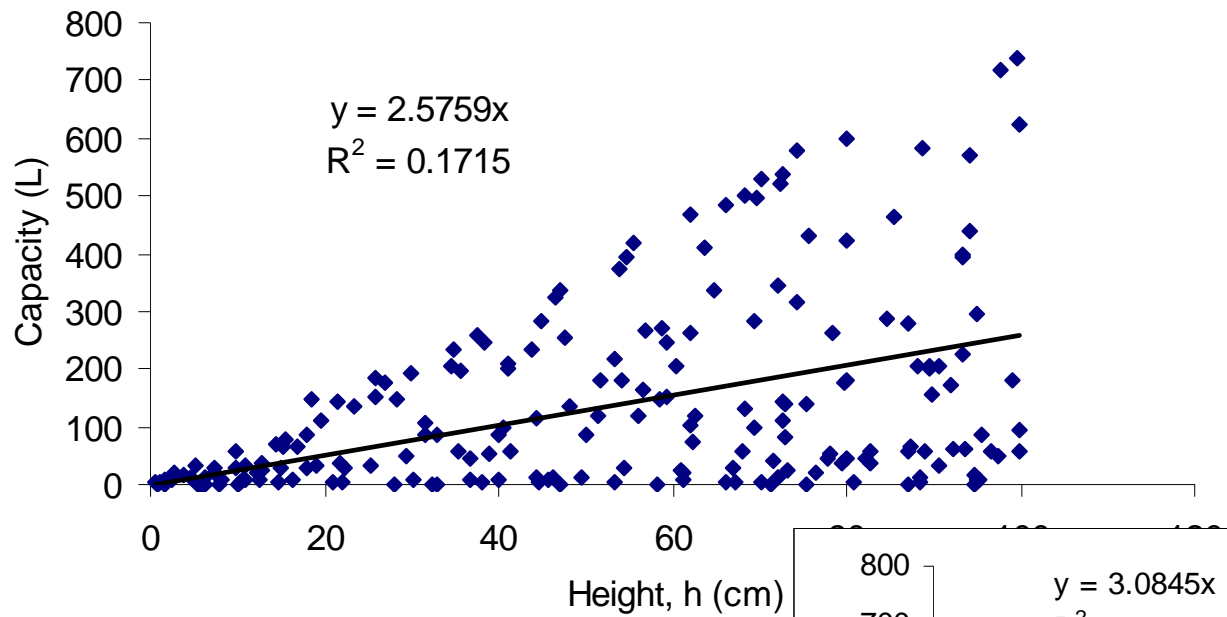
capacity of cylindrical containers



h, D parameters generated randomly (200 data points)



