A review of the methodologies for modelling cycling within junction appraisal

Modelling on the move seminar
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Outline

Modelling

1. Deterministic modelling
2. Micro-simulation modelling
3. Cellular automata modelling

Inputs to modelling

5. Positioning on links (unavailable on web version)
6. Positioning at junctions (unavailable on web version)

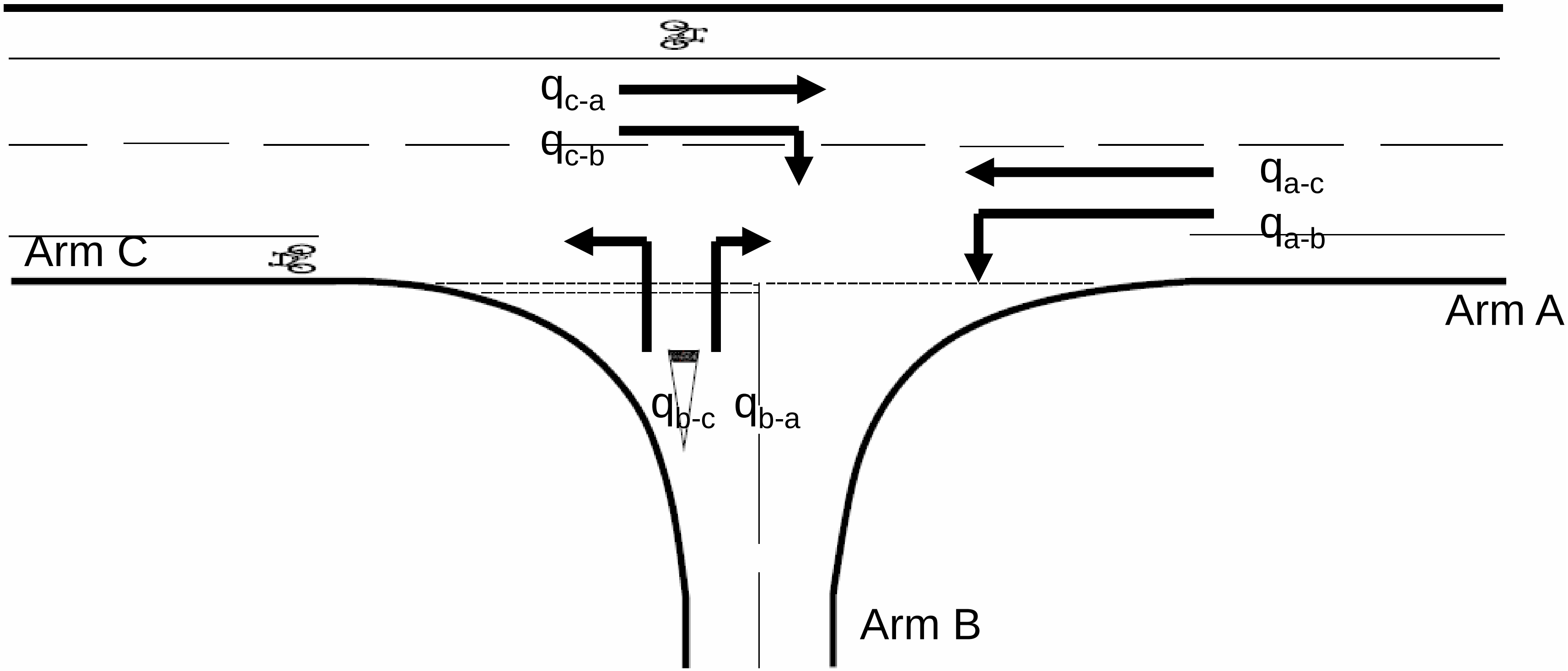
1 Deterministic modelling

Priority junctions, roundabouts and signals based on predictive equations (Kimber and Coombe, 1980; Kimber, 1980; and Vincent et al., 1980)

- Time gaps not easy to measure
- Results sensitive to values used
- Rules for more than one stream unclear
- Gap acceptance affected by geometry
- In congested conditions, more interactive relationships

	Scraggs (1964)	Webster and Cobbe (1966)	Kimber et al. (1985)	TfL (2010)	Wang et al. (2008)
Passenger car unit	1.00	1.00	1.00	1.00	
Medium goods vehicles	1.75	1.75	1.5	1.5	
Heavy goods vehicles	1.75	1.75	2.3	2.3	
Buses and coaches		2.25	2.0	2.0	
Articulated bus				3.2	
Motorcycles		0.33	0.4	0.4	
Pedal cycles		0.2	0.2	0.2	0.28 0.33 (turners)

