Relationship between CAPACITY and DRIVER BEHAVIOUR

Presenter: Rahmi Akçelik

First an international journey of roundabouts …
Roundabouts: Spain

No give-way (yield) line!

Roundabouts: Paris, France
Roundabouts: Bodrum, Turkey

An intersection: India’s solution to the problem of pedestrians and cyclists at intersections
Capacity and Driver Behaviour

A roundabout in Australia

Roundabout after deluge: Melbourne, Australia …
Capacity and Driver Behaviour

Roundabouts: Montreal, Canada

Fitzsimons Lane - Porter St Roundabout, Melbourne, Australia

Using SIDRA INTERSECTION, Vic Roads engineers redesigned a highly congested two-lane roundabout in Melbourne as a three-lane roundabout eliminating persistent congestion.
Lane use at roundabouts: Australia

Not for approach-based models!

UK Roundabouts: Flare and lane use !!

Effectively single lane!

Empty lane!
UK Roundabouts: Continuous lane without kerb

Drivers avoid this circulating lane resulting in upstream approach lane underutilisation!

UK Mini-roundabouts

1 in 20 drivers went around the island: effectively 4-way yield!
Analytical models use capacity as a basic parameter in traffic performance estimation. Traffic characteristics that affect capacity are not often clearly explained or understood. This causes difficulties in practice when professional judgement has to be used in interpreting output and calibrating models for specific applications.

There is also a need to establish relationships between traffic parameters used in analytical models and microsimulation models. In this context, gap-acceptance parameters are very important in modeling roundabouts using these two types of models.
This paper

A general analytical model is given to provide a common formulation relating key variables in intersection analysis to various driver behaviour (driver-vehicle) characteristics. These key variables are:

- **follow-up headway** for gap-acceptance situations (roundabouts, sign control, and filter / permitted turns at signals), and
- **saturation flow rate** for signalised intersections.

**CAPACITY: a common formulation for signalised and unsignalised intersections (including roundabouts)**

\[
\text{Capacity} = u \times s = u \times \frac{3600}{(t_r + L_{hj} / v_s)}
\]

\( u \) = proportion of time when the vehicles can depart from the queue:
- signals are green \( u = g / c \), or
- gaps are available

\( s \) = saturation (queue discharge) flow rate.
Queue discharge headway, $h_s$
(follow-up headway in gap-acceptance, $t_f$)

$$h_s = t_r + \frac{L_{hj}}{v_s}$$

- $t_r$ = driver response time during queue discharge (seconds)
- $L_{hj}$ = jam spacing (m or ft)
- $v_s$ = saturation speed (m/s or ft/s)
- $S$ = saturation flow rate (veh/h)

**Gap-acceptance capacity**

Capacity at zero opposing flow,
$$s = \frac{3600}{t_f}$$
($u = 1.0$)

Capacity reduced with increased opposing flow rate because less gaps are available ($u < 1$)
For example:

**Follow-up headway:** \( t_f = 3.0 \) seconds  
**Saturation flow rate** = \( \frac{3600}{3.0} = 1200 \text{ veh/h} \)  
**Proportion of time available:** \( u = 0.50 \)  
**Capacity** = \( 0.50 \times 1200 \text{ veh/h} = 600 \text{ veh/h} \)
Queue discharge speeds:
General Holmes Dve and Bestic St, Sydney (through traffic lane)

saturation speed = 53 km/h
speed limit = 70 km/h

At signalised intersections

<table>
<thead>
<tr>
<th>Site</th>
<th>s (veh/h)</th>
<th>h_s (s)</th>
<th>v_s (km/h)</th>
<th>L_hj (m)</th>
<th>t_r (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney Site</td>
<td>2278</td>
<td>1.58</td>
<td>52.8</td>
<td>6.6</td>
<td>1.13</td>
</tr>
<tr>
<td>Average Through</td>
<td>2083</td>
<td>1.73</td>
<td>45.1</td>
<td>6.9</td>
<td>1.17</td>
</tr>
</tbody>
</table>
A one-lane roundabout with a central island diameter of 20 m (66 ft), circulating road width of 8 m (26 ft), and flow rates of 200 veh/h with no heavy vehicles for all movements (hence all circulating flow rates = 600 veh/h) was analysed using SIDRA INTERSECTION. The software estimated:

- follow-up headway of \( t_f = 2.34 \text{ s} \)
- negotiation speed of 26.2 km/h (16.3 mph), hence \( v_s = 7.3 \text{ m/s} (23.9 \text{ ft/s}) \).

Using a jam spacing of \( L_{hj} = 10 \text{ m} (33 \text{ ft}) \), the driver response time was determined as \( t_r = 0.97 \text{ s} \).

(not too different from those observed at signalised intersections)
Capacity and Driver Behaviour

Example continued: HCM version

- When an Environment Factor value of 1.2 (default in the HCM version of SIDRA INTERSECTION) is used for the above example, the software estimated $t_f = 2.86 \text{ s}$ (instead of 2.34 s).

Using a jam spacing of $L_{hj} = 10 \text{ m (33 ft)}$, a driver response time of $t_r = 1.49 \text{ s}$ is found (instead of 0.97 s).

Thus, about 0.5 s increase in the follow-up headway value is attributed to the longer driver response time for US drivers. Hence lower capacities for US roundabouts.

Example continued: longer vehicle

- If a longer vehicle length is assumed resulting in a longer jam spacing, e.g. $L_{hj} = 11 \text{ m (36 ft)}$, a driver response time of $t_r = 1.35 \text{ s}$ is found.

In this case:
  - about 0.4 s of the 0.5 s increase in the follow-up headway is attributed to the driver response time and
  - about 0.1 s is attributed to the longer vehicle length.
In conclusion

- The formula given provides a direct relationship between capacity and parameters representing driver behaviour, namely:
  - driver response time during queue discharge,
  - spacing between vehicles in the queue (jam spacing), and
  - saturation (queue discharge) speed.

The relationships given in this paper provide a link between analytical and microsimulation models.

This could help to improve compatibility between microsimulation methods and established analytical techniques used in traffic engineering practice, and to improve the practical usefulness of microsimulation tools through better model calibration and verification.
Research is recommended on:
- calibration of the relationship presented in this paper using field studies of many different traffic situations, and
- investigation of driver and vehicle parameters used in various microsimulation software packages (how do they compare with the values given in this paper?).