Regression on h & D << the “empirical” approach

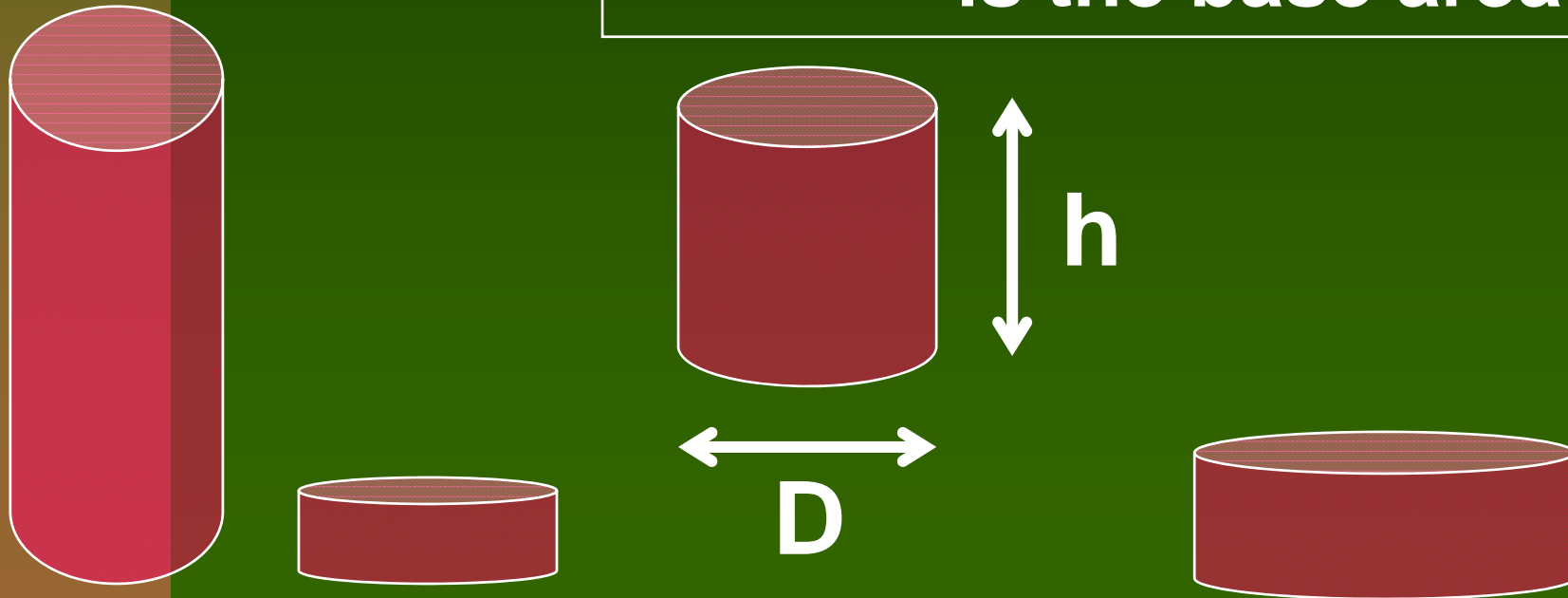


Mathematical model: << the aaSIDRA approach

$$C = h A$$

$$\text{where } A = \Pi (D/2)^2$$

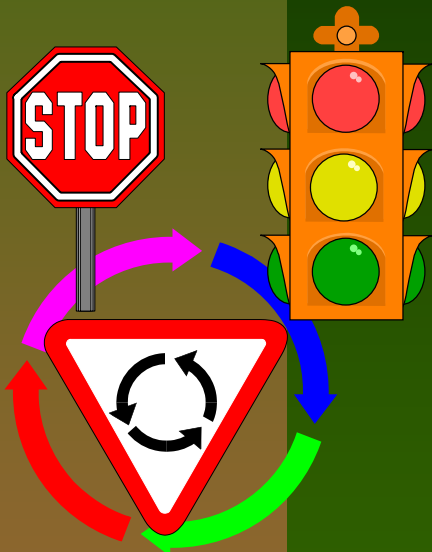
is the base area



aaSIDRA performance model for intersections

(more general form of the HCM two-term delay models)

