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

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Presentation schedule

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

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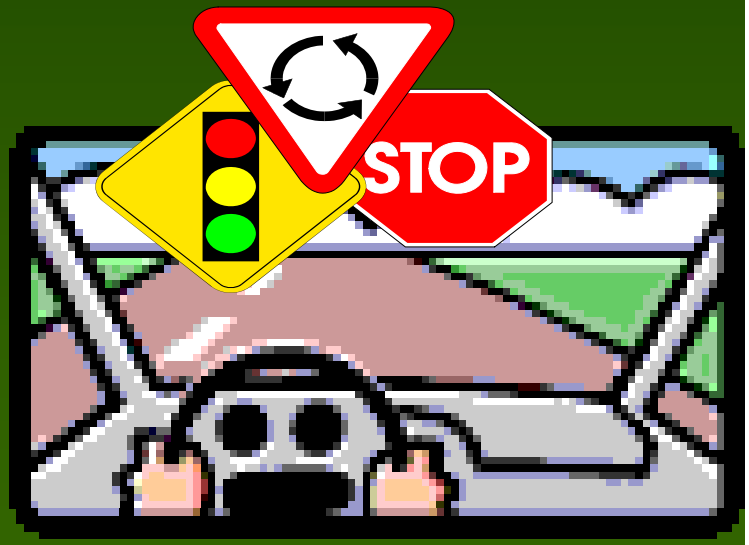
Research Summary



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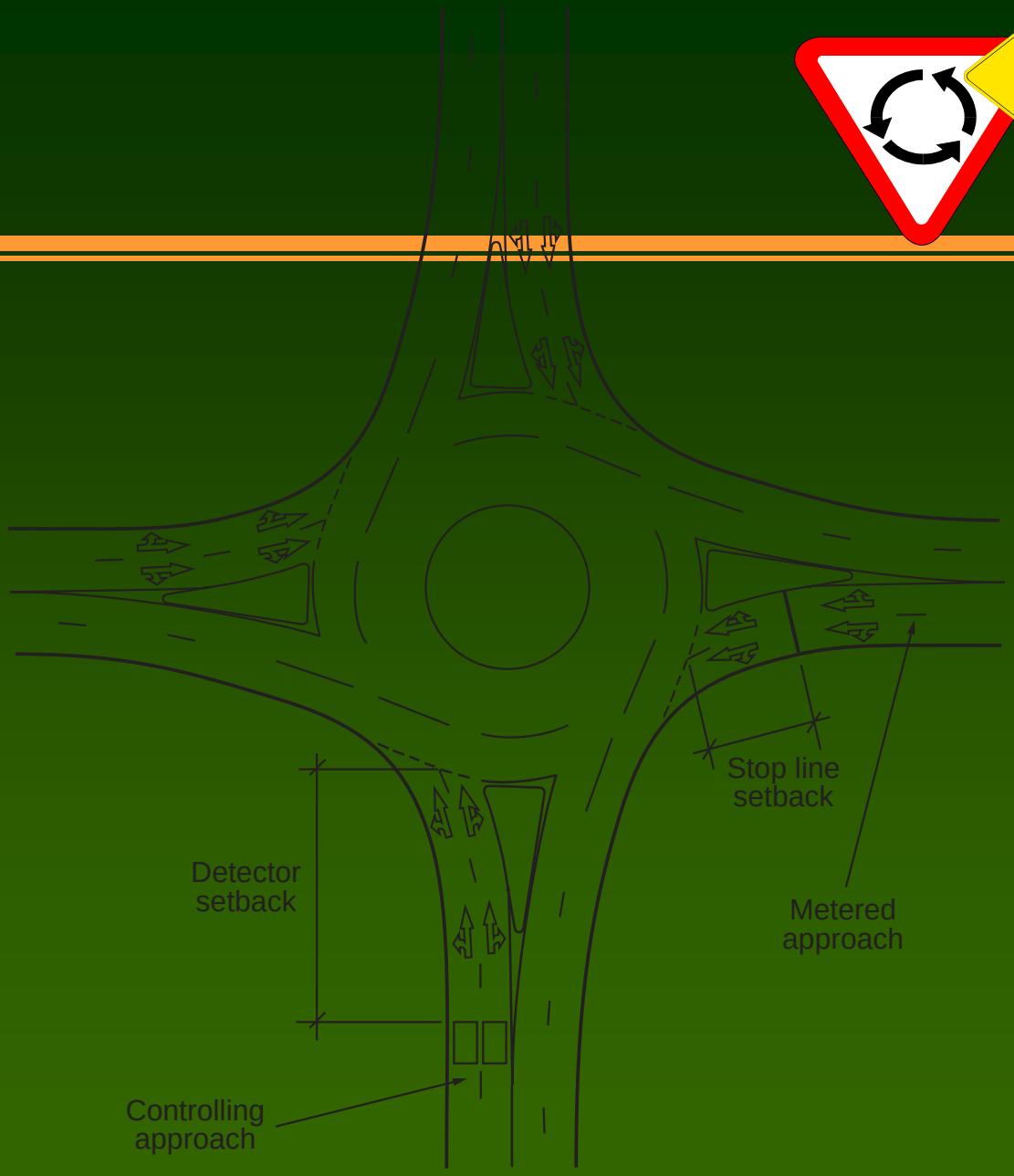
Roundabouts: capacity and performance

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

Roundabout Metering Signals
(current research)



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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*).

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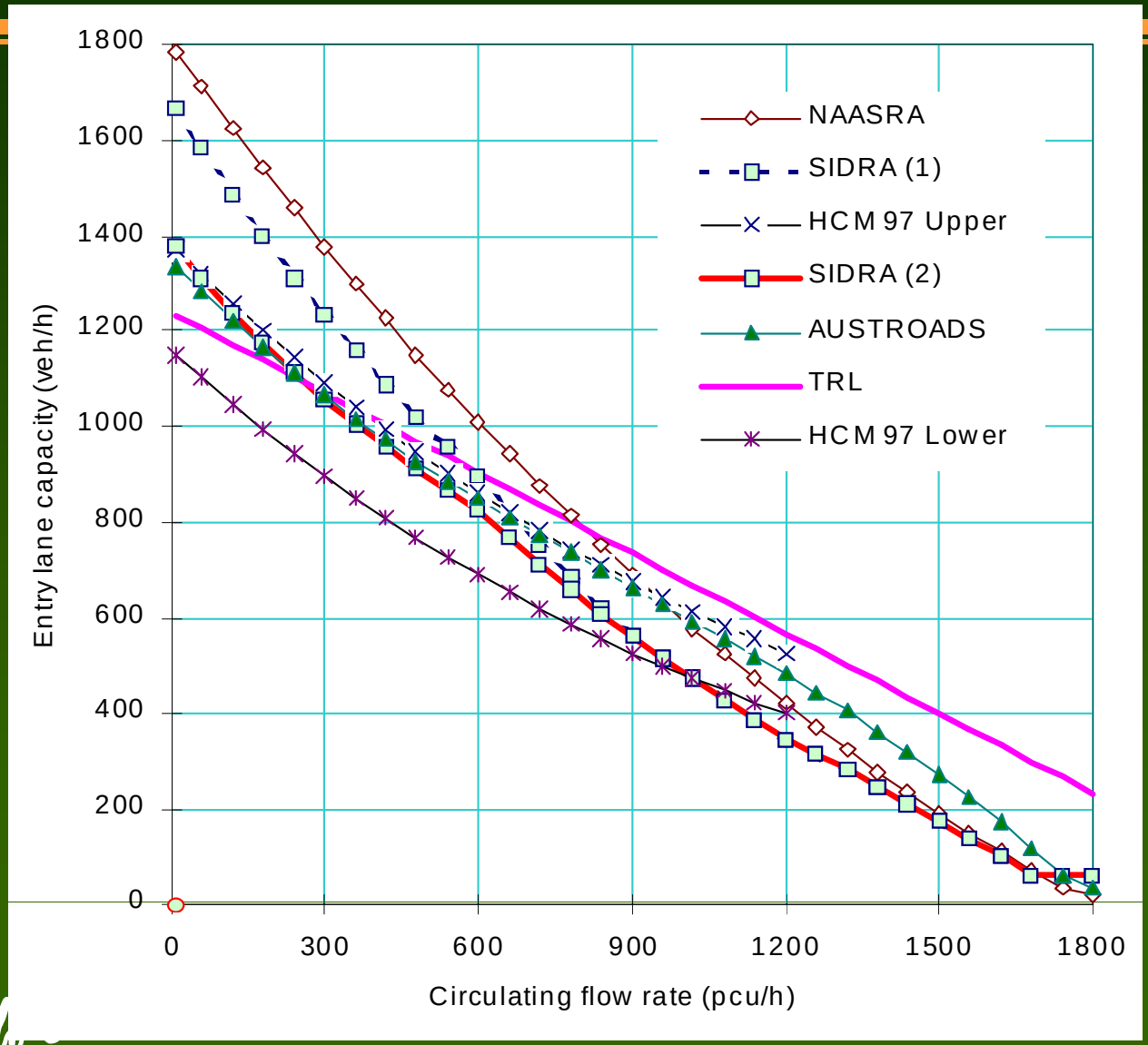
ARR 321



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Roundabout Capacity and Performance Modeling: ISSUES