- Typically based on headway ratio, problematic for two wheelers
- TfL suggests when cycle flow >20% ‘disproportional effect on modelling results’



$$q^{S}_{B-A} = X_1\{627 + 14W_{CR} - Y[0.364.\,q_{A-C} + 0.144.\,q_{A-B} + 0.229.\,q_{C-A} + 0.520.\,q_{C-B}]\}$$

$$X_1 = \{1 + 0.094(w_{B-A} - 3.65)\}\{1 + 0.0009(V_{rB-A} - 120)\}\{1 + 0.0006(V_{lB-A} - 150)\}$$

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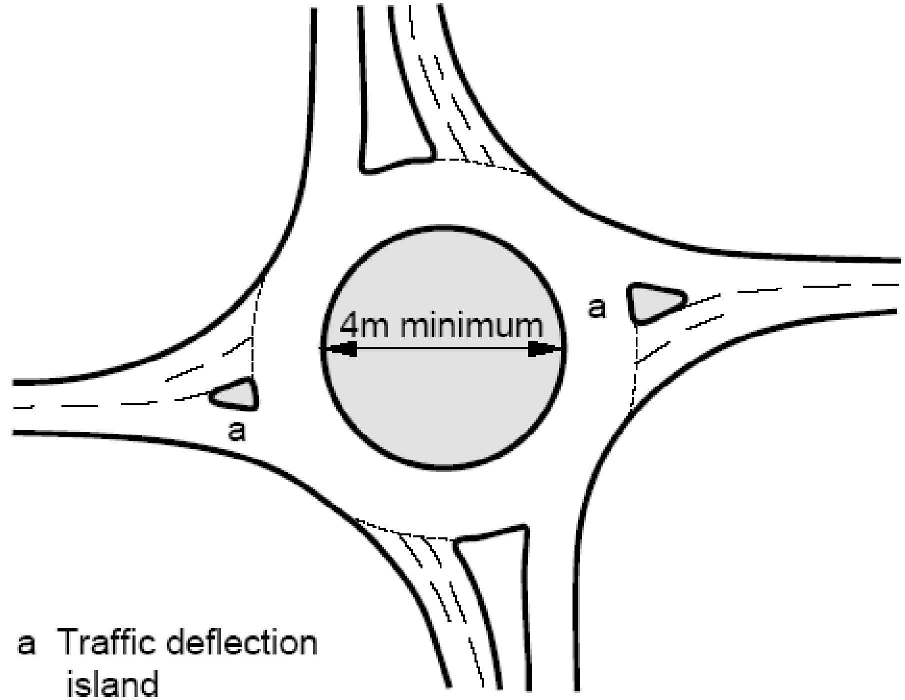
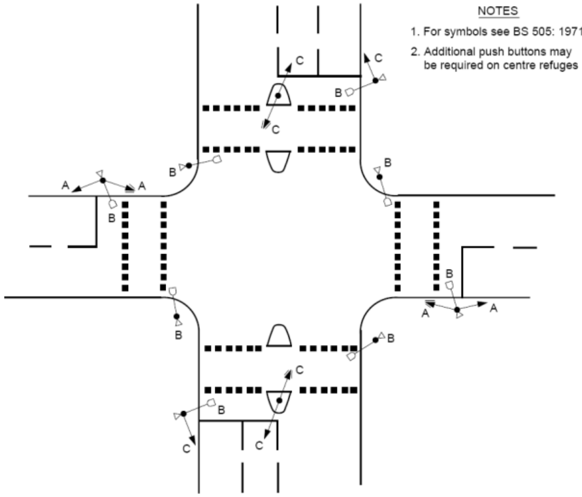
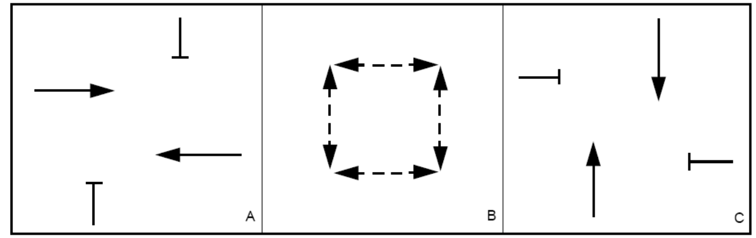
$$Q_e = k(F - f_c . Q_c)$$



