Microsimulation and Analytical Models for Traffic Engineering

Presentation at the
ARRB - AUSTROADS
Microsimulation Forum
19-20 Sep 2007

Presenter:
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Information related to this presentation

PAPER - download from:
www.sidrasolutions.com/traffic_resources_downloads.htm

Akçelik, R., and Besley M. (2001).
Microsimulation and analytical methods for modelling urban traffic. Presented at the Conference on Advance Modeling Techniques and Quality of Service in Highway Capacity Analysis, Truckee, California, USA.

WEB info:

Traffic Models
www.sidrasolutions.com/traffic_resources_models.htm

Simulation
www.sidrasolutions.com/traffic_resources_simulation.htm
References included

Rise of microsimulation as a practical analysis tool

- increasing power of personal computers
- animation
- search for Intelligent Transport Systems solutions

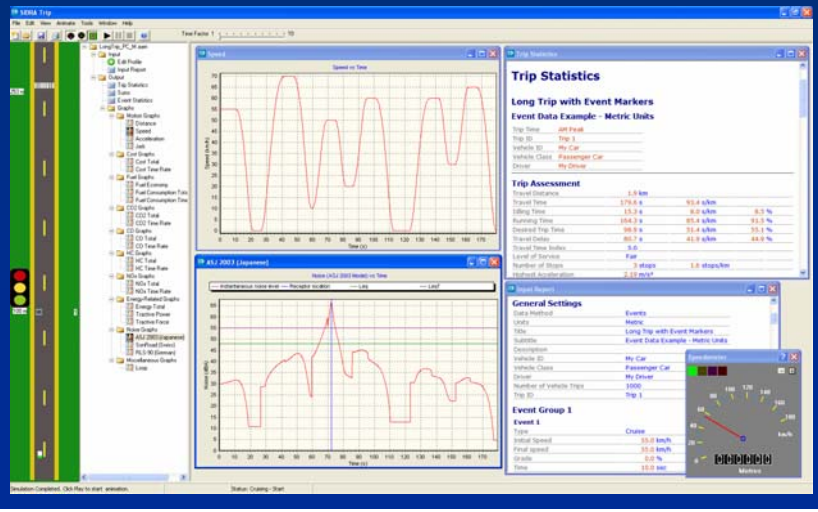
Microsimulation software

- PARAMICS (UK)
- AIMSUN (Spain)
- VISSIM (Germany)
- SIMTRAFFIC, CORSIM (USA)
- Many others

Australian
(unused or unsupported):

- SITRAS (University of NSW)
- TRITRAM (CSIRO)
- PARKSIM (Monash University)
- INSECT (RTA NSW)
- TRARR (ARRB)

- SIDRA TRIP
(New from Akcelik & Associates)



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TNS microsimulation (1970-74)

Akçelik PhD research into route control and signal control

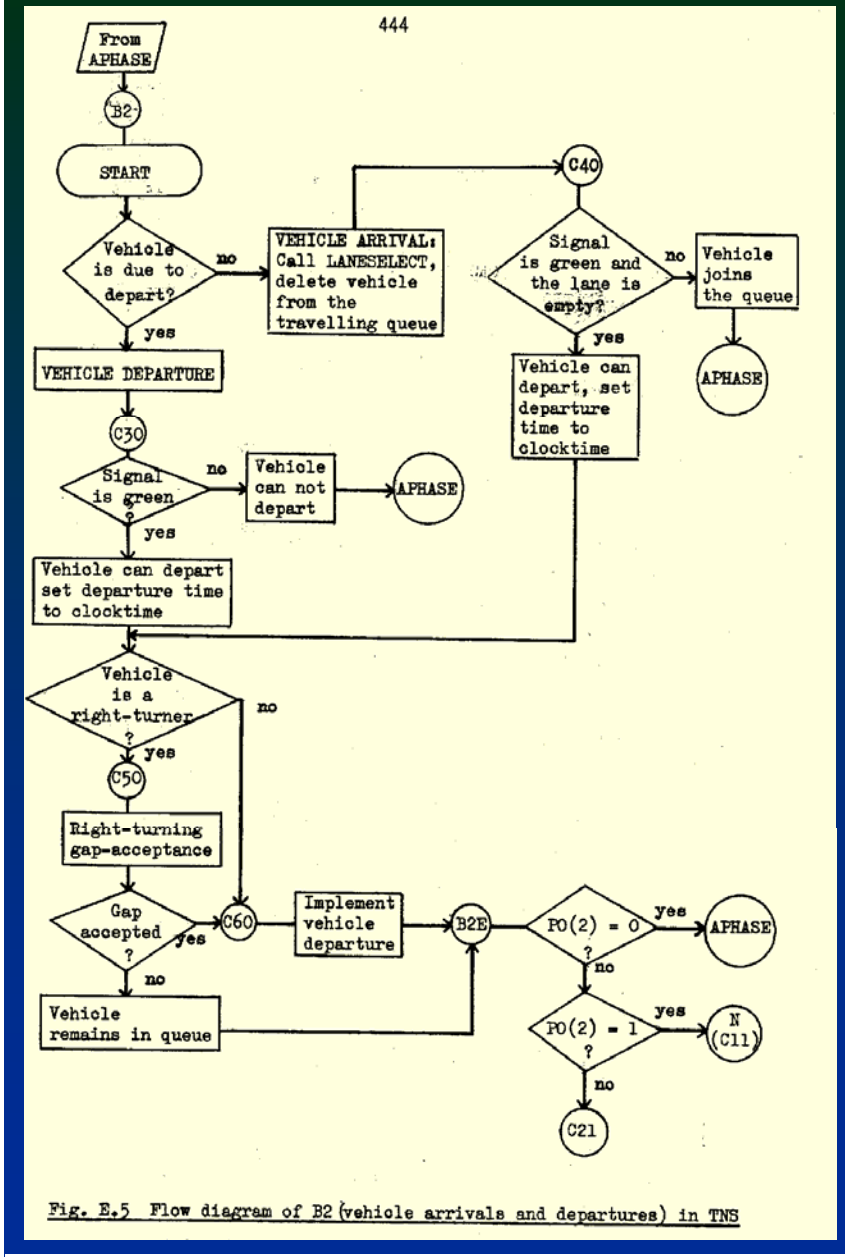
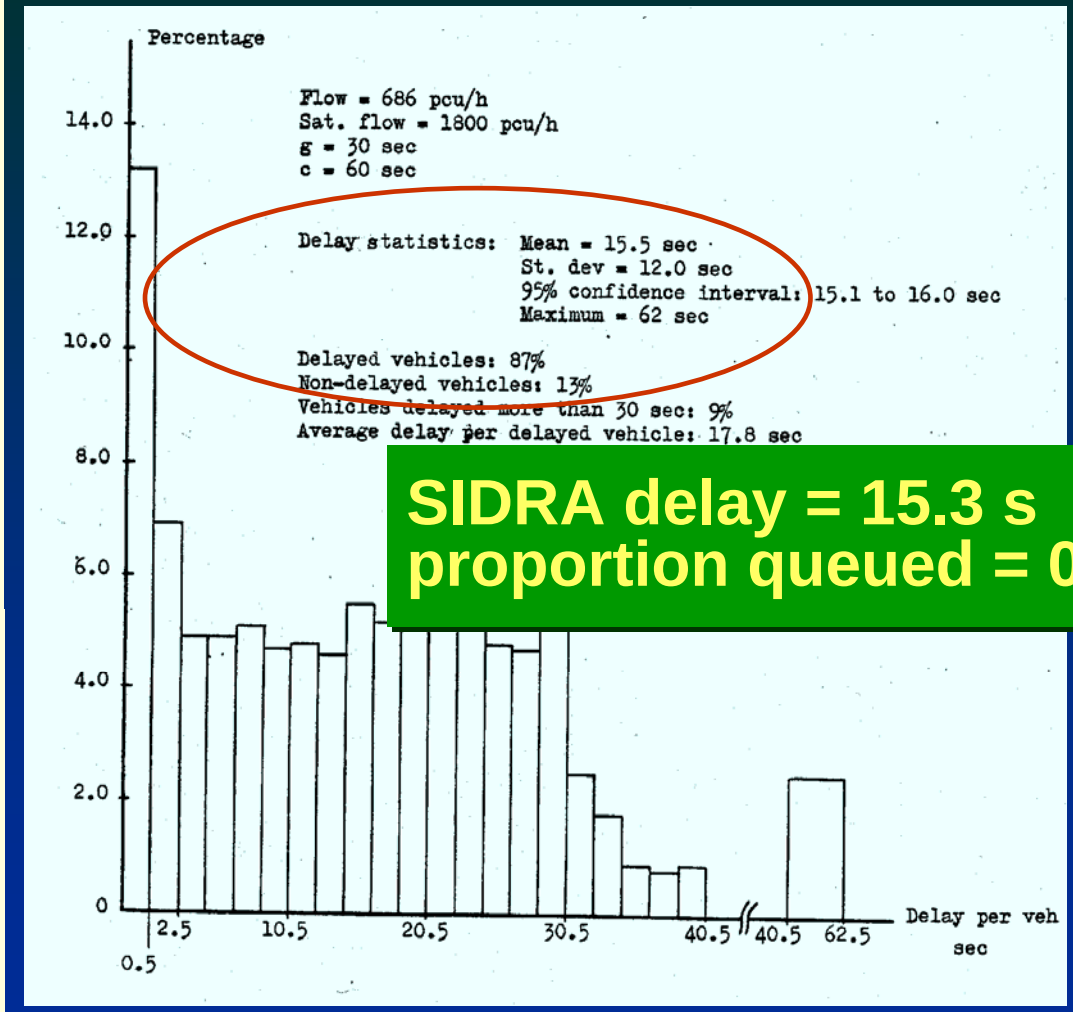