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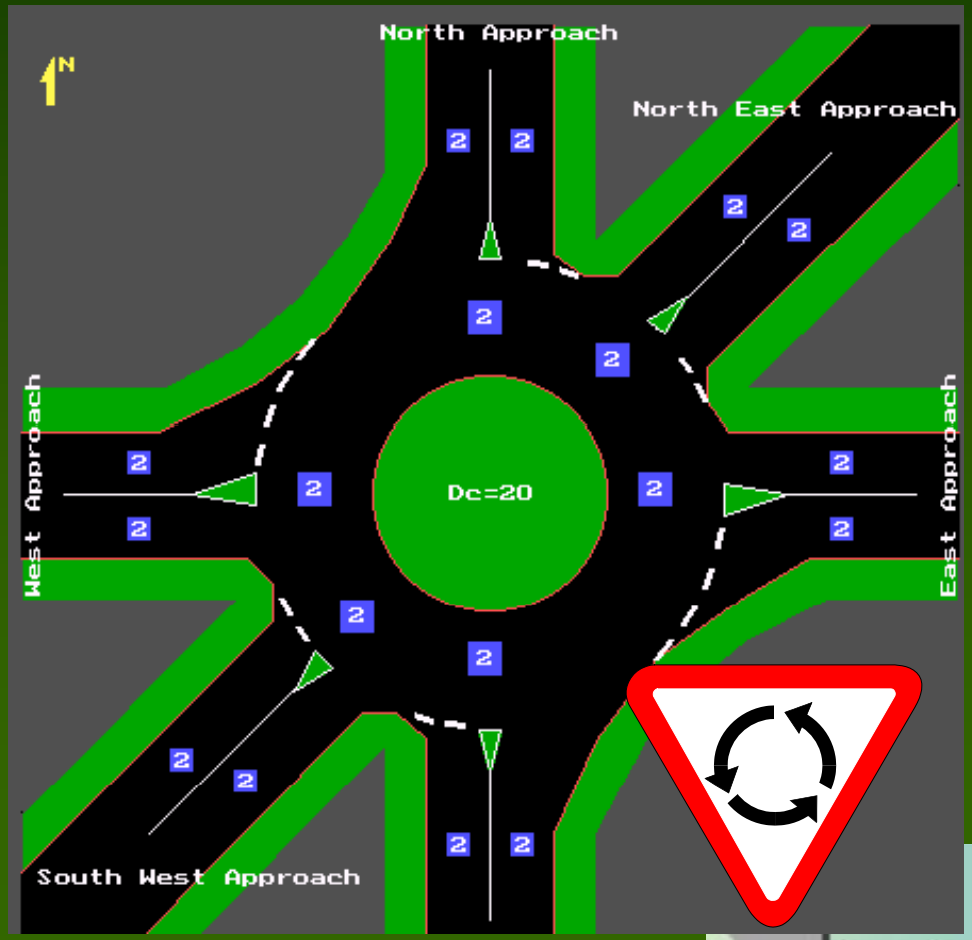
Estimating roundabout entry lane capacity and performance measures

- Analytical models (not simulation)



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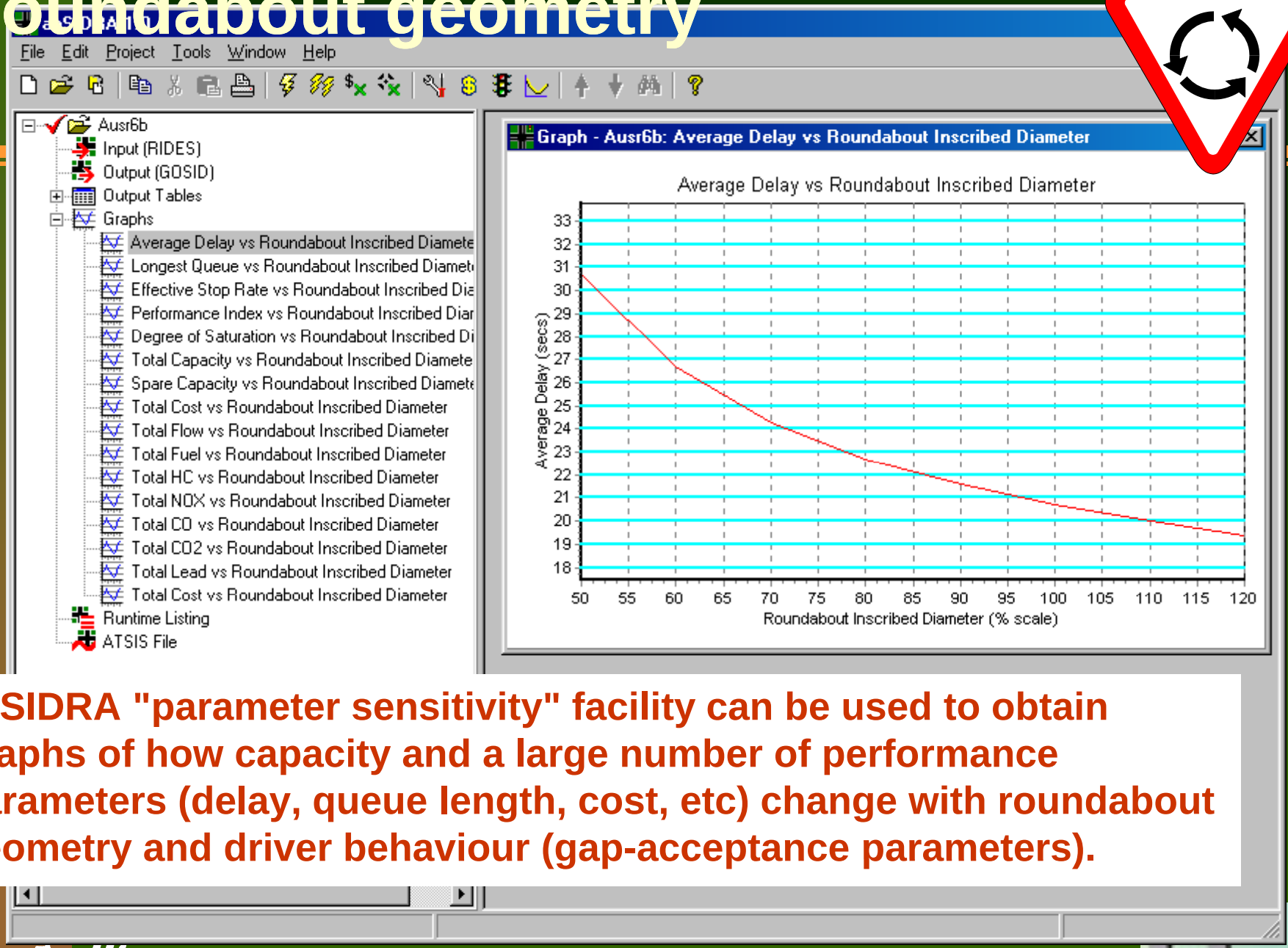
Capacity and performance models

- 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

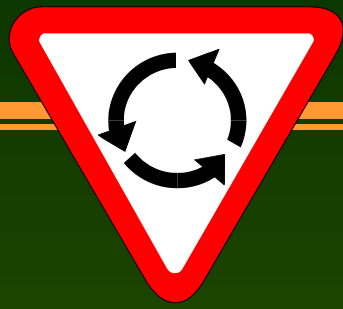
- **“Yield” means gap-acceptance !**
  (applicable to roundabouts, signals, sign control, freeway merge)
- **Gap-acceptance model is EMPIRICAL** in calibrating driver behaviour parameters:
  - **entry stream characteristics**
  - **opposing / circulating stream characteristics**

Roundabout geometry



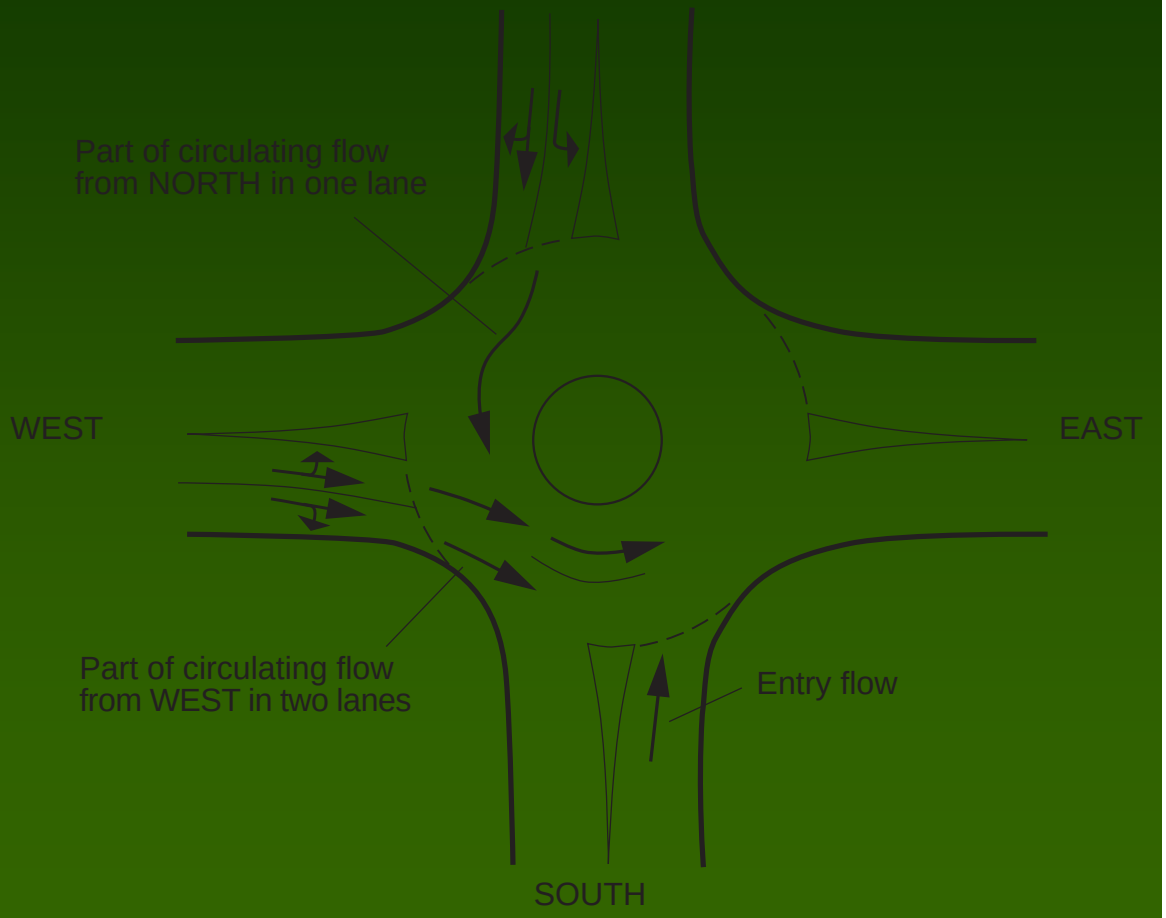
- **aaSIDRA "parameter sensitivity" facility can be used to obtain graphs of how capacity and a large number of performance parameters (delay, queue length, cost, etc) change with roundabout geometry and driver behaviour (gap-acceptance parameters).**

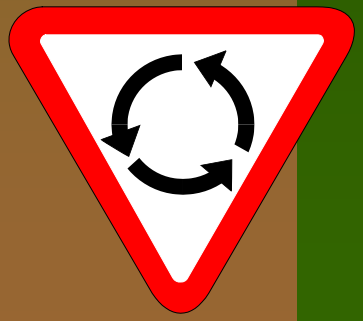
Modeling interactions amongst approach flows