$$P = P_1 + P_2$$



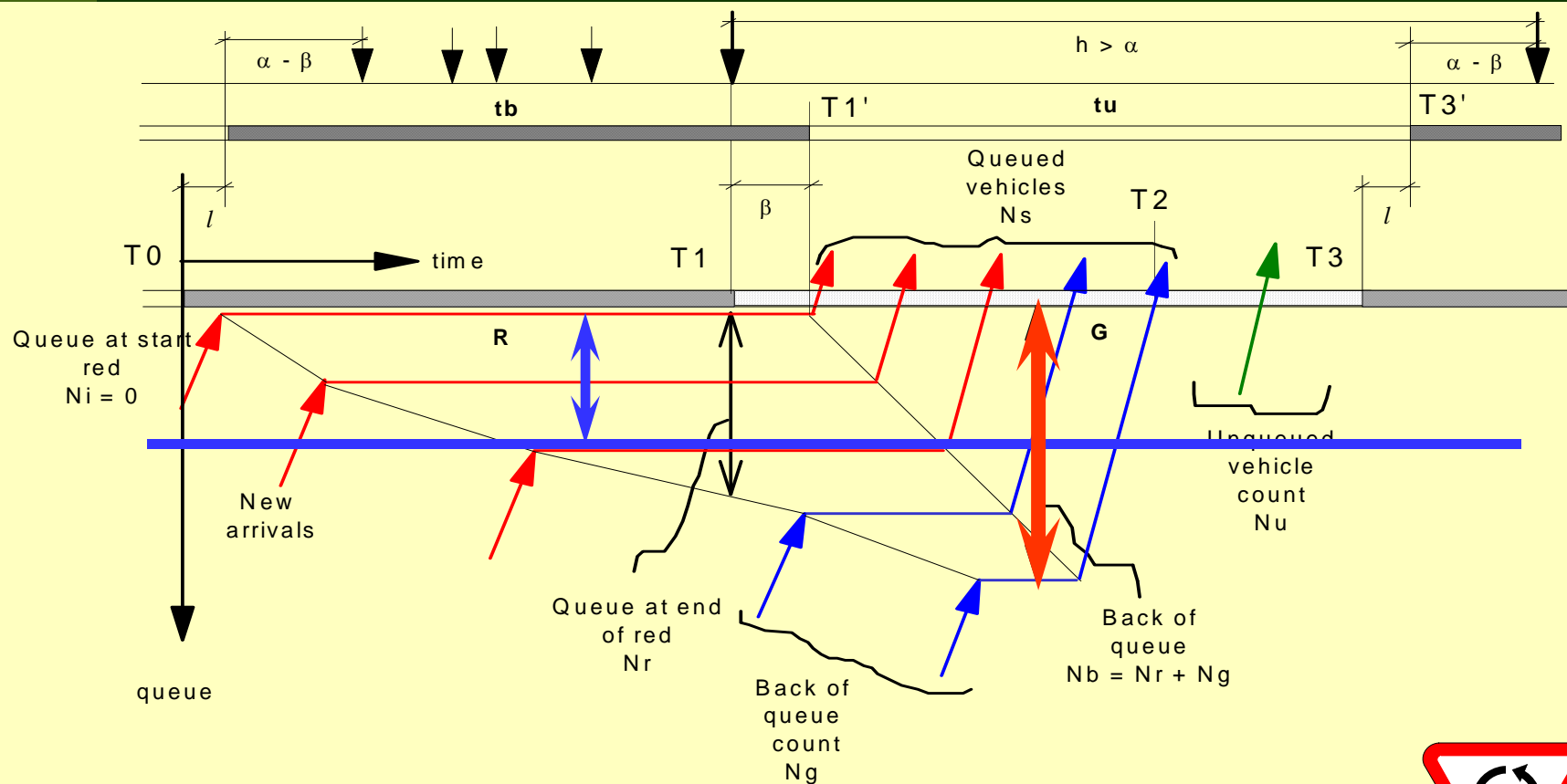
Performance measure	P_1 (non-overflow term)	P_2 (overflow term)
Delay	☰	☰
Queue length	☰	☰
Effective stop rate	☰	☰
Queue clearance time	☰	NA
Proportion queued	☰	NA
Queue move-up rate	NA	☰

We know traffic

Why gap acceptance model?

