SATURN UGM:
Modelling Motorway Merges - Discussion

Thursday 3rd December 2015

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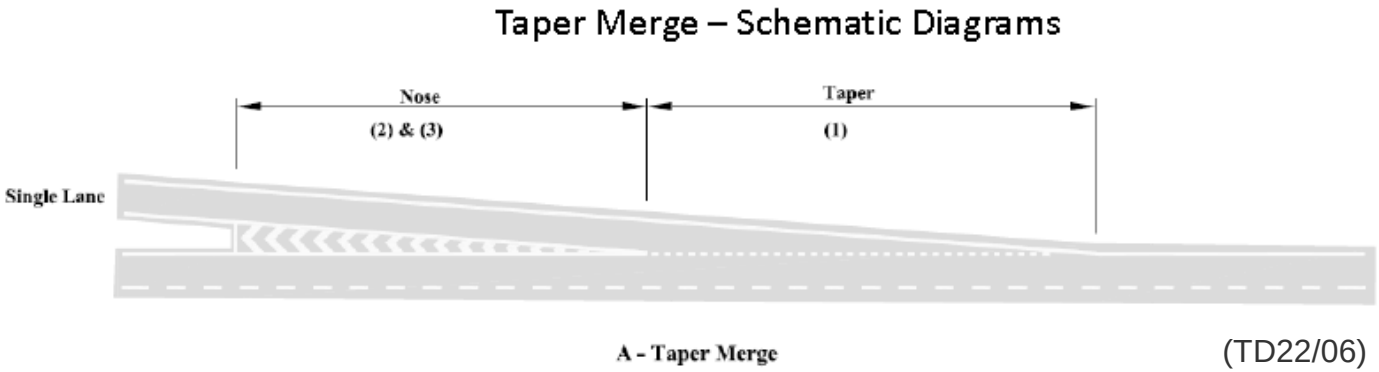
Atkins Limited

Web Download

Overview



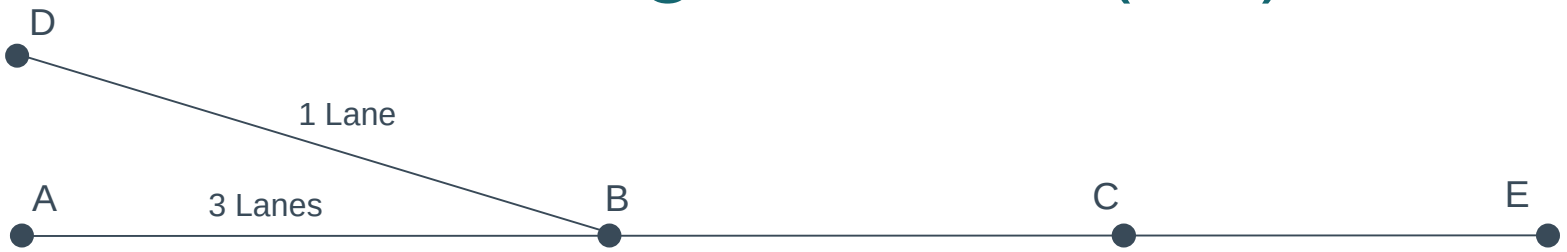
(TD22/06)

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 QVCMIN, 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

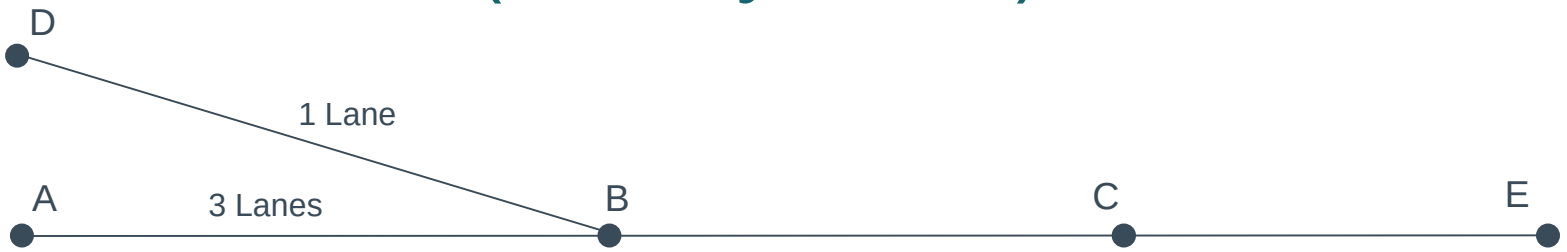
CAPMIN (default = 30 pcu/h)