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





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

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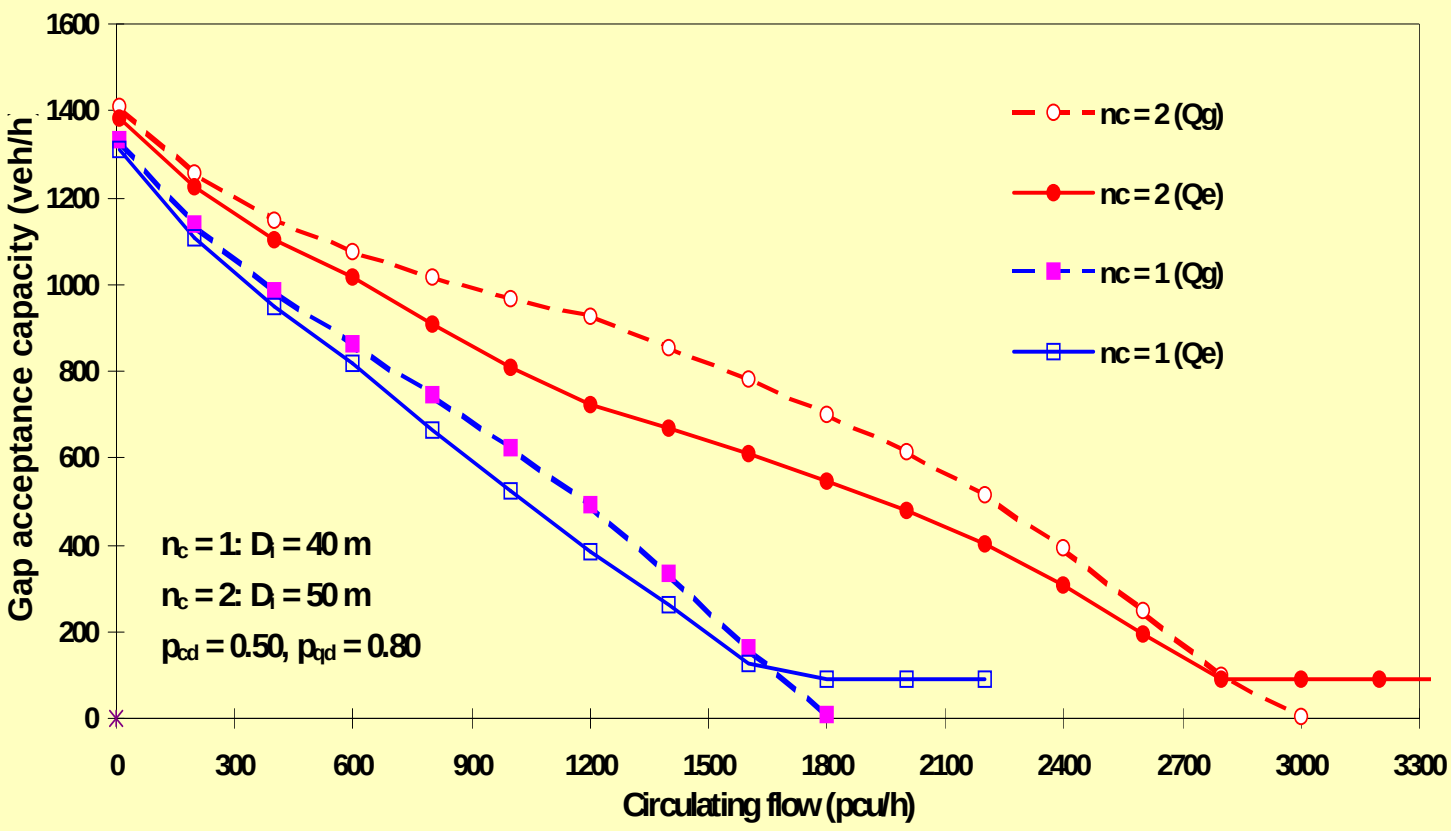
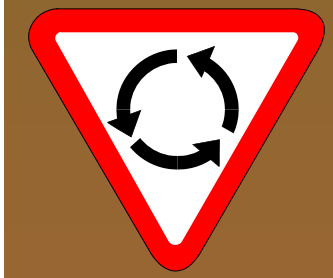
Ignoring approach flow interactions cause overestimation of capacity (underestimation of delays and queue lengths





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Issue: Analysis detail (level of aggregation)

more detailed model of traffic stream

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

UK "empirical model" falls in this category

more detailed model of road geometry

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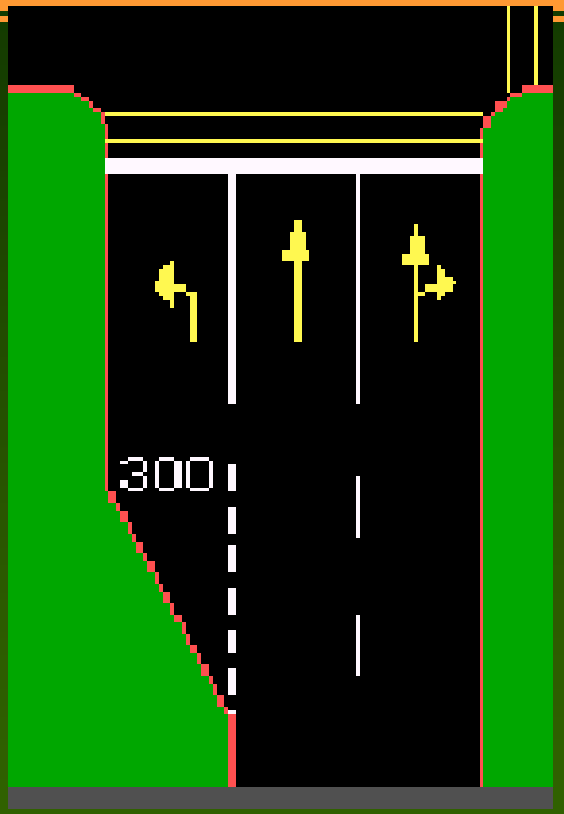
Lane-by-lane analysis

- 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

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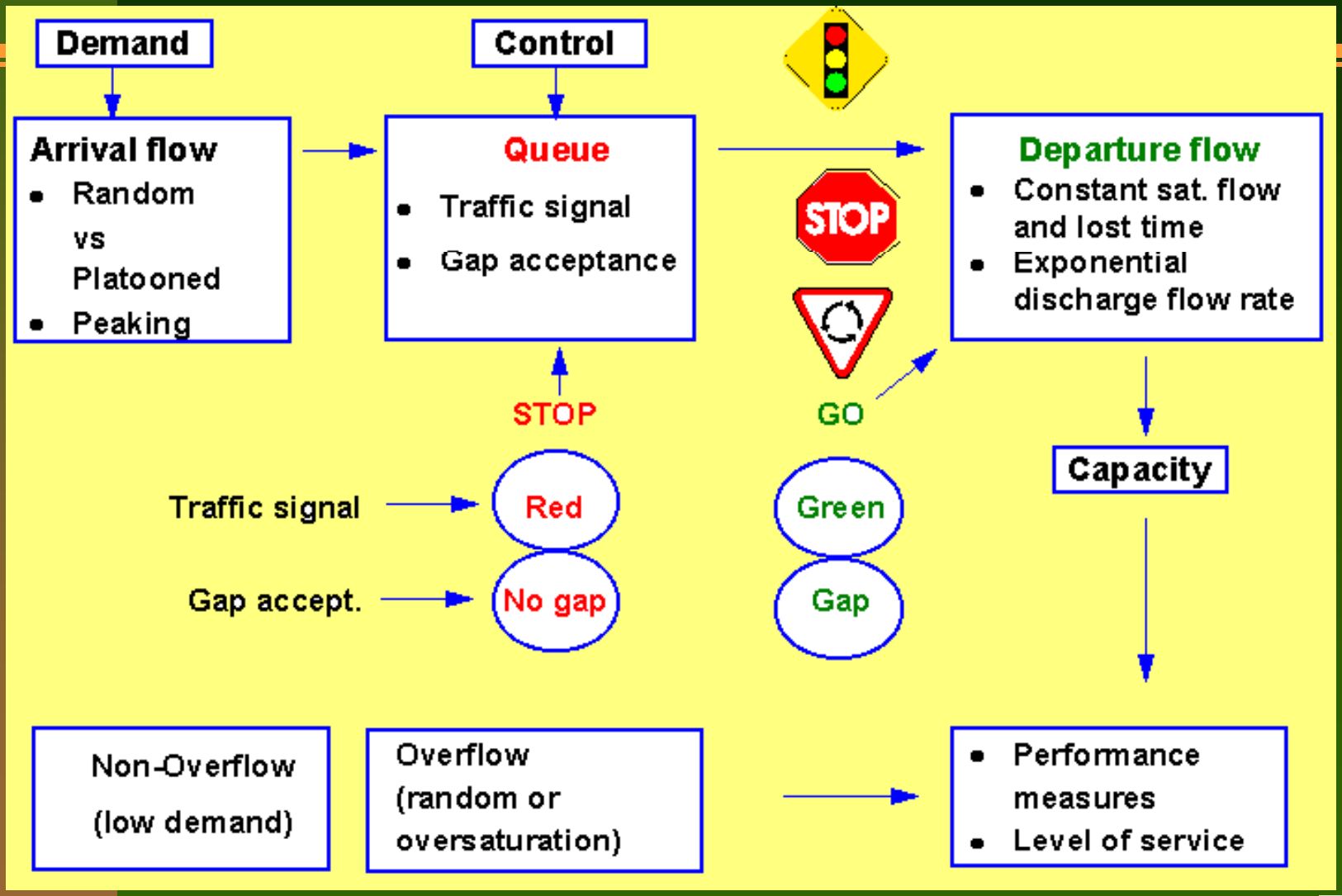
Basic concepts of traffic analysis