**Gap-acceptance model is
needed to estimate
performance statistics
(not just CAPACITY)**

Issue: Cycle-average queue vs average back of queue

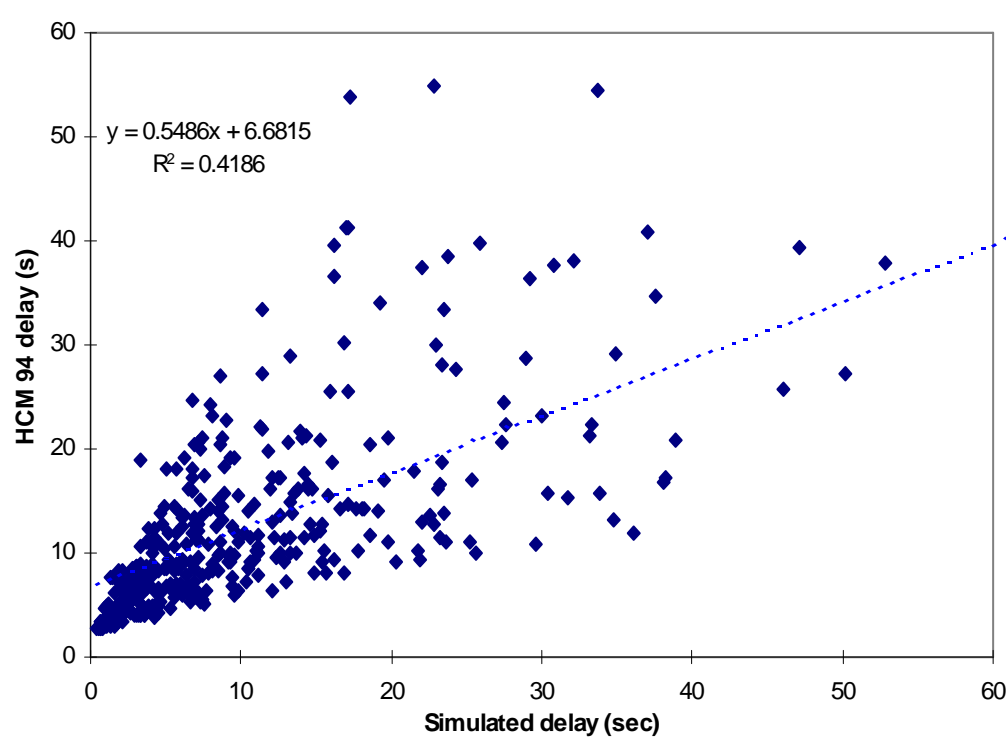


Unsaturated cycle: $T_2 < T_3$

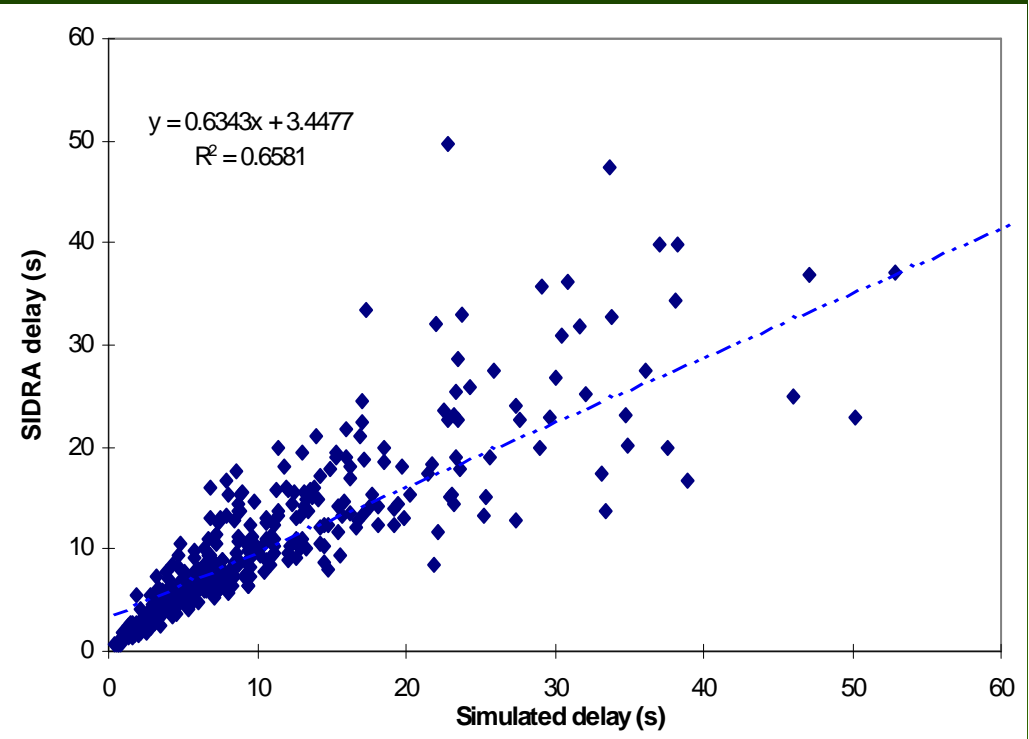


Issue: Need for delay model comparisons

HCM 94/97



aaSIDRA



Issue: Modeling of flares / short lanes

- Short lane capacity is flow dependent
- aaSIDRA model uses back of queue and predicts excess flow into adjacent lane

Issue: Lane utilisation

Lane under-utilisation is best modeled using a lane-by lane method as in aaSIDRA

This helps with design of lane disciplines

Traffic Engineering + Control MARCH 1997
ISSN: 0041-0683

**ARCADY Health Warning:
Account for unequal lane usage
or risk damaging the Public Purse!**

The ARCADY computer program was first released in 1986. It is used to predict traffic flow and delays on roundabout approaches from user origin-destination data. The latest release, Visual A, was released in October 1996.

Over the years, several features have been added to the program. However, the basic model has remained unchanged. This model is based on the assumption that traffic flow is uniform across all lanes. This is not always the case, and can lead to lane under-utilisation and increased delays.

This model is well proven. However, if used on roundabouts with unequal lane usage, it can produce unrealistic results. (see photograph). ARCADY is in fact completely blind as a consequence may produce hopelessly over-optimistic results.

Following the author's public warning of these concerns in December 1996, the Transport Research Laboratory (TRL) has agreed to place a Warning in their new release, Visual ARCADY/4 documentation. They have also invited the author to submit a report illustrating the problem and any proposed solution methodology, this for their consideration and possible inclusion in future ARCADY User Manual documentation.