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: $V^1_{AB} + V_{DBC} * APRESV = V^2_{AB}$

where

V^1_{AB} = Flow in Major Lane 1

V^2_{AB} = Flow in Major Lane 2

So:

If APRESV = 0 then

$V^1_{AB} = V^2_{AB} = V^3_{AB}$

If APRESV = 1 then

$V^1_{AB} + V_{DBC} = V^2_{AB} = V^3_{AB}$

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

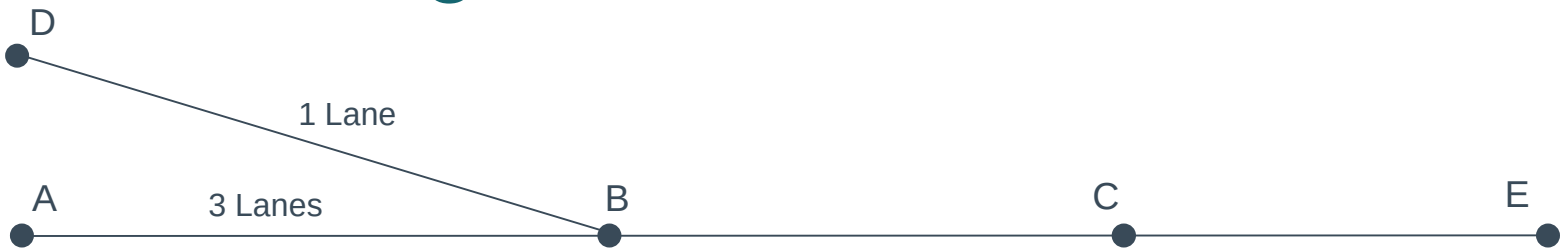
Therefore, higher probability that gaps available in lane 1 & hence more capacity for slip

See Section 8.8.3.1 et al

Current default = 1.0

Options available - Queueing ‘Q’ Node

ATKINS



Add Queueing Delay at Merge Node

Equation Q.1: $d_c = \mathrm{QDMAX} * \left(\frac{V_{BCE}}{C_{BCE}} - \mathrm{QVCMIN}\right)$

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

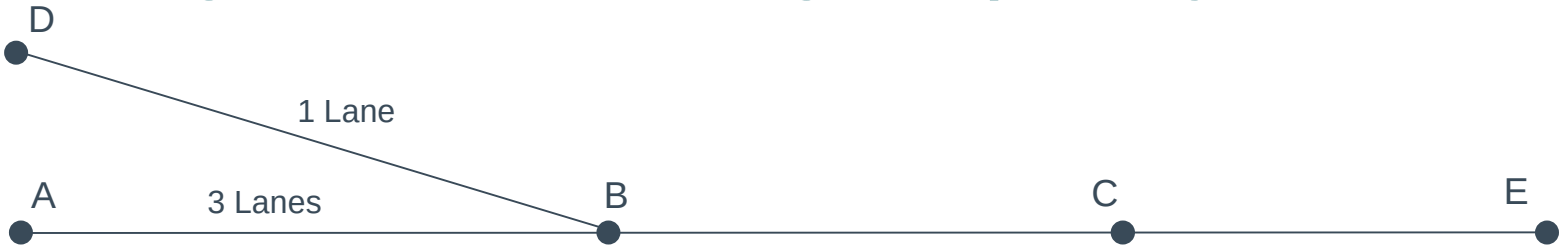
C_{BCE} = Total capacity on Turn BCE

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

Options available - Negative Stacking Capacity



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’