Issue: Capacity measurement method

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

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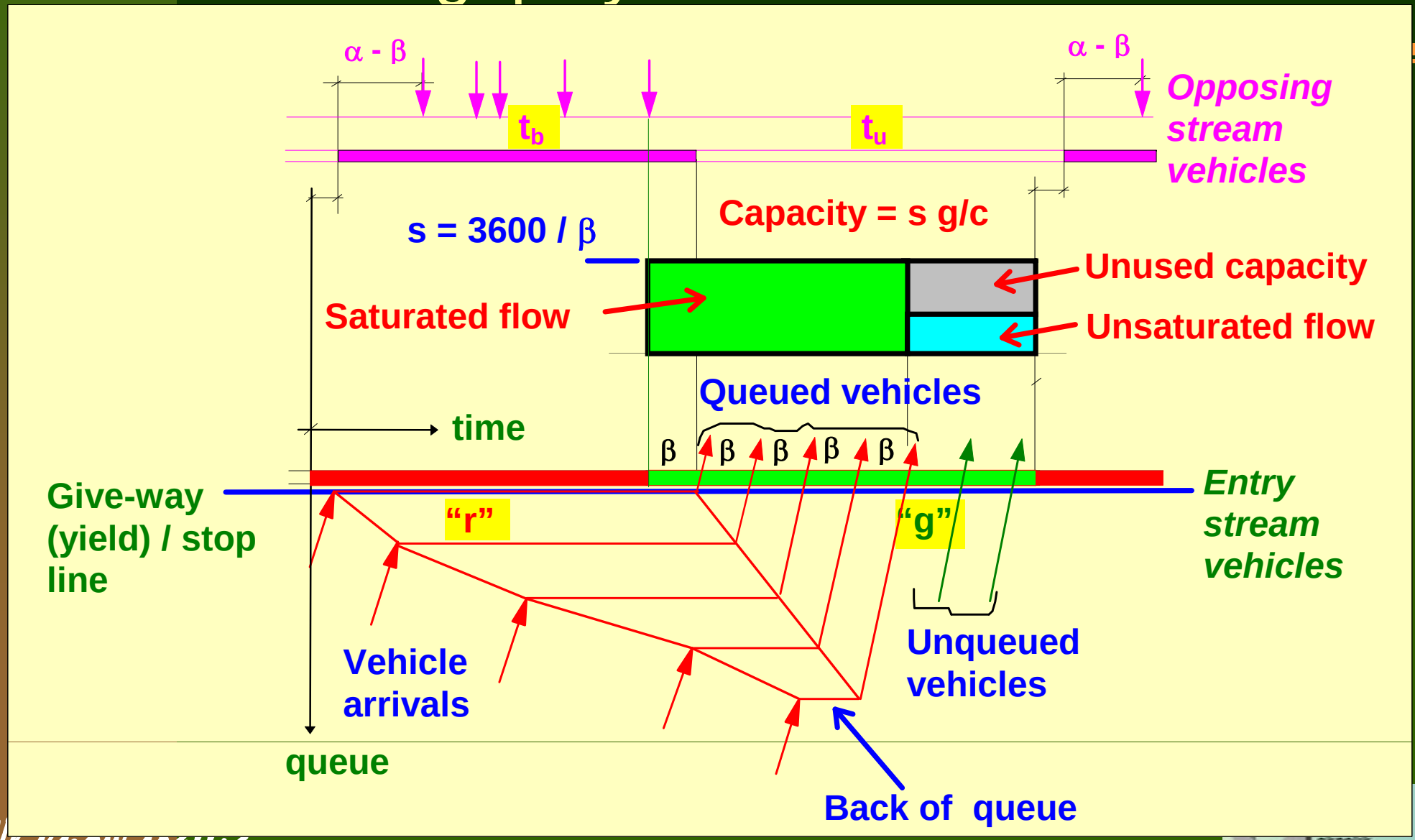
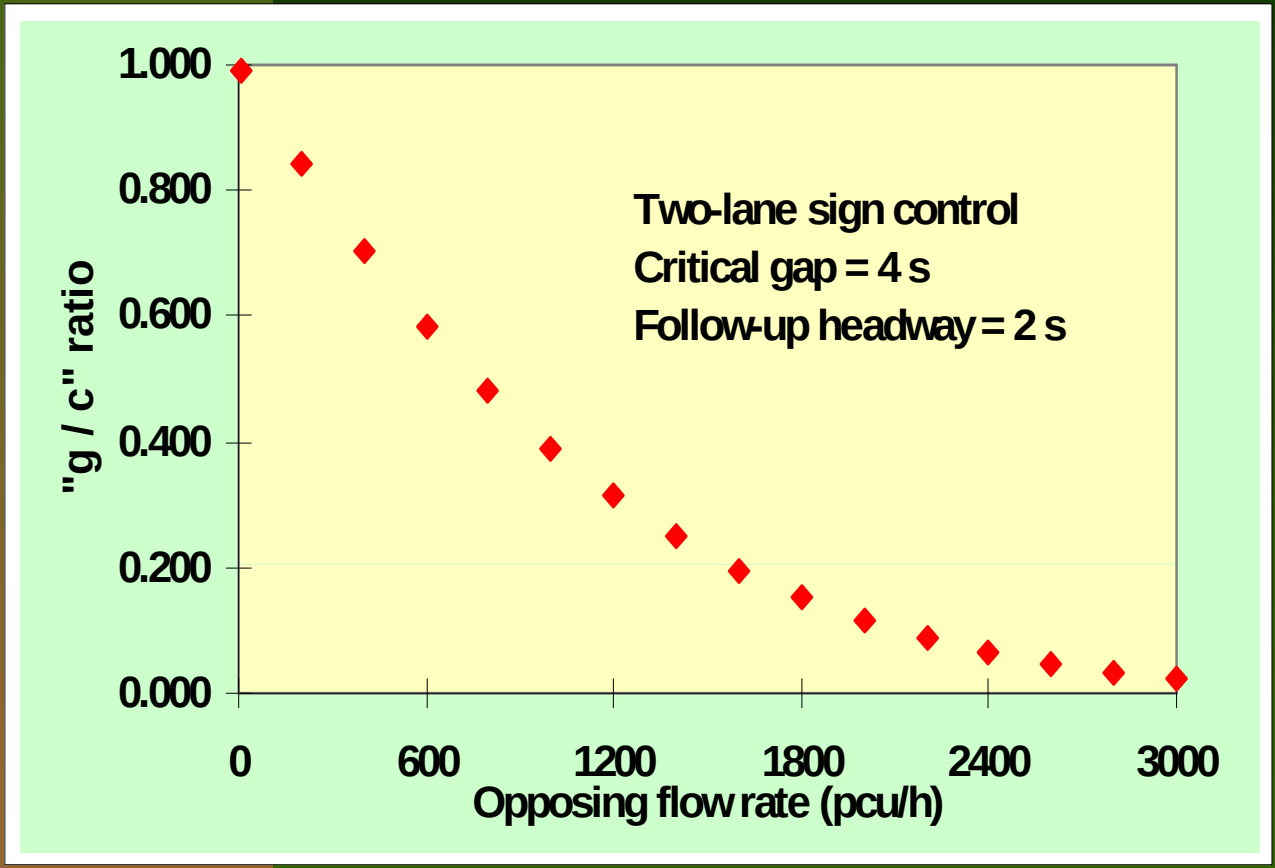
Measuring capacity : unsaturated gap cycles



"g / c" ratio



Capacity = s (g/c)

where
s = 3600 / β

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 !!!

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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!

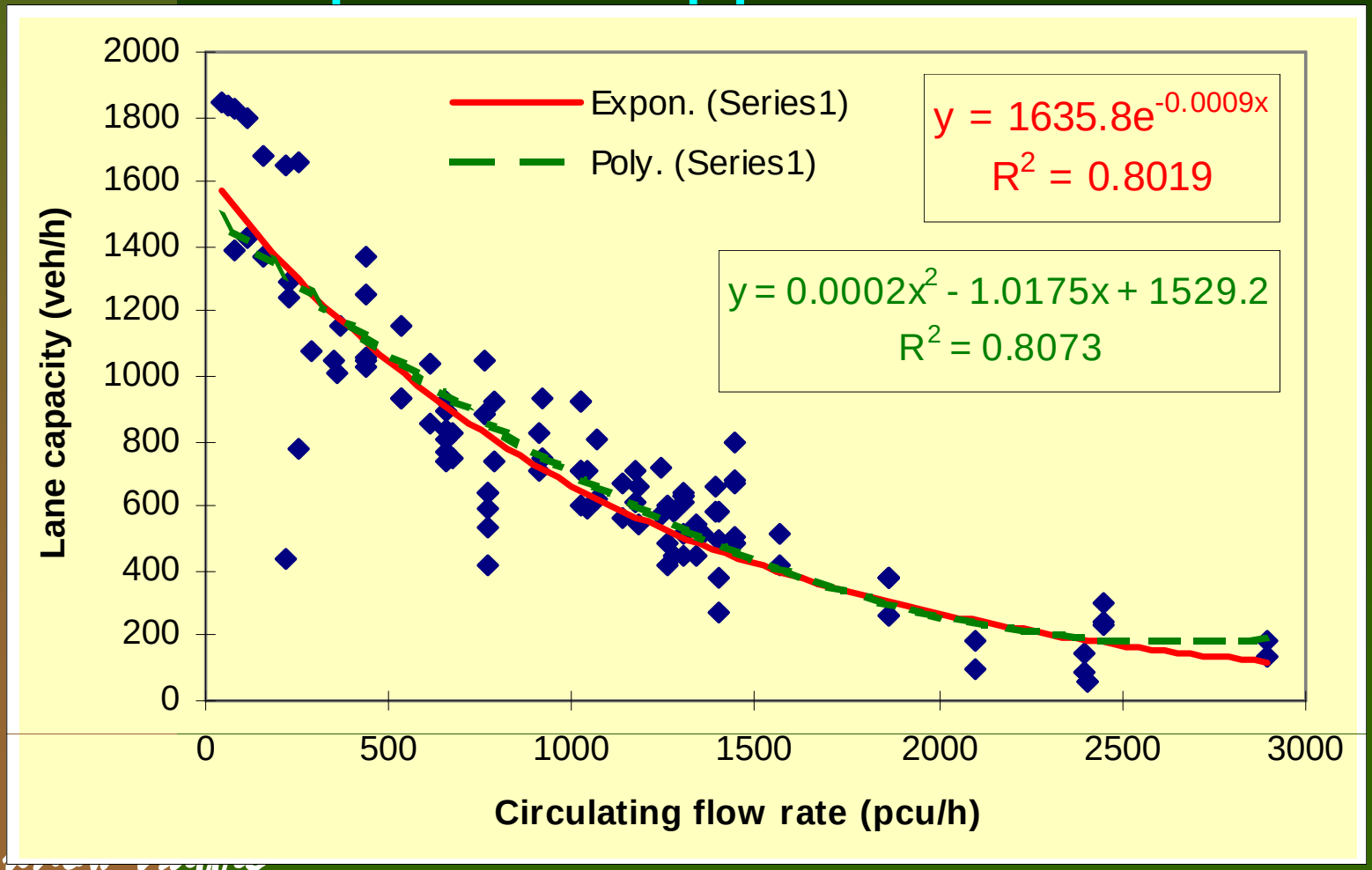
Issue: Linear regression (UK) vs Gap acceptance (US & Australia)