Normal Roundabout
Figure 2/1

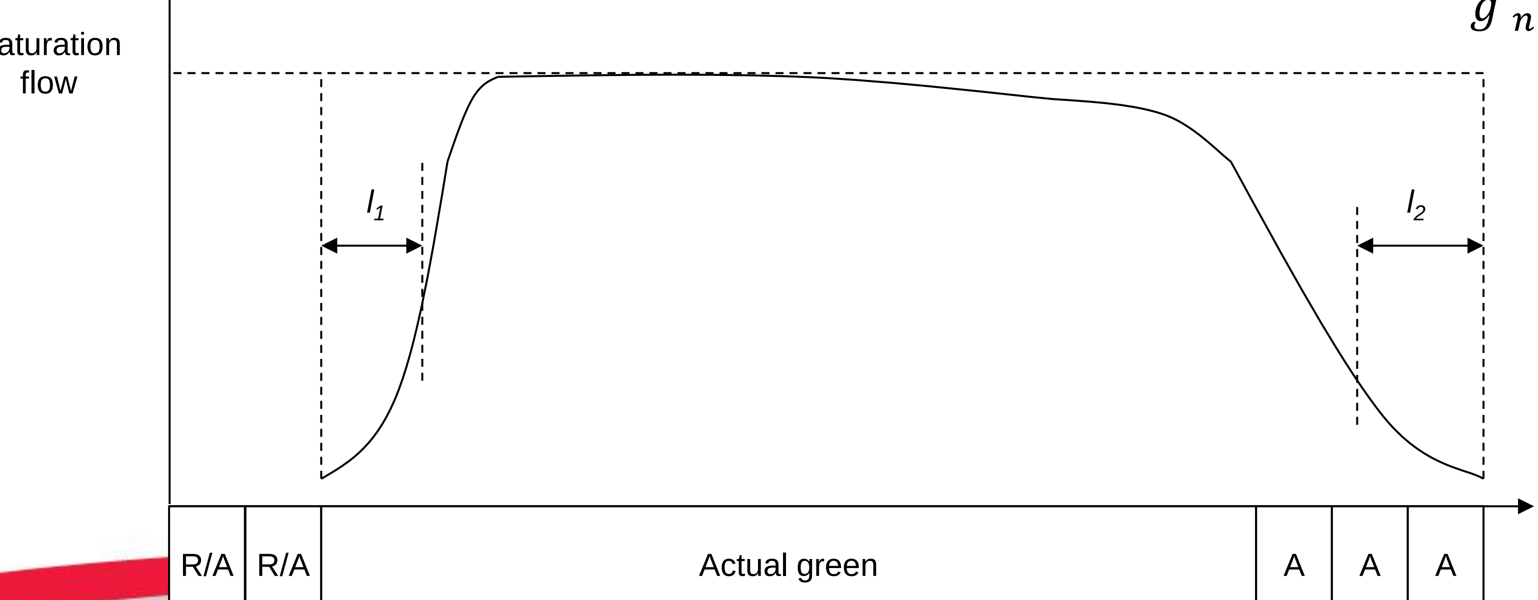




$$y = q/s$$

$$C_o = \frac{1.5L + 5}{1 - Y}$$

$$g'_n = \frac{y_n}{Y}(C_o - L)$$



2 Micro-simulation

Models estimate:

- Target speed (limit, gradient, geometry, maximum vehicle speed)
- Car following
- Lane changing / overtaking
- Gap acceptance

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Title	Country of origin	Limitations	Reference
HUTSIM	Finland	Users need to provide bicycle behaviour characteristics; interactions with motor vehicles only at crossings	Kosonen (1996)
FLEXSYT-II	The Netherlands	Bicycles not allowed on same section as motor vehicles; bicycle speeds not affected by surroundings, hence speed and acceleration fixed	Taale (1997)
BICSIM	USA	Bicycles separately modelled. But specific bicycle following, gap acceptance, lane changing, acceleration and deceleration need to be based on field studies	Faghri and Egyhaziova (1999)

Speed and acceleration

(Raksuntorn,2002)