Fig. E.5 Flow diagram of B2 (vehicle arrivals and departures) in TNS



SIDRA delay = 15.3 s
proportion queued = 0.87

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MODELC

Single intersection microsimulation model

Used for calibrating SIDRA INTERSECTION analytical models.

CHUNG, E., YOUNG, W. and AKÇELIK, R. (1992). ModelC: a simulation model for roundabout design. Proc. 7th REAAA Conference, Vol. 1, pp 66-74.

Concerns about microsimulation

Various issues arose in practice:

- Data hungry
- User specialisation
- Slow for large applications
- Animation implying unjustified accuracy
- Concern about traffic **model quality**:
  - **calibration difficulties** and
  - **benchmarking**

Warning has always been there …

Drew (1968):

"Simulation is a powerful tool, and like all powerful tools it can be dangerous in the wrong hands. "

ALGERS, S. et al (2000):

"Microsimulation is useful but dangerous."

and …

Bargiela (2000):

"It is paradoxical however that the development of more natural interfaces leads to unnatural adaptations or changes in the user.

In the progressively tighter coupling of user to interface, the user evolves as a cyborg. "

Focus of this paper

Answer the question:

- **When is microsimulation inappropriate?**

We could similarly ask:

- **When is analytical modelling inappropriate?**

Focus of this paper

- We need to distinguish between **Software Functionality** and **Fundamental Model**

  e.g. Model Classification according to “Project” in the RTA NSW PARAMICS Manual, Sections 1 and 2

- We need to clarify the **General Modelling Context** used in our profession.

Focus of this paper

Discuss some key aspects of microsimulation models

- ***with a view to:***

Compatibility between microsimulation methods and established analytical techniques used in traffic engineering, and

- ***towards:***

Improving the practical usefulness of microsimulation tools through better model calibration

A general framework for road traffic models

(Model detail and complexity)

TRAFFIC ELEMENTS ↓	ROAD GEOMETRY ELEMENTS		
	APPROACHES (All lanes aggregated)	**LANE GROUPS** (or LINKS)	**LANES** (or Lane Segments)
Individual vehicles	*NA*		*Micro-simulation*
Platoons	*Macro-simulation*		*Meso-simulation*
Drive cycles	*NA*		*Micro-analytical*
Traffic flows	*Macro-analytical*	*Meso-analytical*	*Meso / Micro-analytical*
Speed-flow models	*Macro-analytical*		*NA*

Traffic modeling software according to the traffic model framework

TYPE	Level of traffic and road geometry detail		
	MACROSCOPIC	MESOSCOPIC	MICROSCOPIC
Simulation	PASSER(?) SATURN SYNCHRO(?) TRANSYT (UK) TRANSYT7F (USA) SCATES	CONTRAM	AIMSUN CORSIM CUBE DYNASIM INTEGRATION PARAMICS (QUADSTONE / SIAS) SIDRA TRIP SIMTRAFFIC TRARR TWOPAS VISSIM WATSIM
Analytical	ARCADY RODEL Transport Planning Packages (*EMME/2, TRIPS, TRAFFIX*)	HCS (US Highway Capacity Software)	SIDRA INTERSECTION

Definitions

Analytical model: uses direct mathematical computations to determine system states

Simulation model: uses various rules (mostly in the form of mathematical equations) for movement of vehicles in a system (individually or in platoons).