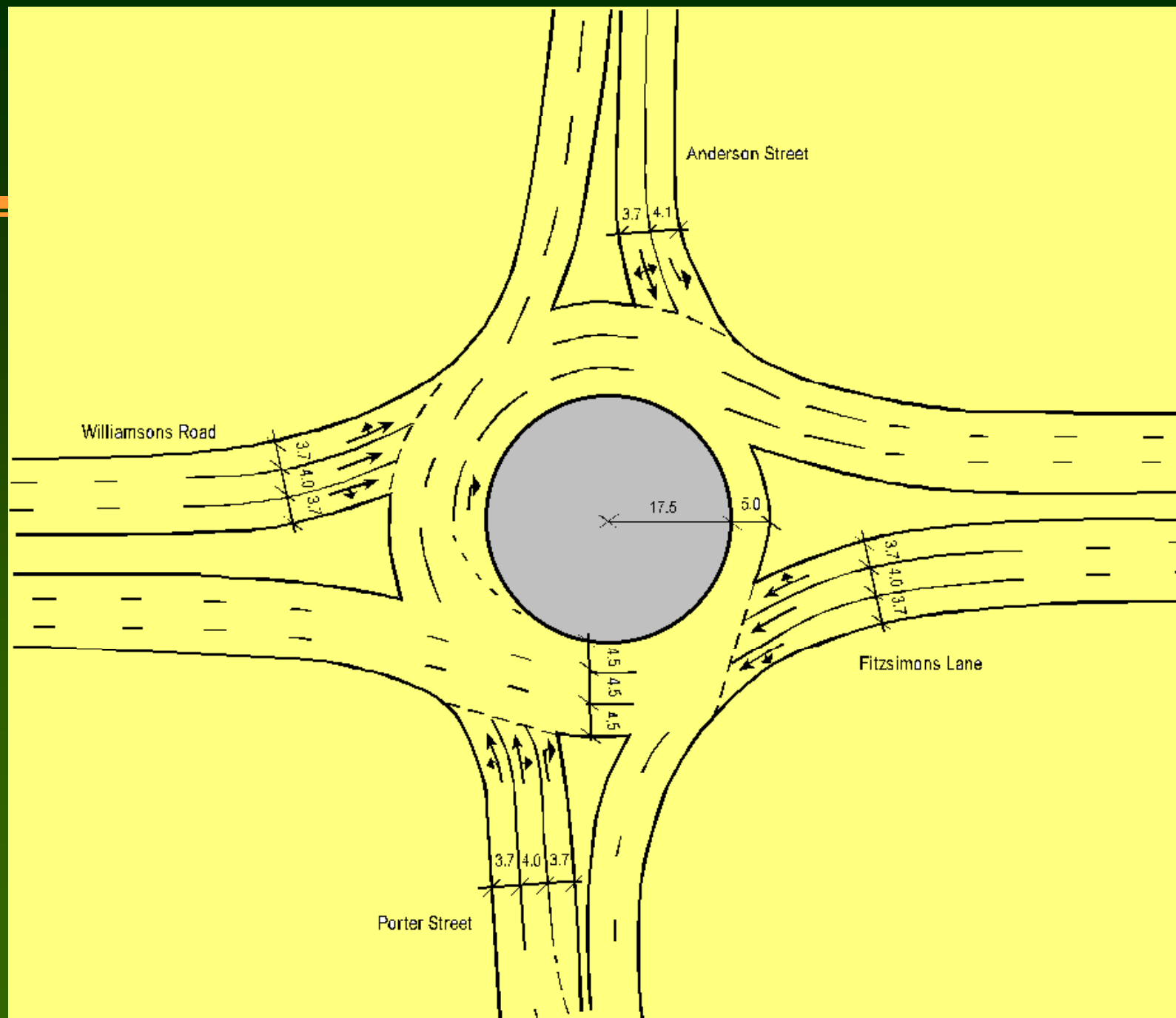
2. ARCADY capacities, queues and demand flows vary with the traffic origin-destination geometry of the roundabout. The "entry capacity" amount of traffic that can enter from a steady stream