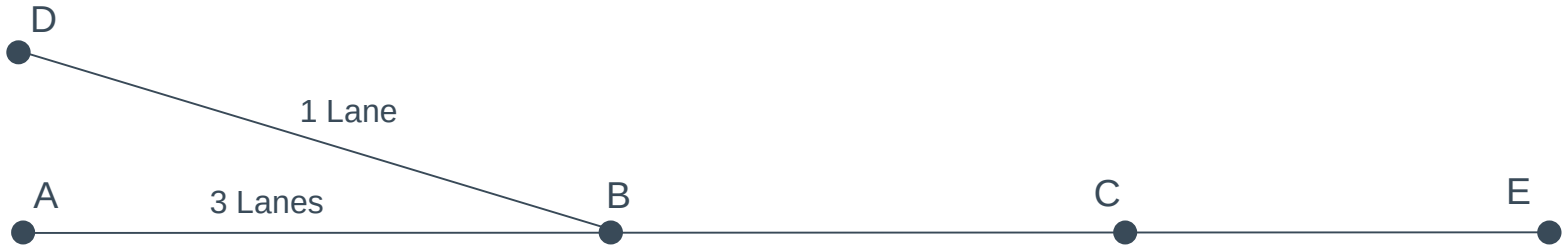
Comments:

See 8.5.5.4 et al

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 $_{BC}$ > Stacking Capacity $_{BC}$, then blocking back occurs at node ‘B’

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: $P_i = 0.5 + 0.5 * \left(1 - \frac{V_i}{S_i}\right)^{G_m}$

Applied to both Major and Minor Arm

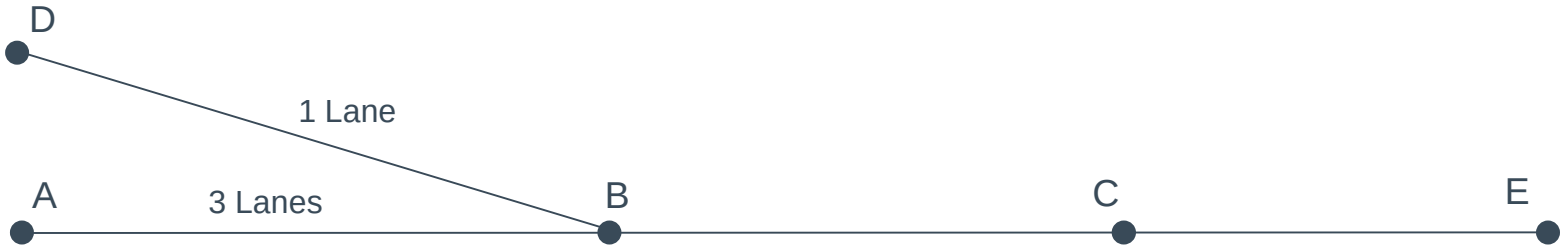
Same lane choice rules apply

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’

See 8.2.2.1 et al + 8.8.3.2 for lane choice

Options available - Others



Stopper Node

Comments:

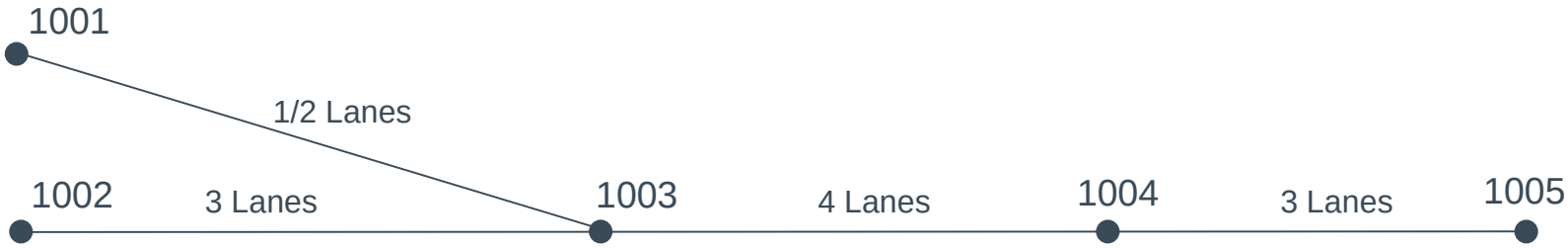
- Conventional 2-arm priority junction at Node ‘C’
- ‘Q’ node applies additional link delay based on step-function

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)

See 8.4.4 et al

How do users model them?