- a simulation model can be **microscopic, macroscopic or mesoscopic**;
- an analytical model can be **microscopic, macroscopic or mesoscopic**;
- a simulation model can be **deterministic or stochastic**.

Modelling myths:

“The system is too complex therefore we need simulation.”

Often expressed in relation to a situation for which an analytical method has not been developed.

Any situation can be modelled using simulation or analytical methods (e.g. modelling of incidents).

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Microsimulation >> analytical

Webster (1958) :

" Since a theoretical calculation of delay is very complex and direct observation of delay on the road is complicated by uncontrollable variations, it was decided to use a method whereby the events on the road are reproduced in the laboratory by means of some machine which simulates behaviour of traffic … "

Modelling myths:

“A model is either THEORETICAL or EMPIRICAL.”

For example, this has been expressed in relation to roundabout capacity models (Australian gap-acceptance model vs UK linear regression model).

A model can be (and better if it is) based on TRAFFIC THEORY but EMPIRICAL at the same time
(e.g. SIDRA INTERSECTION).

Modelling myths:

"A simulation model is STOCHASTIC and an analytical model is DETERMINISTIC."

This is usually stated to mean stochastic model is better quality.

- **Analytical traffic models usually incorporate stochastic elements (e.g. overflow queue models) although each application of the model produces the same outcome.**
- **Analytical model with randomised elements possible.**
- **The cost of stochastic model is the need to do multiple runs.**

>>>

The cost of a stochastic model is the need to do multiple runs …

- **How many runs are adequate?**

  Choa and Milam paper presented at the US Traffic Modelling Conference (Truckee, CA, 2001) gives an example:
  25 simulation runs were needed for **90 per cent** confidence interval.

- A **serious problem** not realised by many modelers and practitioners: Increased simulation time does not deal with congested conditions adequately due to **time-dependence of demand**

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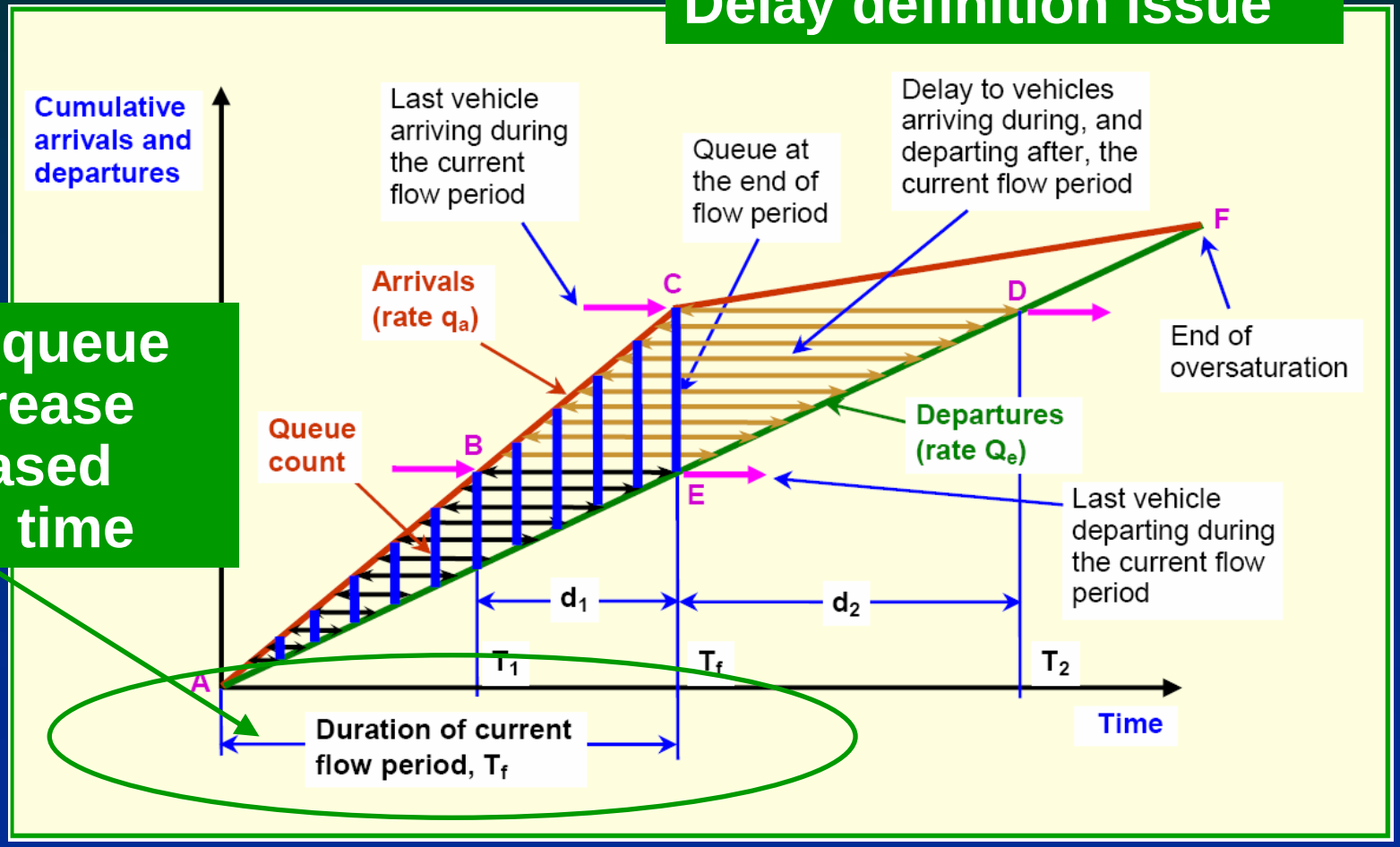
Modelling of oversaturated conditions

(Increased simulation time does not deal with congested conditions adequately due to time-dependence of demand)

Delay definition issue



Delay and queue length increase with increased simulation time

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Modelling myths:

Wikipedia entry (now corrected):

"Empirical modelling software such as LINSIG, TRANSYT or aaSIDRA provide little meaningful information when a road or junction reaches saturation. Microsimulation models will continue to provide results at high degrees of saturation …"

- **Also stated by US consultants (anecdote)**
- **Downstream blockage: This can be accommodated in analytical models**

Modelling myths:

“Microsimulation is more detailed therefore it must be more accurate.”