Speed $V_n = 15 - 25\ km/h$

Junction width 100 feet $V_{max} = 1.38. V_n$

Junction width 50 feet $V_{max} = 1.68. V_n$

Acceleration

Junction width 100 feet

$$V_x = 0.223. V_n. X^{1/3}$$

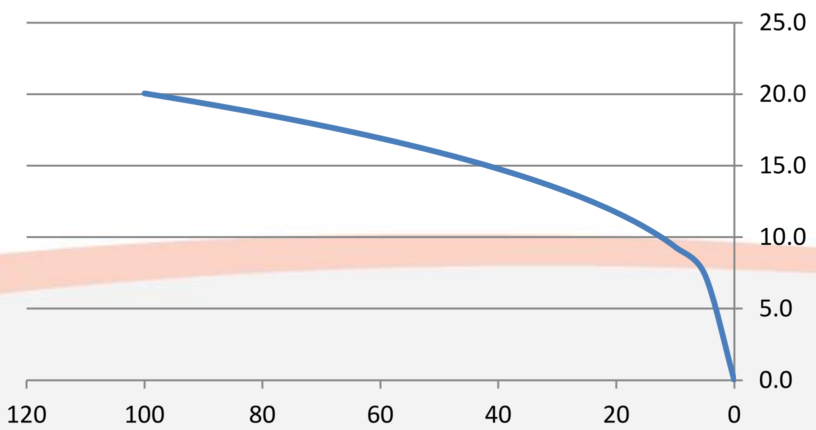
Junction width 50 feet

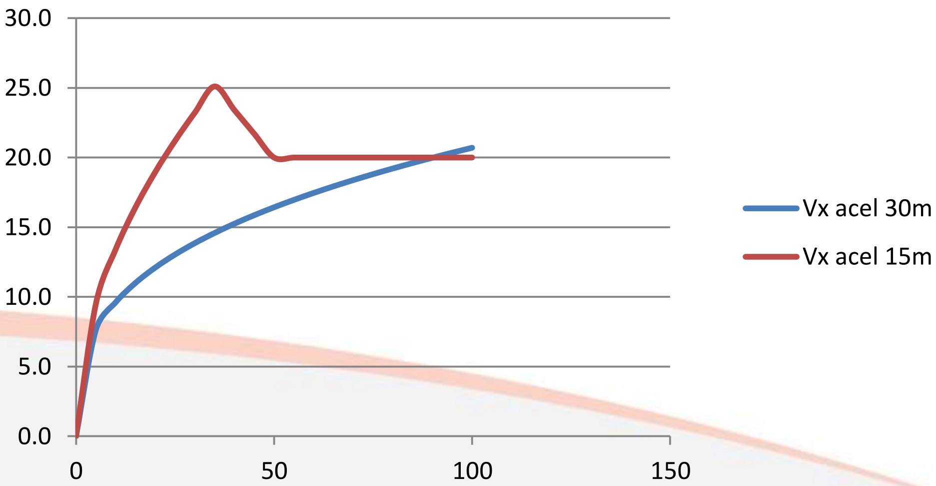
$0 \leq X < 35ft$ $V_x = 0.212. V_n. X^{1/2}$

