SATURN UGM:
Modelling Motorway Merges - Discussion

Thursday 3rd December 2015

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Web Download
An area of great debate …

- complex vehicle interactions
- limited survey data currently available
- Multiple options already available in SATURN
  - Traditional ‘M’ marker
  - ‘Q’-nodes (default or QVDMIN, QDMAX)
  - ‘Stopper’ Nodes
  - Simulation speed-flow curves
  - APRESV (0 -> 1)
  - Node specific GAPM
  - Combinations thereof (including double ‘M’ markers)

We want to provide more advice and/or functionality but we need your help!
Options available
- Standard Merge Marker (‘M’)

Single ‘M’ Marker

Equation 8.1: \( C_m = S_m * P_i \)
where
\( C_m \) = Entry Capacity for merge
\( S_m \) = Saturation Flow for merge
\( P_i \) = Probability of a Gap in major lane 1

Equation 8.2: \( P_i = \left(1 - \frac{V_i}{S_i}\right)^{G_m} \)
where
\( V_i \) = Flow in major lane 1
\( S_m \) = Saturation Flow for major lane 1
\( G_m \) = Node Gap parameter / # of major lanes

Comments:
- No impact on major arm
- CAPMIN (default = 30 pcu/h)
- As Merge, focus on Inside Lane only

Coded GAPM / # of Lanes

See Section 8.2.2 et al
Options available
- APRESV (After you …)

Affects Lane Choice (i.e. Allocation) on Major Arm

Equation 8.10: \( V_{1AB} + V_{DBC} \times APRESV = V_{2AB} \)

where

\( V_{1AB} = \) Flow in Major Lane 1
\( V_{2AB} = \) Flow in Major Lane 2

So:

If APRESV = 0 then
\( V_{1AB} = V_{2AB} = V_{3AB} \)

If APRESV = 1 then
\( V_{1AB} + V_{DBC} = V_{2AB} = V_{3AB} \)

Comments:

Same flow in all three major lanes for GAPM calculation
Merging flow volume moved from major lane 1 and split between major lane 2 and 3
Therefore, higher probability that gaps available in lane 1 & hence more capacity for slip
See Section 8.8.3.1 et al
Current default = 1.0
Options available  
- Queueing ‘Q’ Node

Add Queueing Delay at Merge Node

Equation Q.1:  \( d_C = QDMAX \times \left( \frac{V_{BCE}}{C_{BCE}} - QVCMIN \right) \)

where
- \( d_C \) = Delay at Node C (seconds)
- \( QDMAX \) = Maximum Delay (Default = 227 sec)
- \( QVCMIN \) = V/C threshold (Default = 0.75)
- \( V_{BCE} \) = Total flow on Turn BCE
- \( C_{BCE} \) = Total capacity on Turn BCE

Comments:
- Must be a Merge node with 2->1 layout
- Mid-link capacity BC = Turn Sat flow BCE
- Applies delay to link BC
- V/C ratio based on BCE turn capacity
- Q Turn delay independent of:
  - Blocking back delays
  - SFC delays
  - Any coded distance
  - Permanent queueing if V/C > 1

See Appendix Q
Counteracts default blocking back using Chains

By default:
- With BB109=T, links BC and CE are considered as a single link BCE when determining blocking back.
- Blocking back at node ‘B’ only occurs if total queue length from node ‘E’ exceeds total stacking capacity for link BC + link CE.
- Queue starts at node ‘E’.

By coding link BC with a negative stacking capacity:
- Chain is broken and link BC and CE considered separately.
- If $V_{BCE} > C_{BCE}$ then a queue will form at node ‘C’.
- If resulting Queue Length $L_{BC} > Stacking Capacity_{BC}$, then blocking back occurs at node ‘B’.