A more detailed model does not necessarily lead to more accurate results (this applies to any model)

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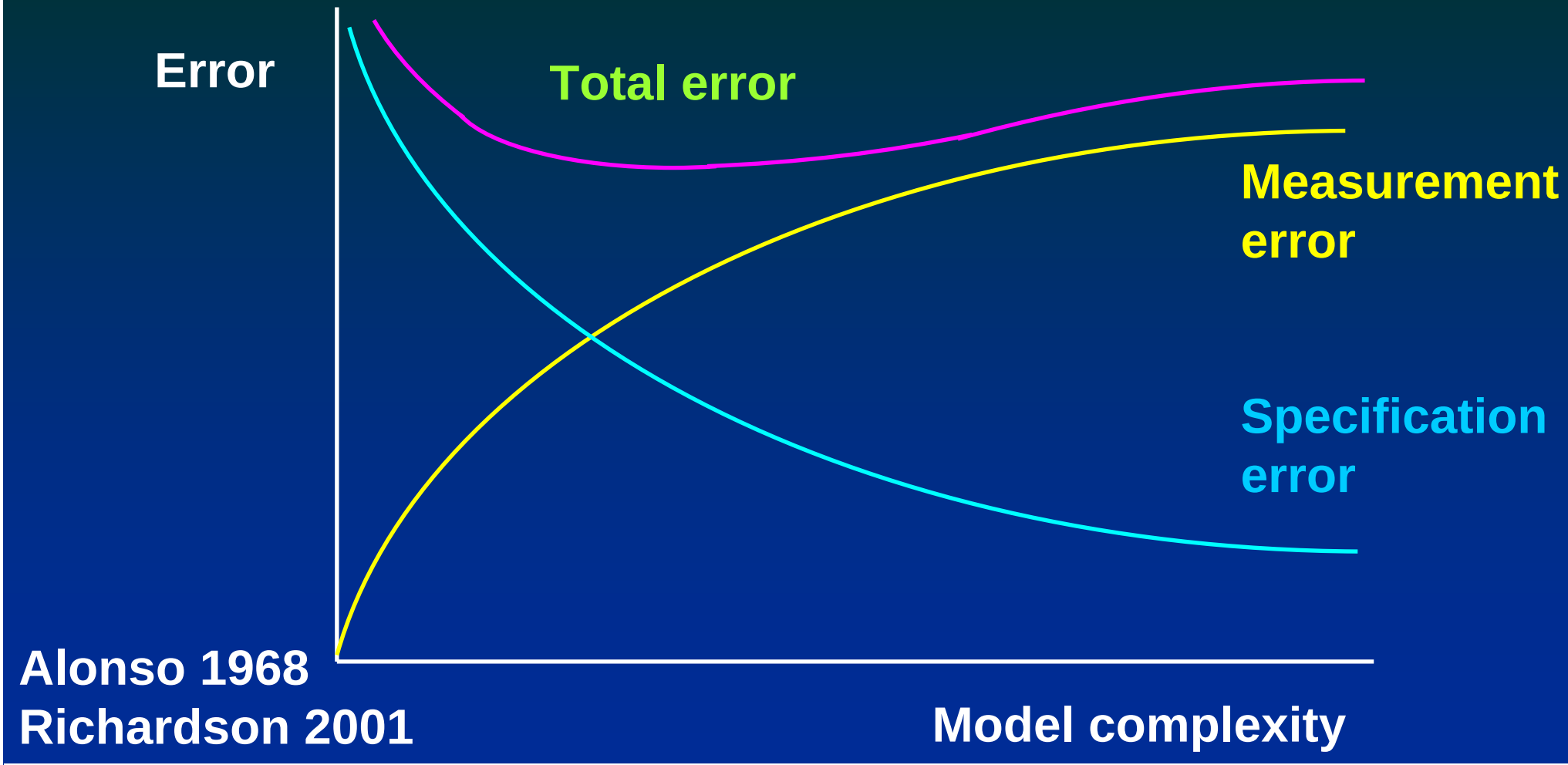
Model complexity vs model error



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MODEL CALIBRATION

(Several key components of traffic models discussed)

- Capacity analysis
- Queue discharge at signalised intersections
- Acceleration profiles
- Gap-acceptance
- Lane flows at intersection approaches
- Definitions and measurement methods for traffic performance variables
- Vehicle and Driver Characteristics

Can microsimulation be used to measure capacity?

Two methods for measuring capacity at intersections:

- measure departure flow rates under saturated (continuous queuing) conditions << problematic
- measure departure flow rates during saturated (queued) portions of individual stop-go cycles and extrapolate << possible

Queue discharge at signalised intersections

(FHWA 1982) : "The simulated behaviour of queue formation and discharge at traffic signals was reviewed. Values for queue discharge lost times were questioned as to their validity. Concern was similarly expressed regarding the acceleration versus speed relationships …"

- **Car following specific to queue discharge?**
- **Reaction time ?**
- **Acceleration profile**
- **Acceleration to cruise ?**