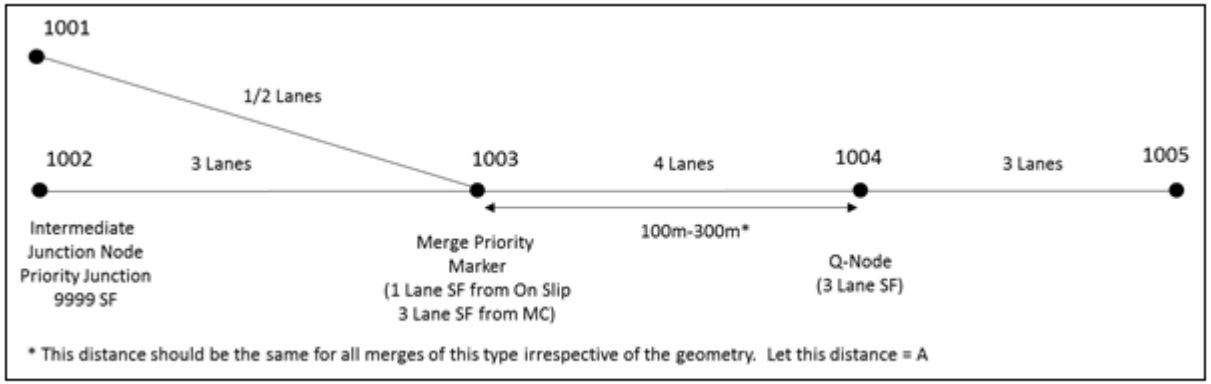


1. A simple Merge Marker is all that I need
2. A family of coding templates gives me the flexibility
3. Q-nodes work for me
4. Q-node with a M twist?
5. Apply speed-flow curves with physical / virtual lanes
6. Use some APRES VOUS
7. Special link distances based on junction geometry
8. Mix it up with 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



								Saturation flows pcus per hour		
Turn	Anode	Bnode	Cnode	Marker	Link Length	Lanes Per Link	Turning Lanes	Min Value	Median Value	Max Value
Main carriageway to intermediate node		1002	1003			3	1-3	89999	89999	89999
Onslip at merge	1001	1003	1004	M		1/2	1-1	1910	1930	1940
Main carriageway at merge	1002	1003	1004			3	1-3	5590	6220	6850
Main Carriageway at Q node	1003	1004	1005	Q	300m	4	1-3	5590	6220	6850
Main carriageway after Q node	1004	1,005				3	1-3	89999	89999	89999

Comments

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

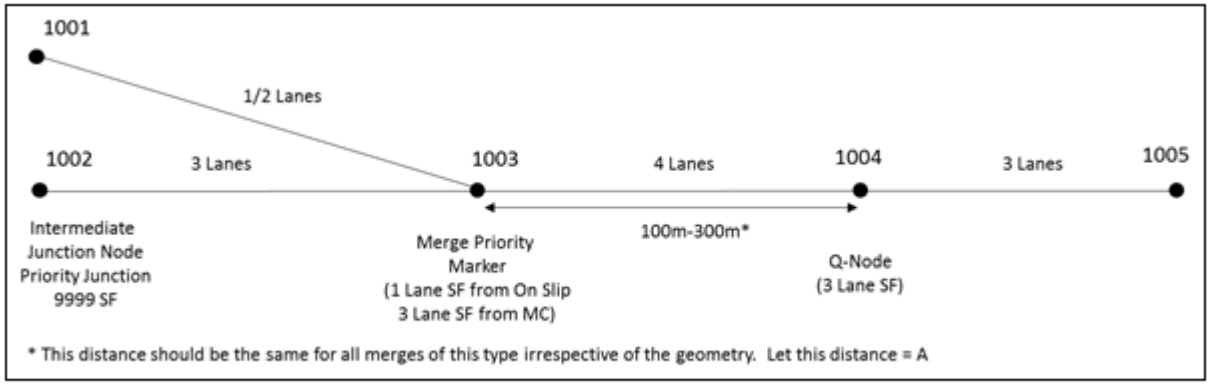
Use of both* Q & M

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

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

* to be confirmed

Emerging Practice (ii)
- Latest Work in Progress



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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