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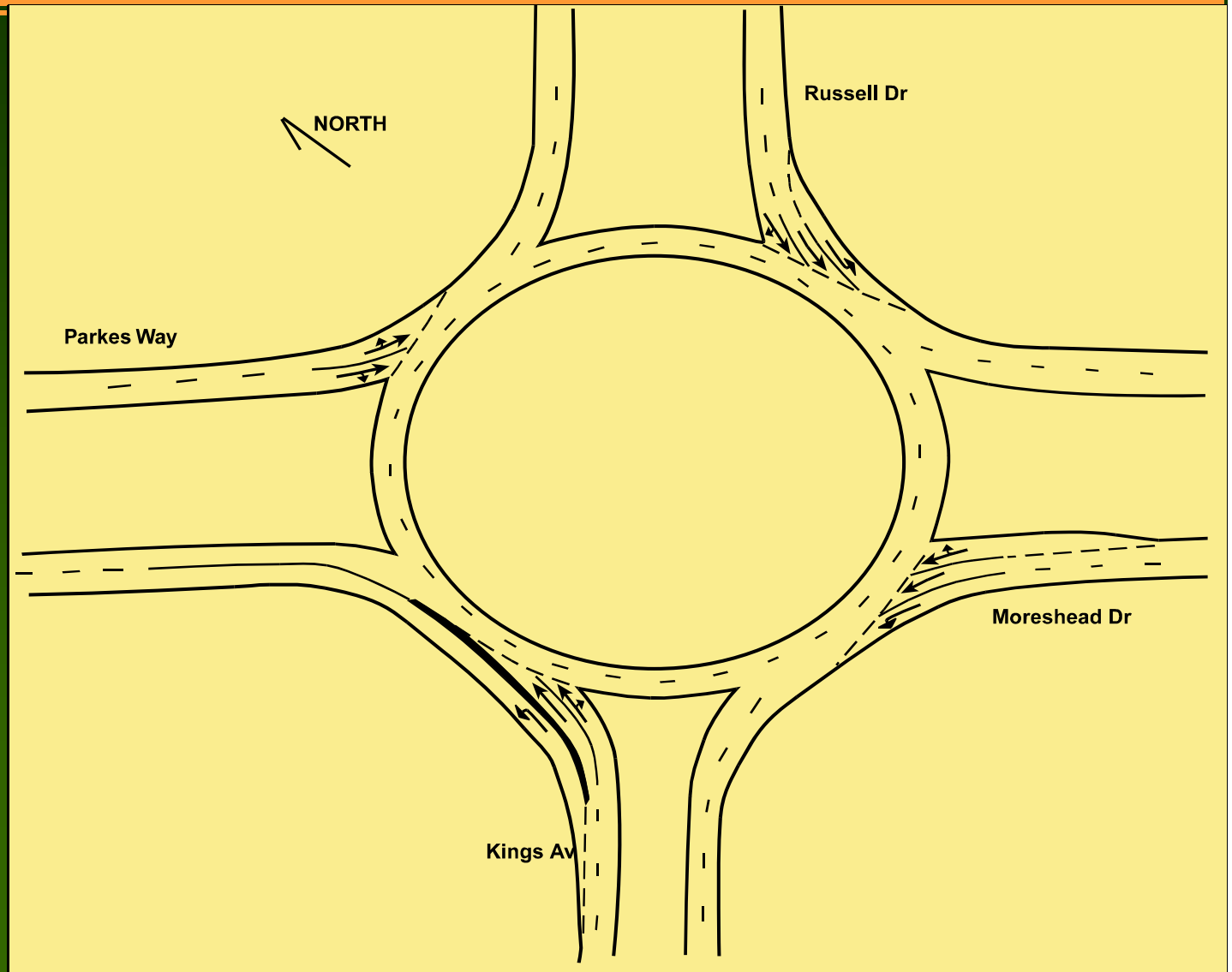
Roundabout case: Melbourne

ITE 67th Ann. Meeting



Roundabout case: Canberra

See ARR 321



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About Australia

Australia compared with United States

6 cars per 10 people



29 miles of road
per 1000 people

Australia

2,974,581 sq. miles

9 cars per 10 people



16 miles of road
per 1000 people

United States

2,974,726 sq. miles

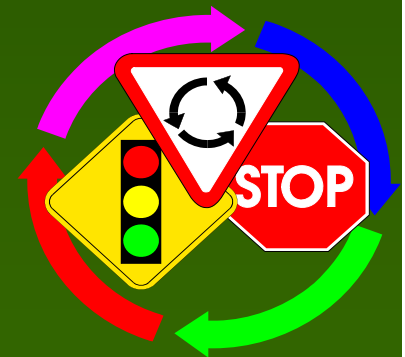
aaSIDRA

aaTraffic Signalised & unsignalised Intersection

Design and Research Aid

Further info available from

<http://www.akcelik.com.au/downloads.htm>



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**“it is still an
unending story”**