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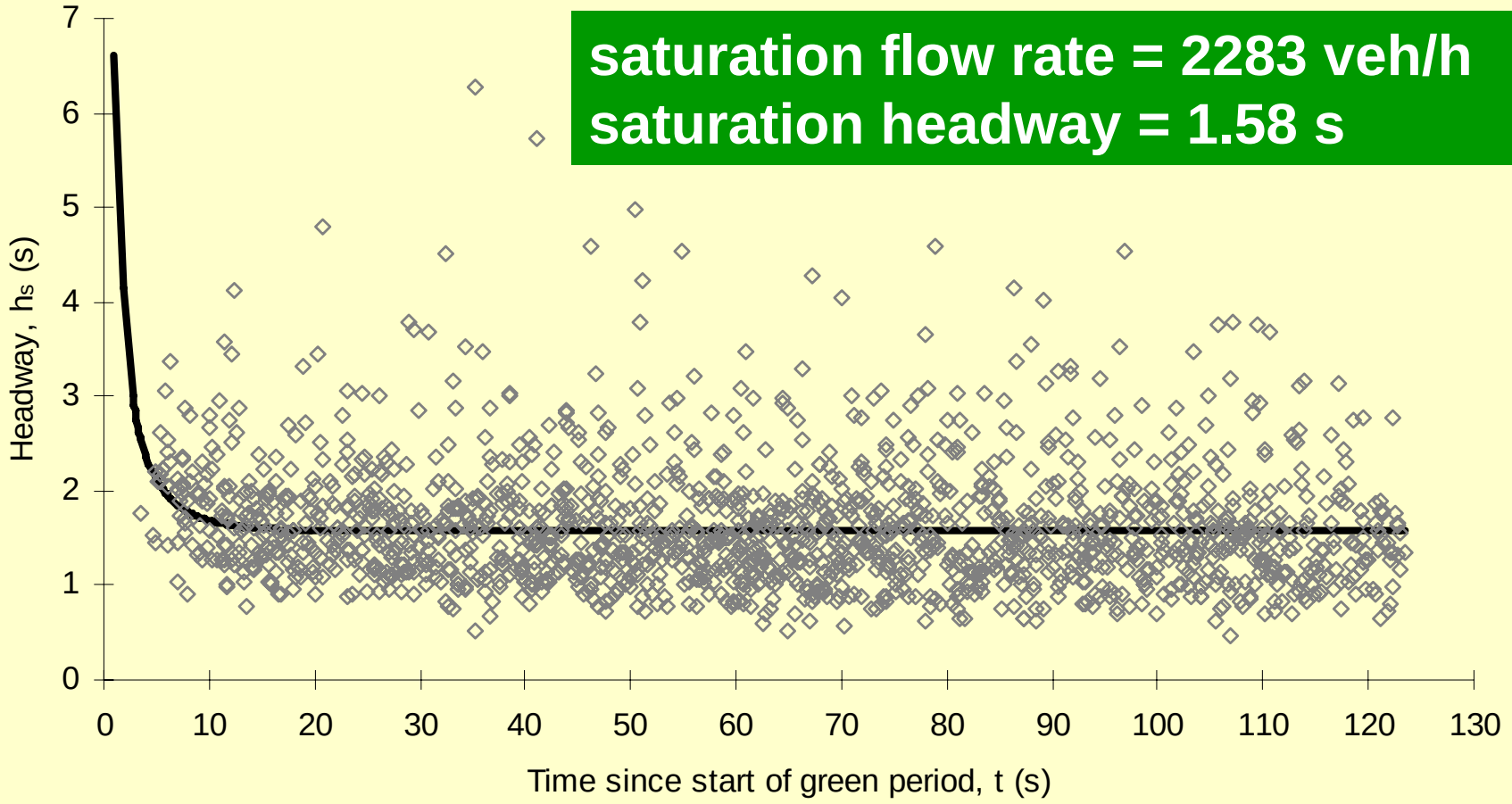
Surveys in Melbourne and Sydney

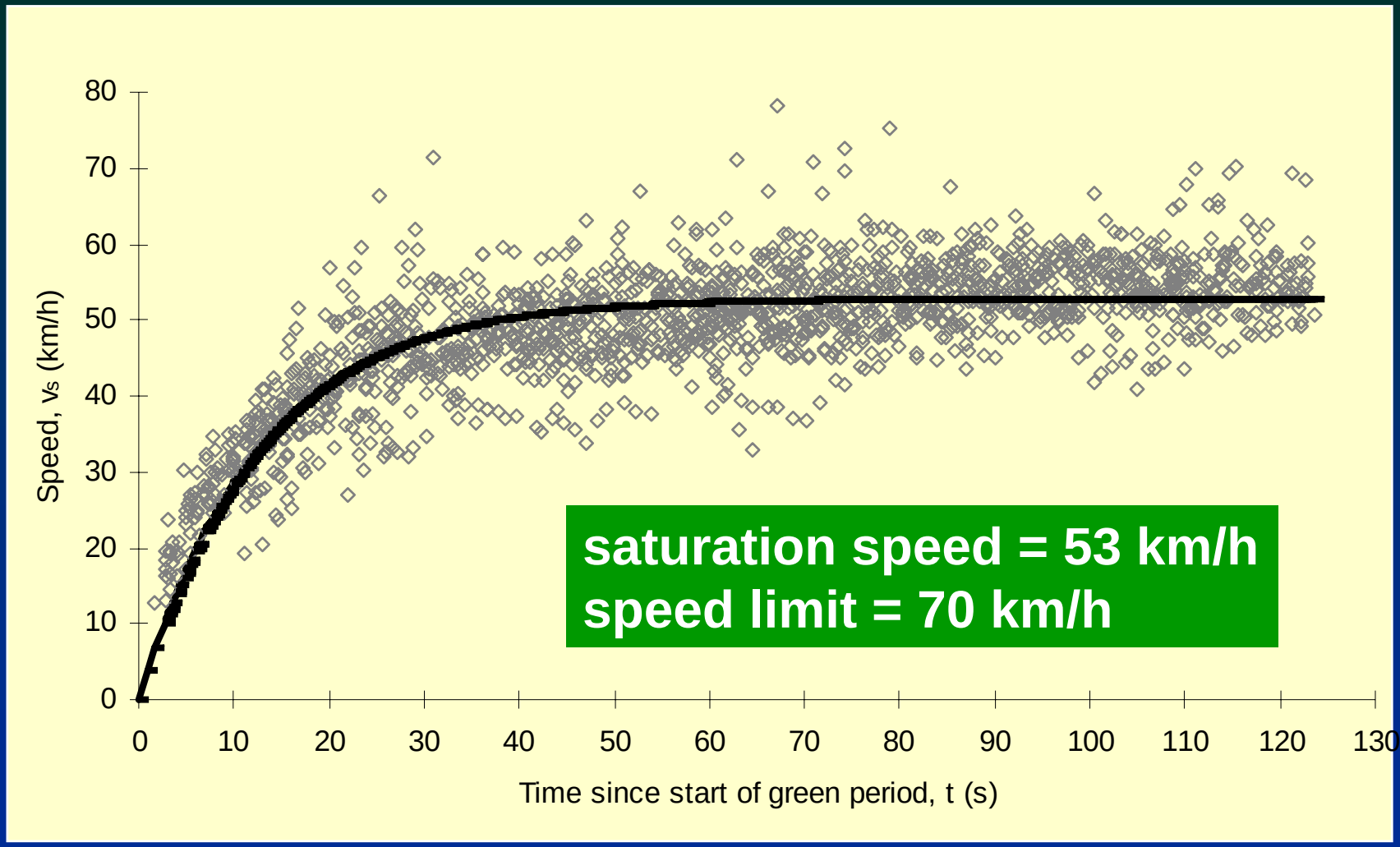
(AKÇELIK, R., BESLEY M. and ROPER, R. ARRB Research Report ARR 340, 1999)