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



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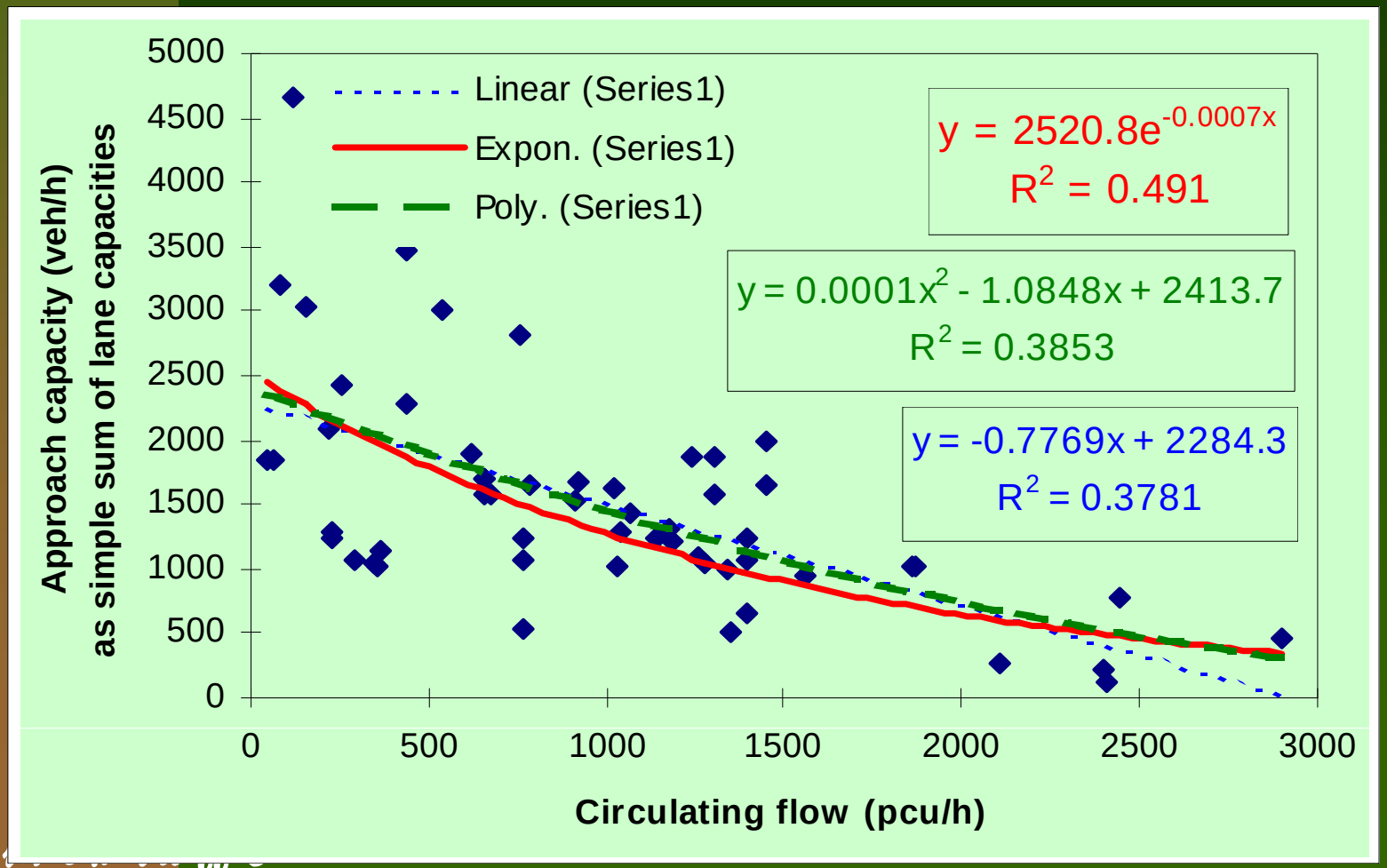
Capacity models: Linear or Non-linear?

APPROACH capacities appear linear

but exponential (non-linear) appears to be better



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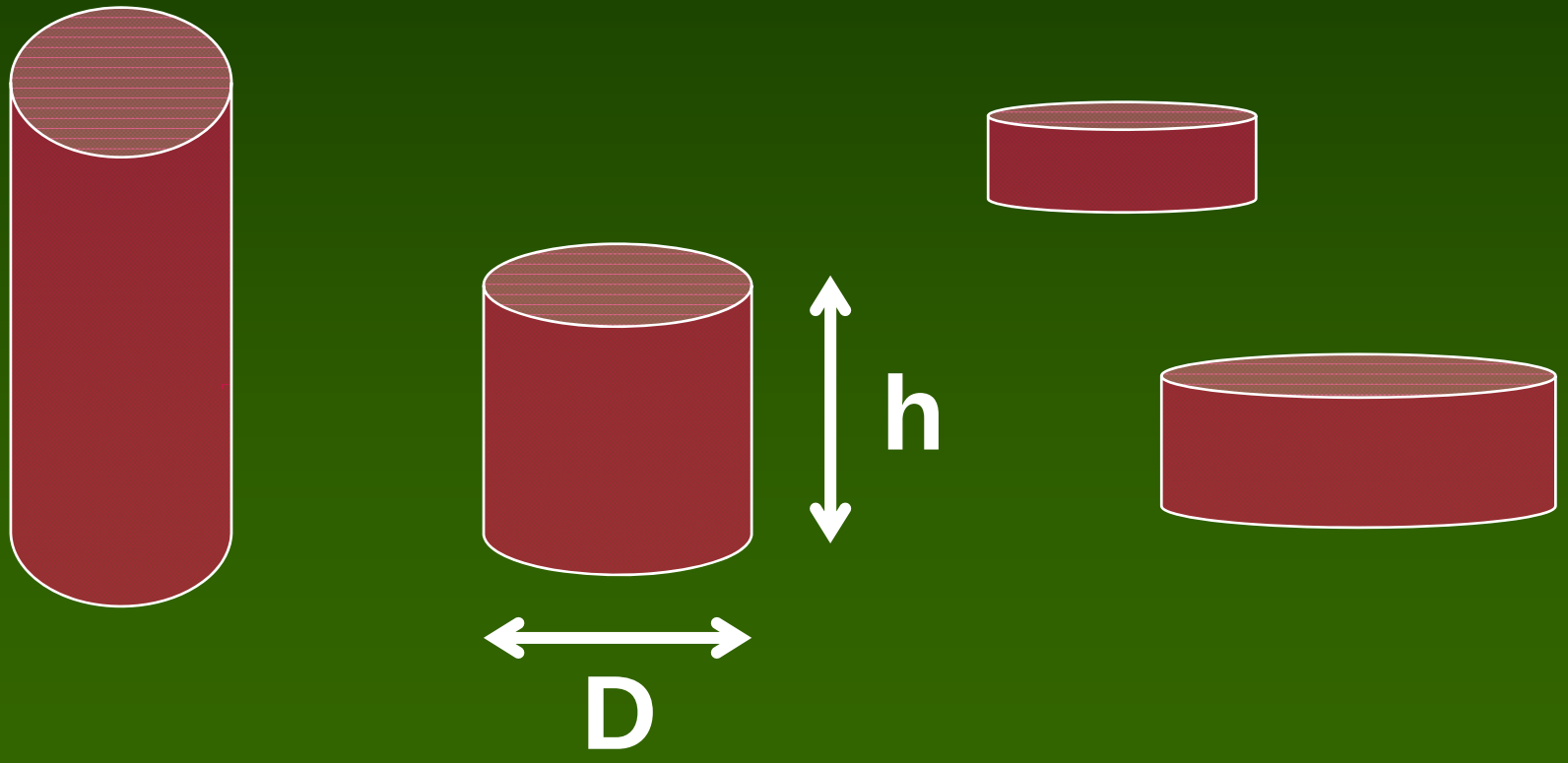
A demonstration of regression vs mathematical model:

capacity of cylindrical containers



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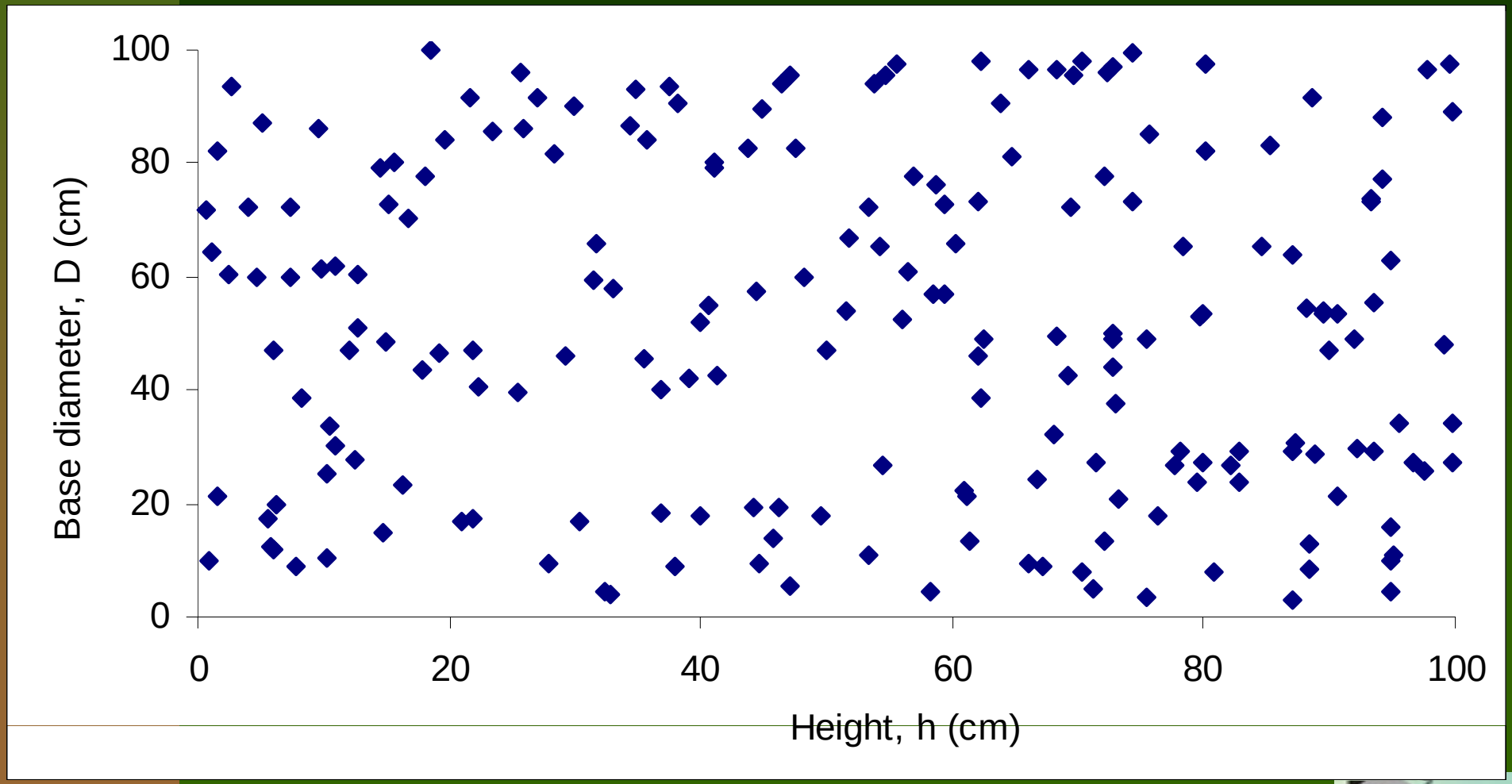
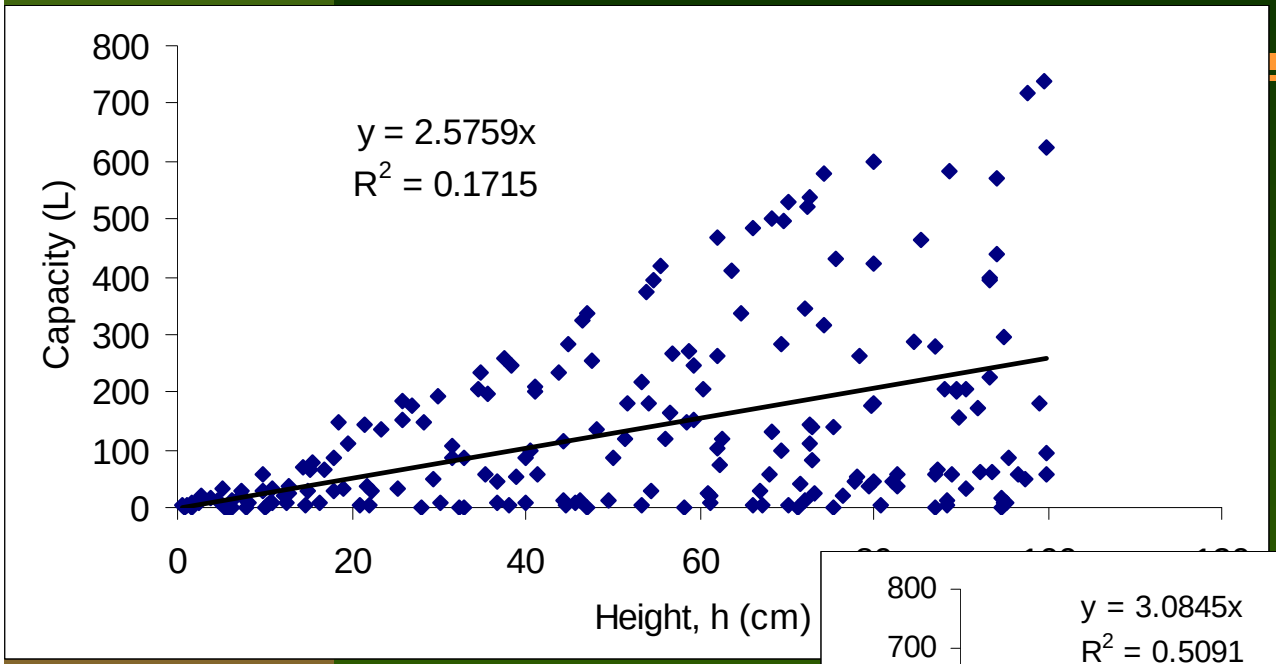
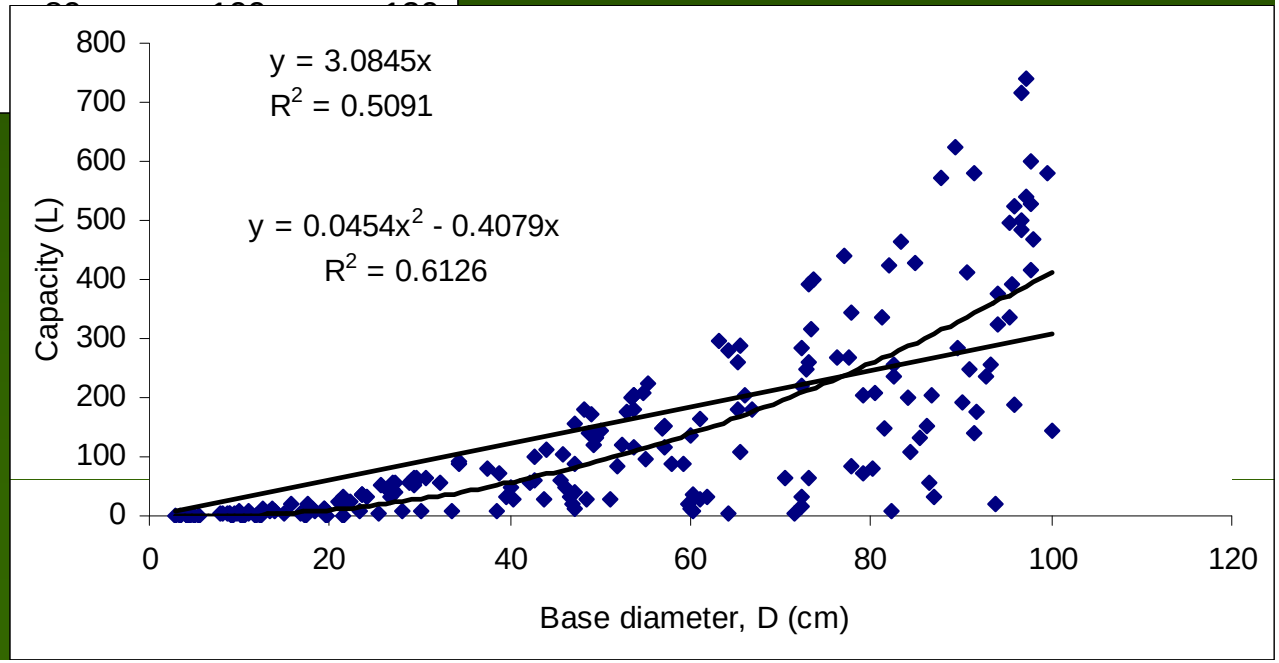
h, D parameters generated randomly (200 data points)



Regression on h & D << the "empirical" approach

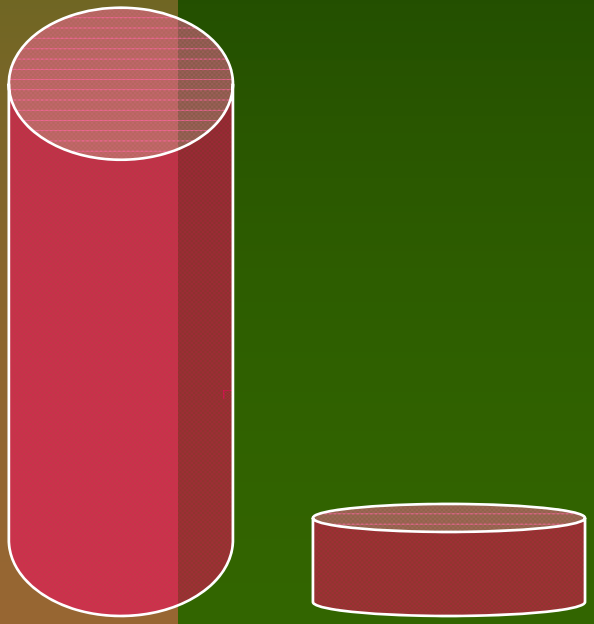


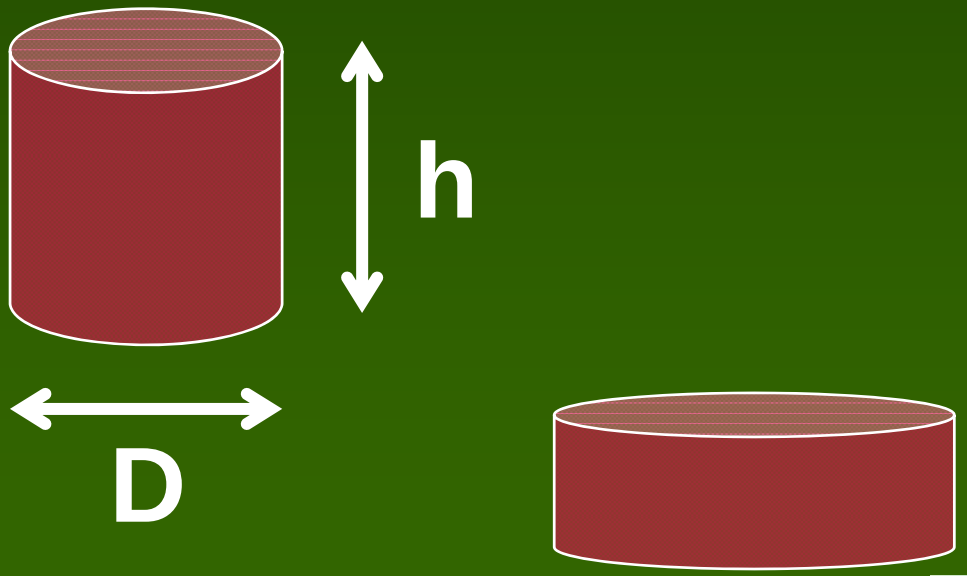


Mathematical model: << the aaSIDRA approach

$$C = h\,A$$

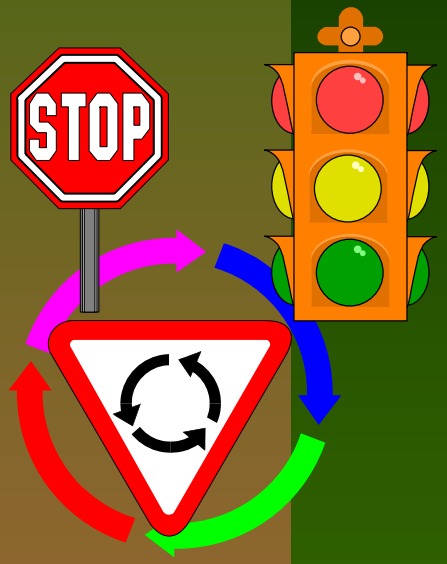
where $A = \pi\,(D/2)^2$ is the base area





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	▮

Why gap acceptance model?

