South African Highway Capacity Research

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Need for South African Highway Capacity Research?
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- Highway Capacity Manual
  - Often prescribed as minimum standard for capacity improvements
  - Capacity improvement required when
    - Level-of-service poorer than
    - LOS D in 30th Highest hour

- Therefore important to
  - Validate/Calibrate the HCM
  - For South African conditions
Recent Contributions

- Capacity Analysis of
  - Two-lane roads
  - Multilane highways & Freeways
  - Signalised intersections
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Capacity Research

Two-Lane Highways
Two-Lane Highways Measures of Effectiveness

- HCM Measures of Effectiveness
  - Percent Time-Spent-Following (PTSF)
  - Average Travel Speed

- PTSF, however, difficult to observe
  - HCM Allows a surrogate measure
  - Percentage vehicles with headways < 3 s
  - Termed “Percentage followers”
Two-Lane Highways
Research Methodology

- Observations using
  - Double inductive loops

- Traffic loggers
  - New traffic loggers capability developed
  - Directly observes percentage followers
  - Can be used to directly observe LOS

- Observations on
  - 25 Different two-lane highways
Two-Lane Highways
Percentage Followers

- Observations indicate that HCM
  - Significantly overestimates Percentage followers

- It was therefore necessary to develop a new local two-lane model
Two-Lane Highways
HCM Model: Typical result

N4-21 Two-lane road, N4-5 Belfast - Machadodorp, 120 km/h
Westbound direction (Pretoria), Overtaking allowed
New Model
Two-Lane Highways
HCM Overestimation
Probably due to shoulder use
Appropriateness of Percentage Followers as a Measure of Effectiveness for establishing Level of Service
Percentage followers as a Measure of Effectiveness

HCM Model — —
HIM Model ______
Approximately 60/40 directional split

N4-32 Two-lane road, N4-5 Wonderfontein - Belfast, Km 25.4, 120 km/h
Westbound direction (Pretoria), Overtaking allowed
New Measure of Effectiveness

“Follower Density”

Approximately 60/40 directional split

Follower density (Veh/km/lane)

One-way traffic flow (PCU/hour)

N4 Two-lane, Wonderfontein - Belfast, Km 25.0, 120 km/h
Eastbound direction (Belfast), Overtaking allowed
New Measure of Effectiveness
“Follower Density”

- Follower Density
  - Percentage Followers x Traffic density
  - Units: Followers per km (per lane)

- Advantages
  - Gives greater weight to traffic flow
  - Automatically takes speed into account
New SANRAL Highway Traffic Model
HTM Highway Traffic Model

Vertical queue

Macroscopic “simulation” model based on catching-up and overtaking rates

Platoon (queue) length modelled every 20m over length of road
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Microscopic Analysis of Highways and Freeways

Highway Traffic Model

Version 2006 (Beta)

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Capacity Research
Multilane Highways & Freeways
Multilane Highways/Freeways Research Methodology

- **Observations using**
  - Double inductive loops
  - Newly developed traffic loggers
- **Observations on**
  - 20 Different freeways/highways
- **Scope of research**
  - Restricted to Basic Freeway Sections
  - Interchanges excluded
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Multilane Highways/Freeways Speed/Flow Relationship

N1 Freeway, Strijdom Park, Section 20, Km 31.000, 120 km/h, Six lanes Southbound direction (Beyers Naude I/C), Flat gradient
Multilane Highways/Freeways
Per Lane Speed/Flow Relationship

N1 Freeway, Maraisburg, Section 20, Km 17.600, 120 km/h, Four lanes
Northbound direction (Maraisburg I/C), Flat gradient
Multilane Highways/Freeways
Lane Distribution

R21 Freeway, Kaalfontein, Km 8.800, 120 km/h, Four lanes
Northbound direction (Pretoria), Slight decline
### Freeways
Typical observed capacities

<table>
<thead>
<tr>
<th>Description</th>
<th>Capacity range Pc/hour/lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCM</td>
<td>2300 2400</td>
</tr>
<tr>
<td>South Africa</td>
<td>1900 2300</td>
</tr>
</tbody>
</table>
Multilane Highways/Freeways
Percentage Followers?

- Multilane Highways/Freeways
- Modelled in terms of
  - Percentage followers

**Advantage: Uniformity**
  - Follower density used as a MOE for all types of highways:
    - Two-lane Highways
    - Multilane Highways/Freeways
Multilane Highways/Freeways
Percentage Followers/Flow

R21 Freeway, Kaalfontein, Km 8.800, 120 km/h, Four lanes
Northbound direction (Pretoria), Slight decline
Multilane Highways/Freeways
Speed/Percentage Followers

\[ U = 116.8x(1-0.0320P - 0.0344P^2/(1-P)) \]

R21 Freeway, Kaalfontein, Km 8.800, 120 km/h, Four lanes Northbound direction (Pretoria), Slight decline
Signalised Intersections
Signalised Intersections
Delay Models

- HCM delay model found to
  - Overestimate delay significantly

- New model was therefore developed
  - University research (Pieter Pretorius)
  - Improve delay estimates significantly

- Study methodology
  - Simulation evaluations
Signalised Intersections
HCM Delay Model

Evaluation of the Highway Capacity Delay Model
Signalised Intersections
New Delay Model

Evaluation of the Modified Newell Delay Model
Conclusions
Conclusions

- Major differences found between USA & South Africa
- A need exists for a South African Highway Capacity Manual
- South Africa has the expertise
  - That can make a significant contribution
  - In the field of traffic engineering
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Thank You

Images courtesy of SA Tourism