Queue discharge HEADWAYS

(General Holmes Dve and Bestic St, Sydney)



Queue discharge SPEEDS
(General Holmes Dve and Bestic St, Sydney)



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Queue Discharge (SIDRA TRIP simulation)

Gap-acceptance modelling

- **Roundabouts:**
  entry flows
- **Two-way sign-control (Stop or Yield):**
  minor movements
- **Signals:**
  filter/permitted turns

Gap-acceptance parameters

Entry stream

- *Critical gap*
- *Follow-up headway*

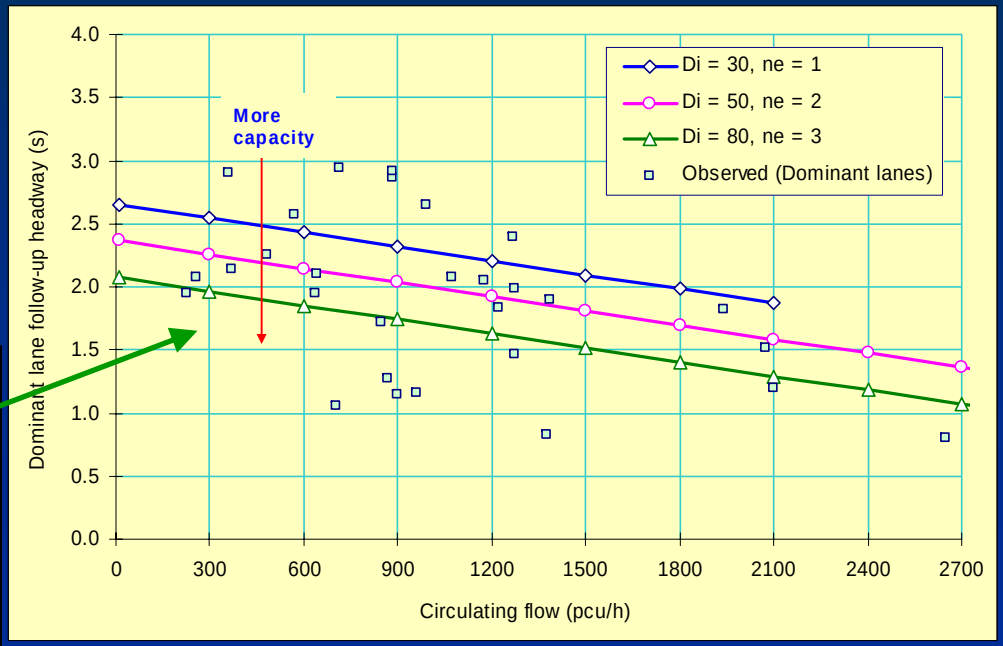
Opposing stream

- *Headway distribution (bunched or not)*
- *Lane use of opposing traffic*

Sensitivity to:

- **Intersection geometry**
- **Driver behaviour**

In SIDRA INTERSECTION, critical gap and follow-up values decrease with increased flow rates, emulating drivers getting more aggressive with increased congestion levels.



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Lane use at intersection approaches

Relation to lane choice and lane change models used in microsimulation

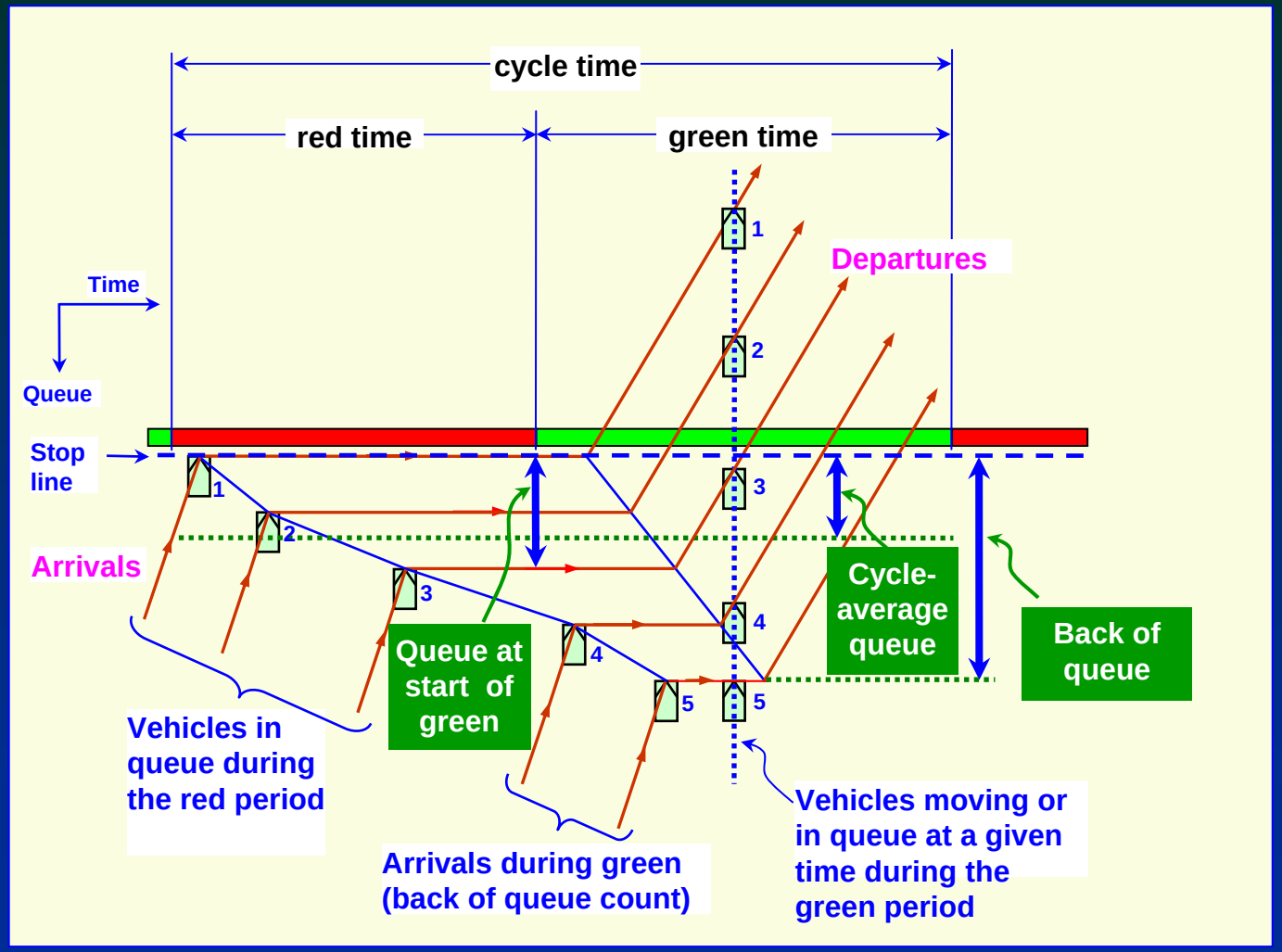
- **Shortest queue vs shortest delay**
- **Many factors causing lane underutilisation**