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

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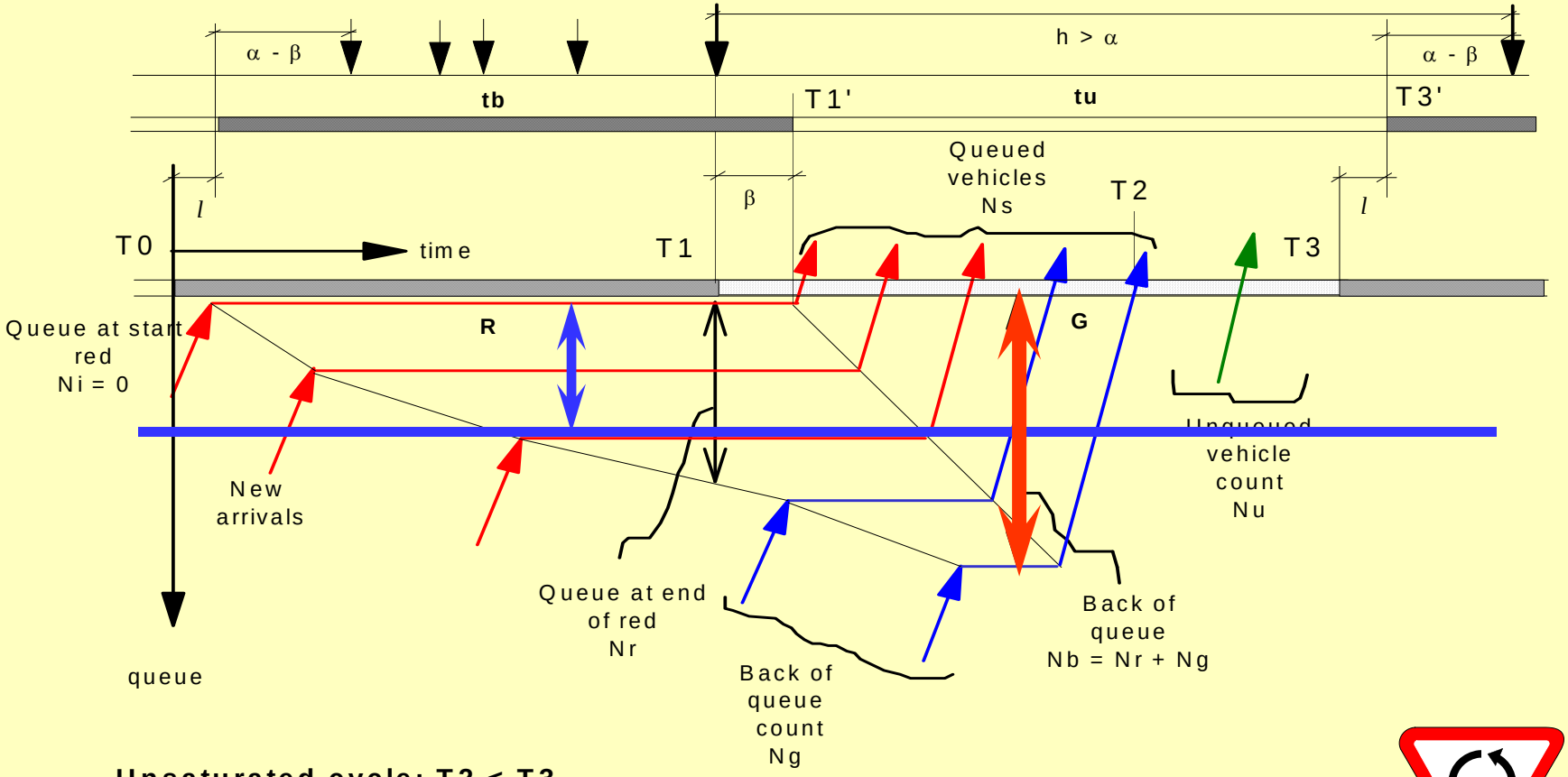
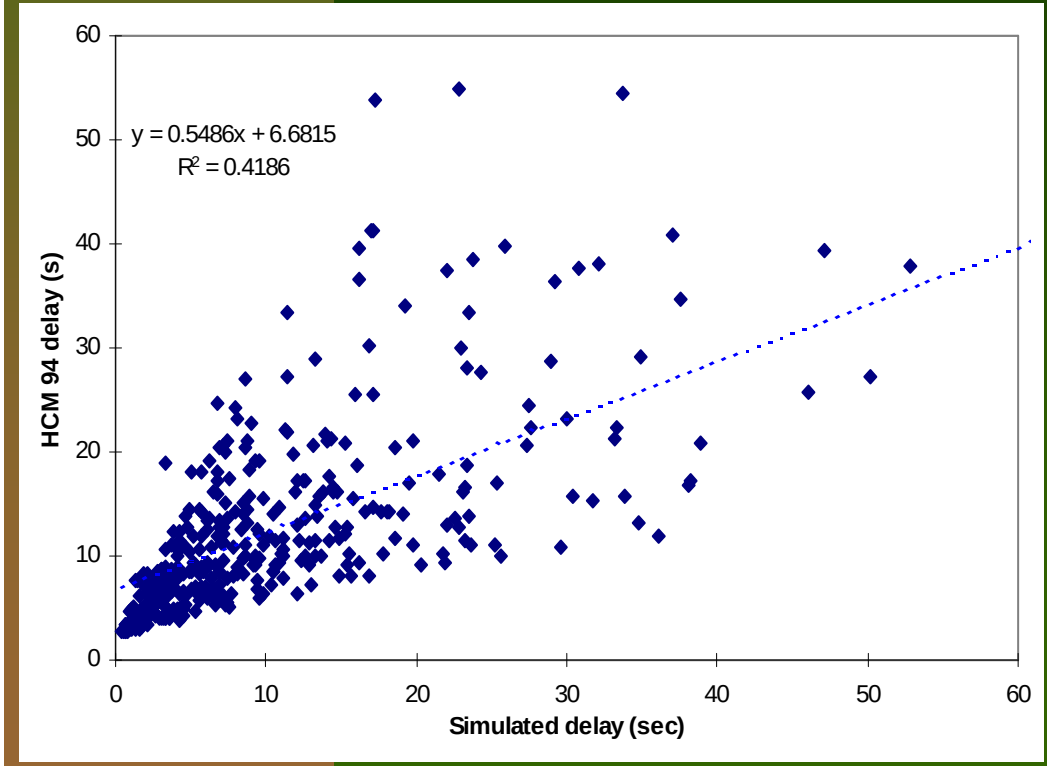
Issue: Cycle-average queue vs average back of queue