Comments:
See 8.5.5.4 et al.
Options available
- Double ‘M’ marker

Both arms give-way (in part) to each other

For Single ‘M’ marker

Equation 8.2: \( P_i = \left(1 - \frac{V_i}{S_i}\right)^{G_m} \)

where

\( V_i = \) Flow in major lane 1, \( S_m = \) Saturation Flow for major lane 1, \( G_m = \) Node Gap parameter / # of major lanes

For Double ‘M’ marker

Equation 8.2: \( P_i = 0.5 + 0.5 \times \left(1 - \frac{V_i}{S_i}\right)^{G_m} \)

Comments:

- Inside lane for Major Arm
- In effect, both turns have a ‘guarantee’ of 50% of their available capacity and ‘fight’ for the other 50%
- Therefore recommend ‘M+M’ not ‘M’

Applied to both Major and Minor Arm

Same lane choice rules apply

See 8.2.2.1 et al + 8.8.3.2 for lane choice
Options available
- Others

Stopper Node
- Conventional 2-arm priority junction at Node ‘C’
- ‘Q’ node applies additional link delay based on step-function

Mid-link Simulation Speed-flow Curves
- Applies SATURN power curve on the link to determine extra link delay
- If calculated downstream node capacity > mid-link capacity, turn capacities will be capped to mid-link value
- Blocking back calculations based on capped turn capacity (via ‘Choke’ factors)

Comments:
See 8.4.4 et al
How do users model them?

1. A simple Merge Marker is all that I need
2. A family of coding templates gives me the flexibility
3. Q-nodes work for me
4. Q-node with a M twist?
5. Apply speed-flow curves with physical / virtual lanes
6. Use some APRES VOUS
7. Special link distances based on junction geometry
8. Mix it up with some Q-node Negative Stacking Capacity
9. M&Ms (or Double ‘M’ markers)
10. One we’ve not mentioned yet

Practical experiences? Validation checks?
Emerging Practice
- Latest Work in Progress

Shape nodes 1002/5
Added for ANPR timing points

Link Speed-flow Curves
Main Carriageway
3 lane - 1002->1003, 1004->1005
4 lane - 1003->1004
On-slip
1 lane - 1001->1003

Clarifications ...
Sat flow = 89999: overridden by Mid-link SFC
4 lane SFC for 1003->1004 for taper – ensure upstream merge flow reaches Q node for correct V/C representation *

With fixed 300m* link length
Use of both* Q & M

Queue Location
- Negative stacking capacity at Q node to fix queue position

Atkins preference for Double 'M' (subject to further testing)

* to be confirmed

### Table

<table>
<thead>
<tr>
<th>Turn</th>
<th>Anode</th>
<th>Bnode</th>
<th>Cnode</th>
<th>Marker</th>
<th>Link Length</th>
<th>Lanes Per Link</th>
<th>Turning Lanes</th>
<th>Min Value</th>
<th>Median Value</th>
<th>Max Value</th>
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</thead>
<tbody>
<tr>
<td>Main carriageway to intermediate node</td>
<td></td>
<td>1002</td>
<td>1003</td>
<td></td>
<td>3</td>
<td>1-3</td>
<td></td>
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<td>89999</td>
<td>89999</td>
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<tr>
<td>Onslip at merge</td>
<td>1001</td>
<td>1003</td>
<td>1004</td>
<td>M</td>
<td>1/2</td>
<td>1-1</td>
<td></td>
<td>1910</td>
<td>1930</td>
<td>1940</td>
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<td>6220</td>
<td>6850</td>
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<td>Main Carriageway at Q node</td>
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<td>1004</td>
<td>1005</td>
<td>Q</td>
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<td>4</td>
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<td>Main carriageway after Q node</td>
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Emerging Practice (ii) - Latest Work in Progress

**Work in Progress**

- ANPR Data collection undertaken for M20/M23 SMP Work
- Detailed analysis underway
- Project led by CH2M Hill
- Provide evidence base
- Updated specification to be developed
- Topic for future presentation

### Turn Analysis

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