Definitions and measurement methods

Consistency of definitions and measurement methods for traffic performance variables:

- **DELAY (stopped, geometric, etc)**
- **QUEUE LENGTH (cycle average vs back of queue)**
- **STOPS (effective stop rate and proportion stopped)**

Back of queue vs cycle average queue



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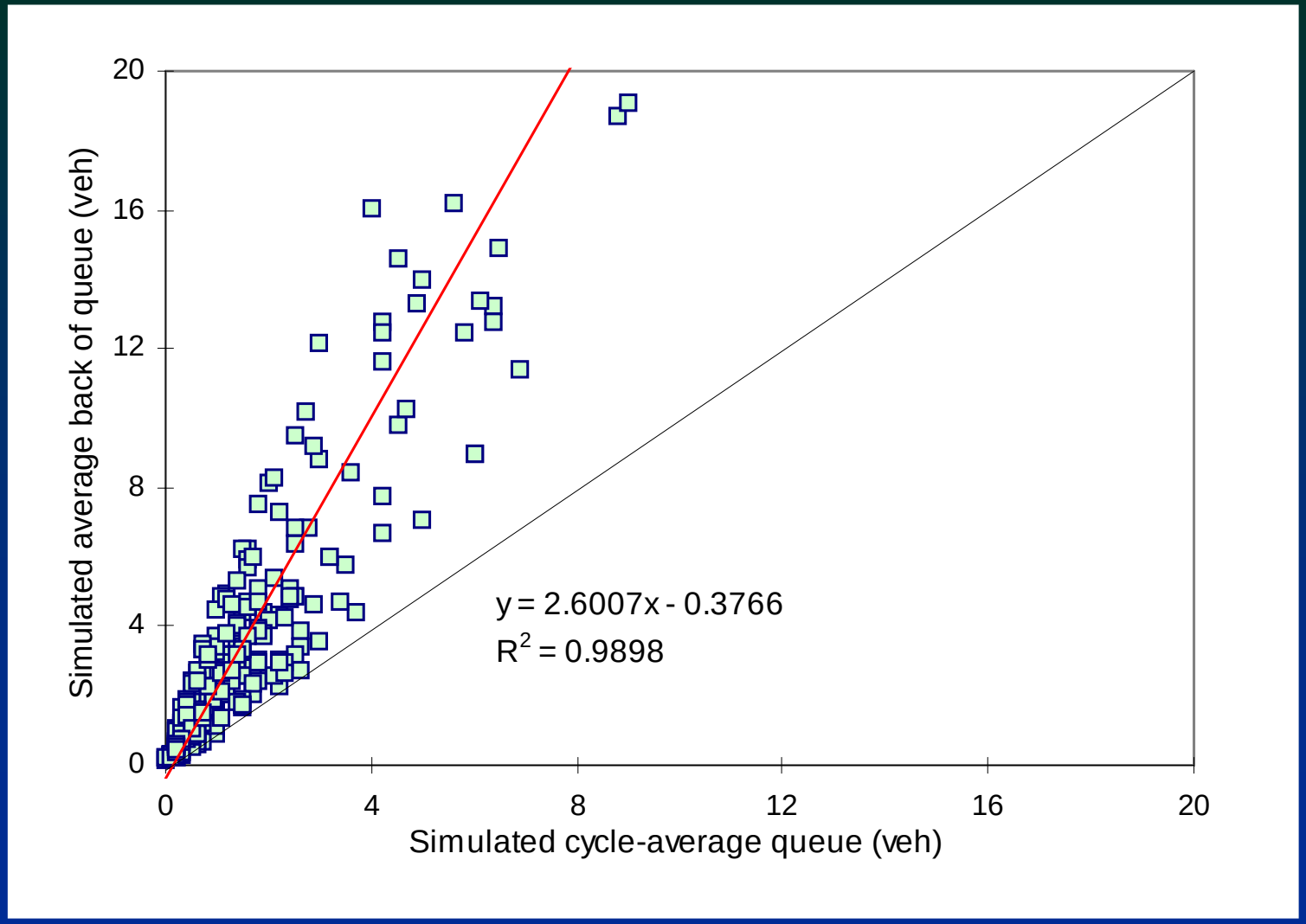
Back of queue vs cycle average queue



Benchmarking

Comparison of specific microsimulation and analytical model components as a benchmarking method for model verification