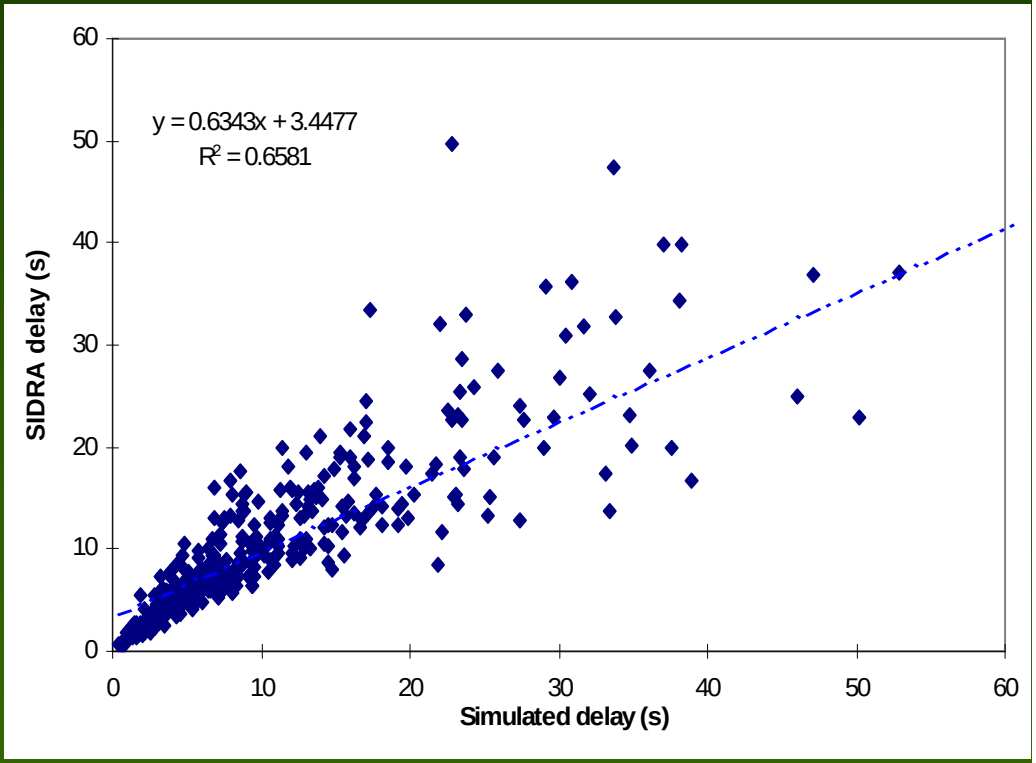
Unsaturated cycle: T2 < T3

Issue: Need for delay model comparisons

HCM 94/97



aaSIDRA



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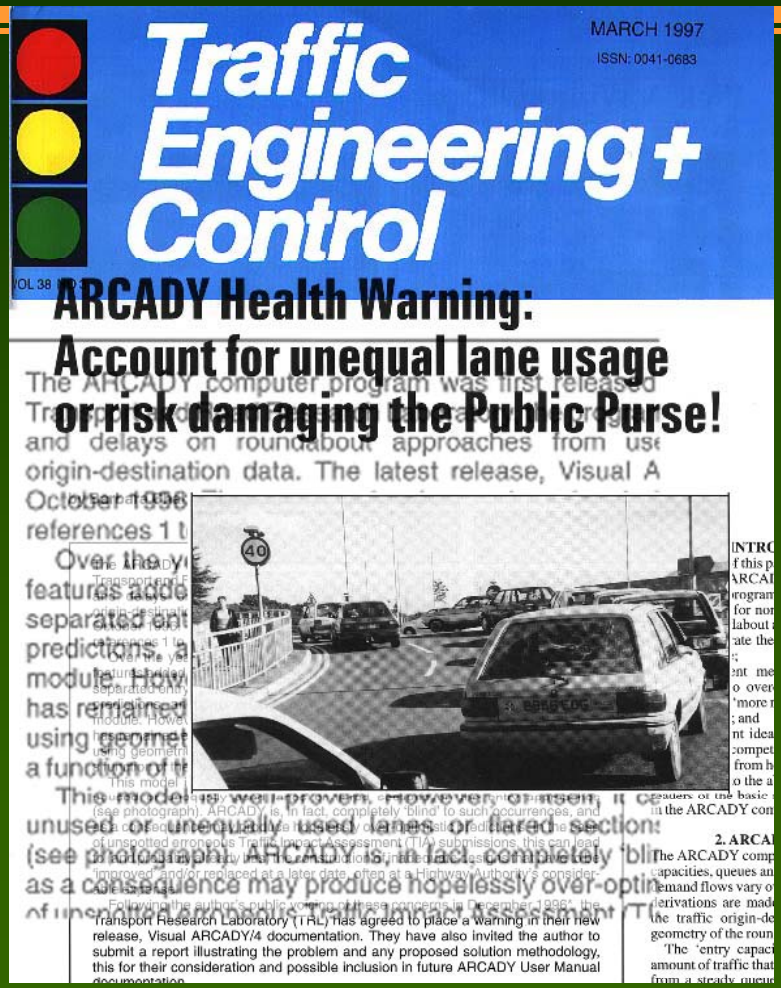
Issue: Modeling of flares / short lanes

- 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



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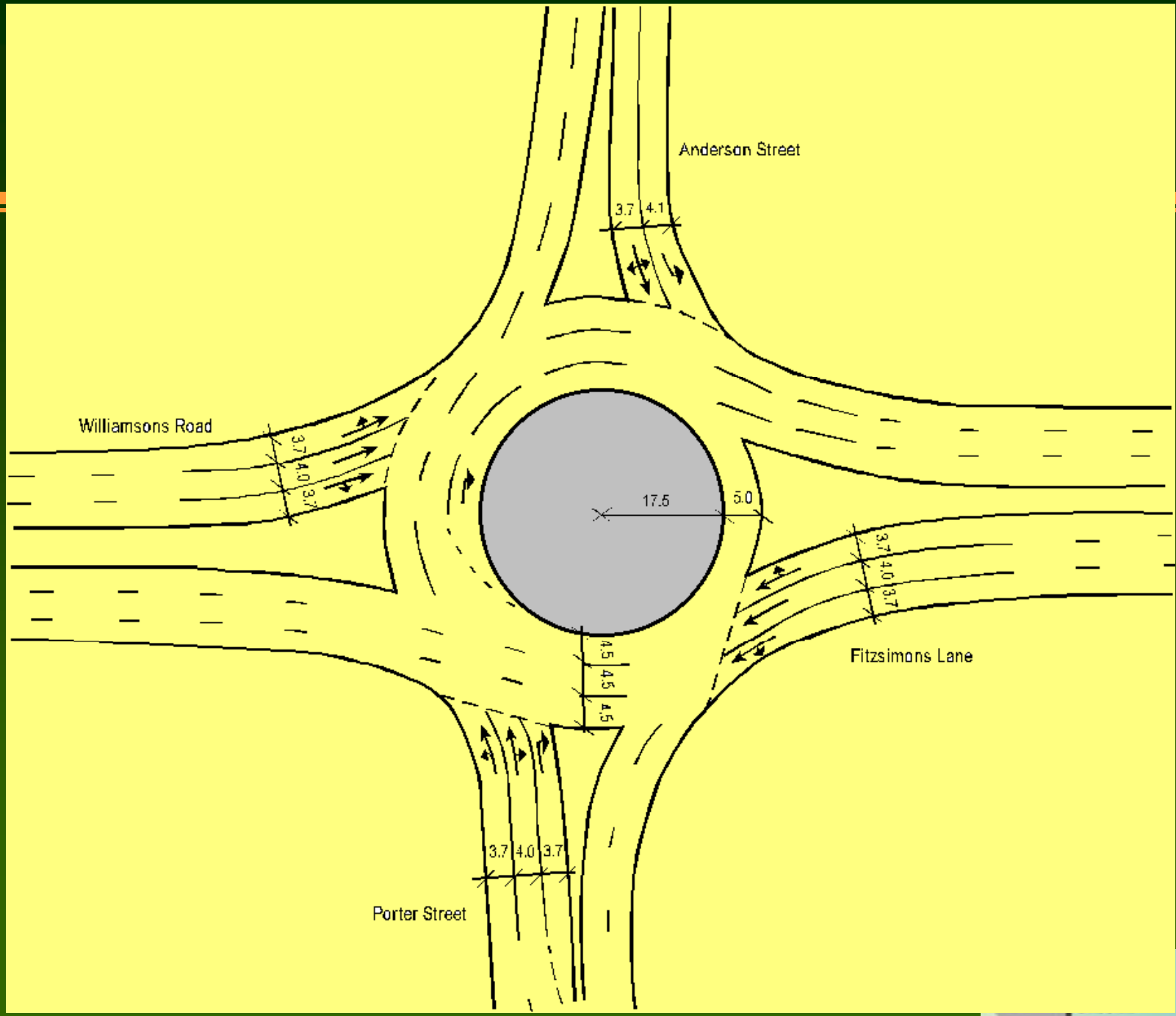
Roundabout case: Melbourne

ITE 67th Ann. Meeting



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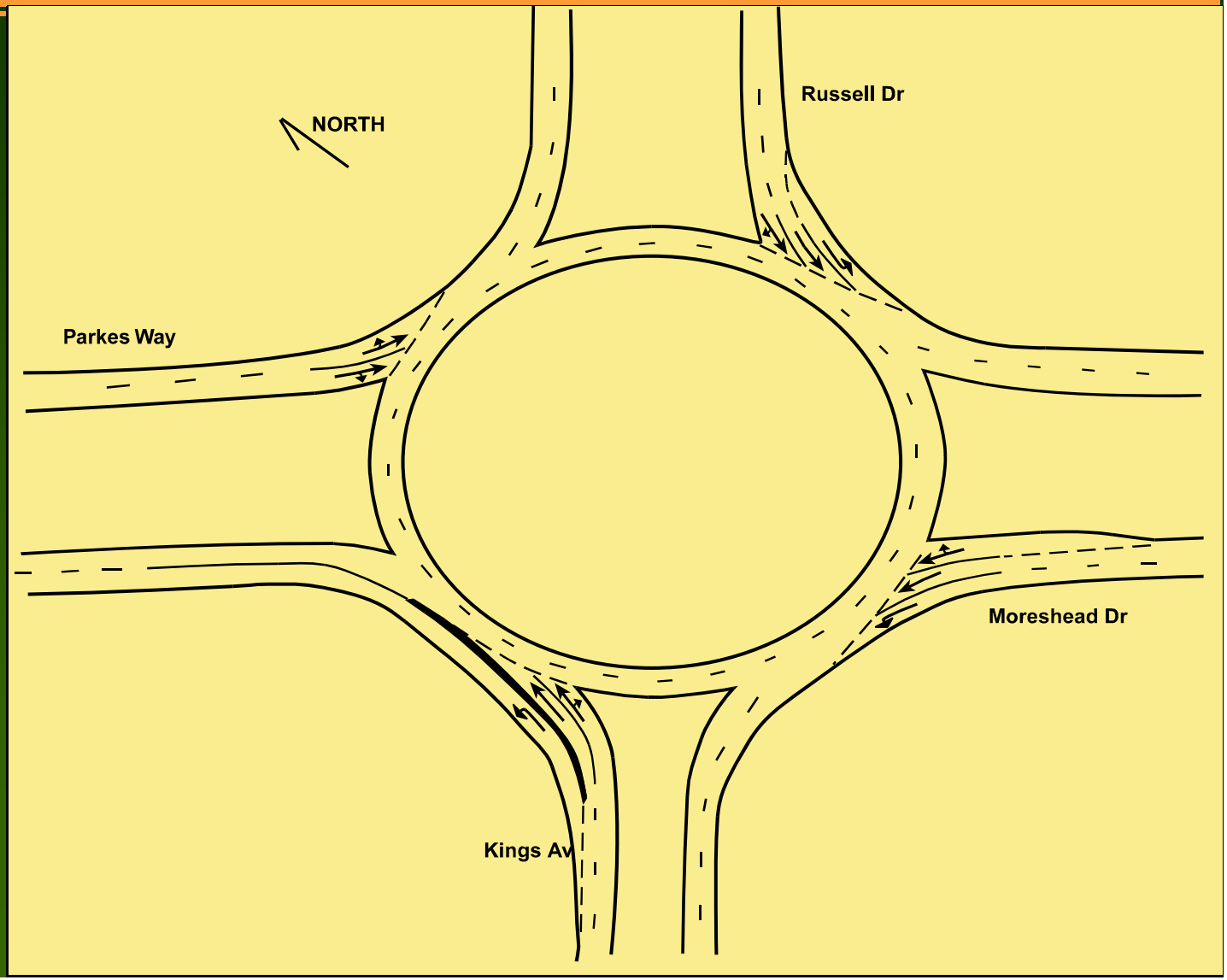
Roundabout case: Canberra

See ARR 321



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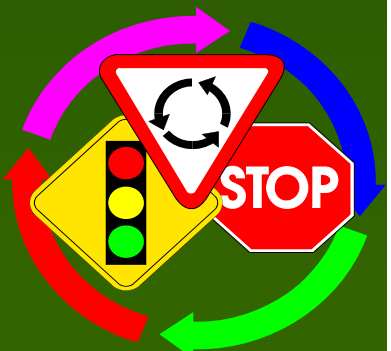
About Australia

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”

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