- **Algers (Leeds, UK, 2000)**
- **Yoshii (Japan, 1999)**

Vehicle and Driver Characteristics

Driver response time

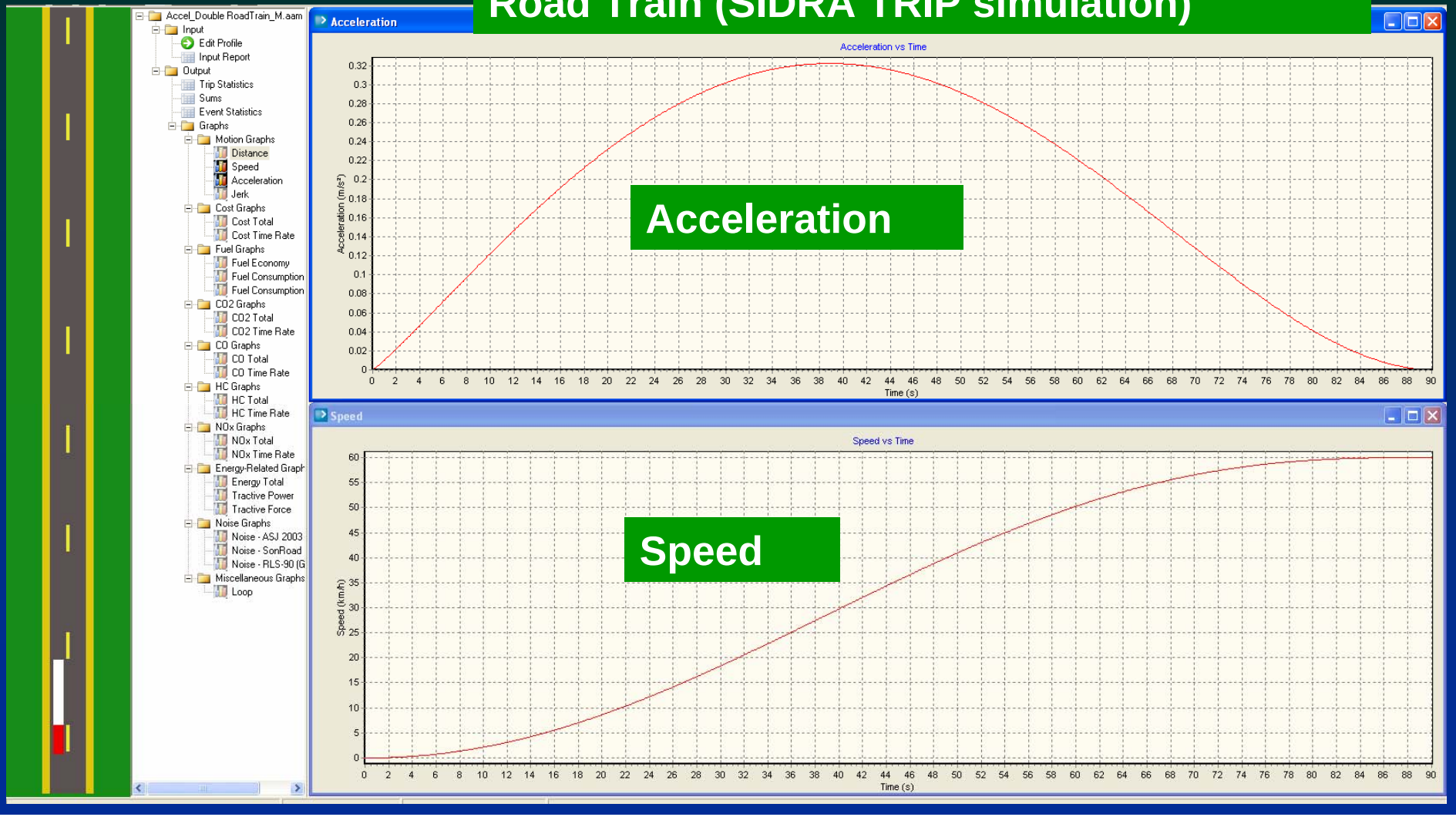
common formulation (integrated framework)

- **follow-up headway** for gap-acceptance situations (roundabouts, sign control, and filter turns at signals)
- **saturation flow rate** for signalised intersections
- **capacity flow** for uninterrupted streams (freeways, highways, urban streets)

Acceleration profiles

(Polynomial model in SIDRA INTERSECTION and TRIP)

Road Train (SIDRA TRIP simulation)



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Model comparisons (SIDRA INTERSECTION vs Microsimulation)

- **Signalised**
  (Akçelik and Besley 2001)
- **Roundabout**
  ("High-Capacity Roundabout Intersection Analysis" by Stanek and Milam (Fehr & Peers, ITE District 6 Annual Meeting, 2004)

Unused short lane in VISSIM causes substantial differences between the two models

Table 2. Case Study #2 Results: Level of Service and Average Delay (sec/veh)

Methodology	Westbound Ramps
RODEL	B / 11
aaSIDRA	B / 15
VISSIM	F / 99

Note: Uses the HCM 2000 level of service criteria for unsignalized intersections.

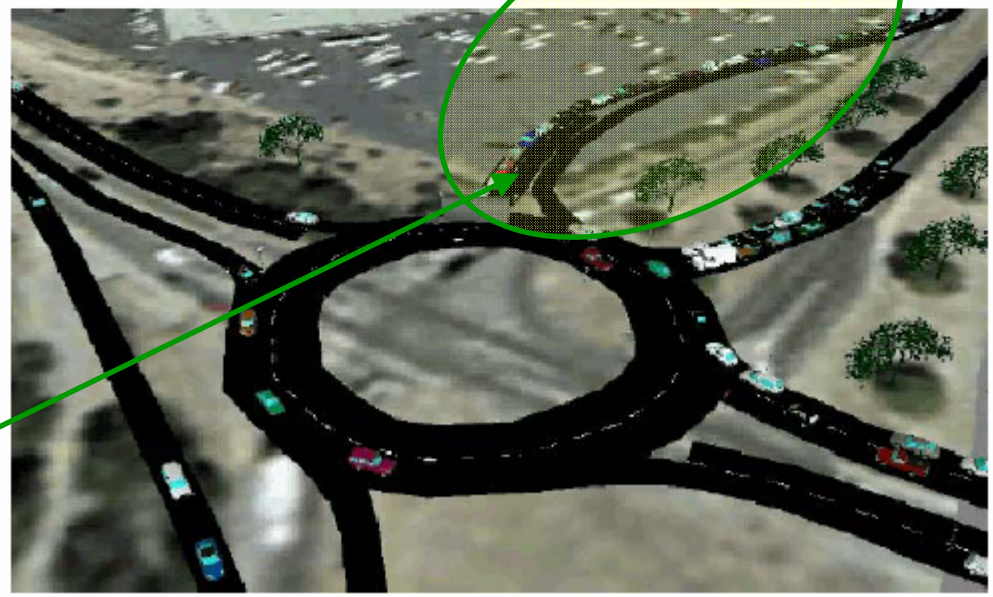

Figure 8. 5-leg Roundabout (VISSIM)

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End of presentation

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