$35 \leq X < 50ft$ $V_x = 1.85. V_n - 0.017. V_n. X$

Deceleration

$$V_x = 0.216. V_n. X^{1/3}$$

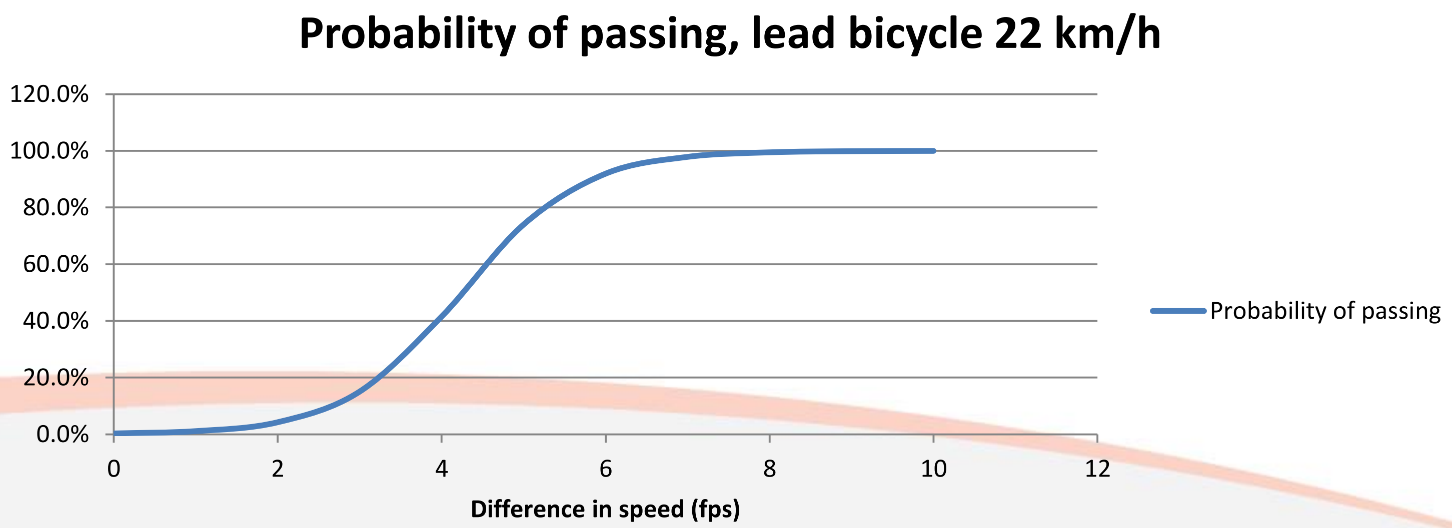




Overtaking model

Raksuntorn (2002)

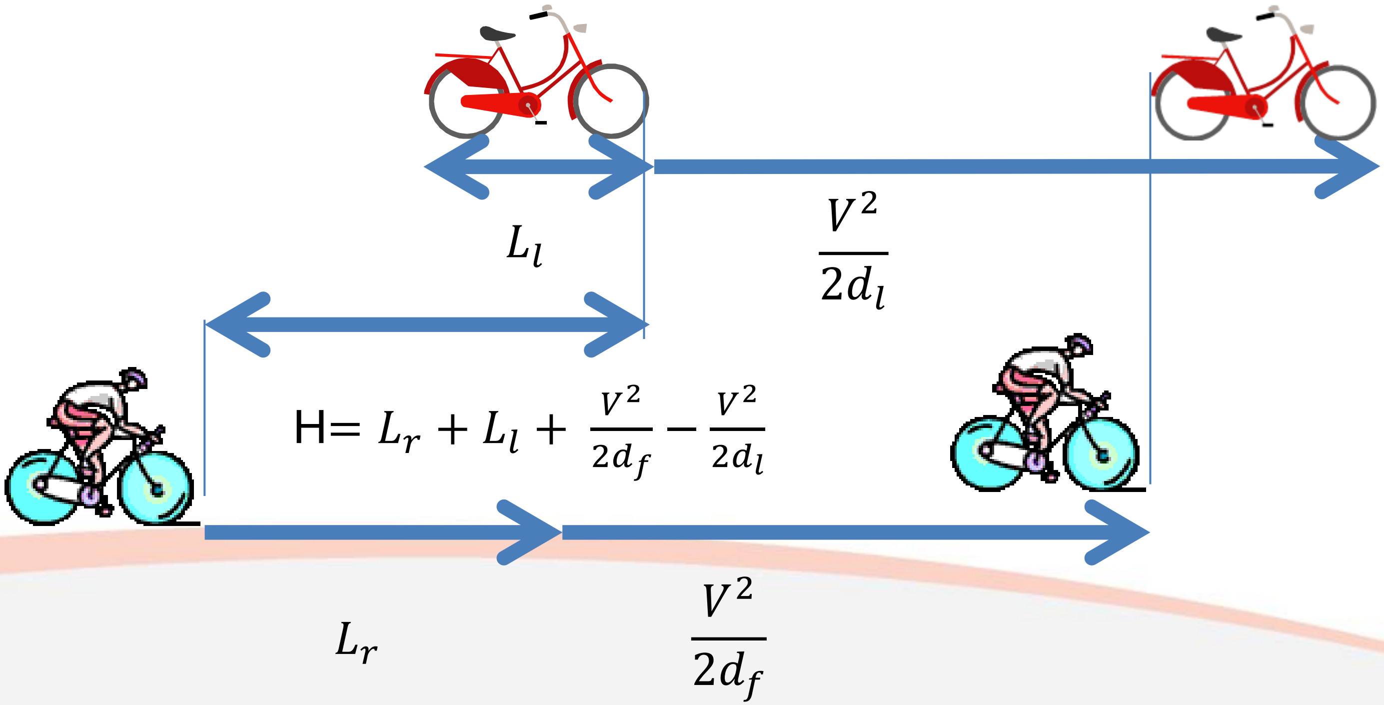
$$P(passing) = \frac{\exp\left(1.388\left(V_f - V_l\right) - 0.800.\,{V_l}^{2/3}\right)}{1 + \exp\left(1.388\left(V_f - V_l\right) - 0.800.\,{V_l}^{2/3}\right)}$$



Following model

Faghri and Egyhaziova (1999)

- Assumes ‘car following model’

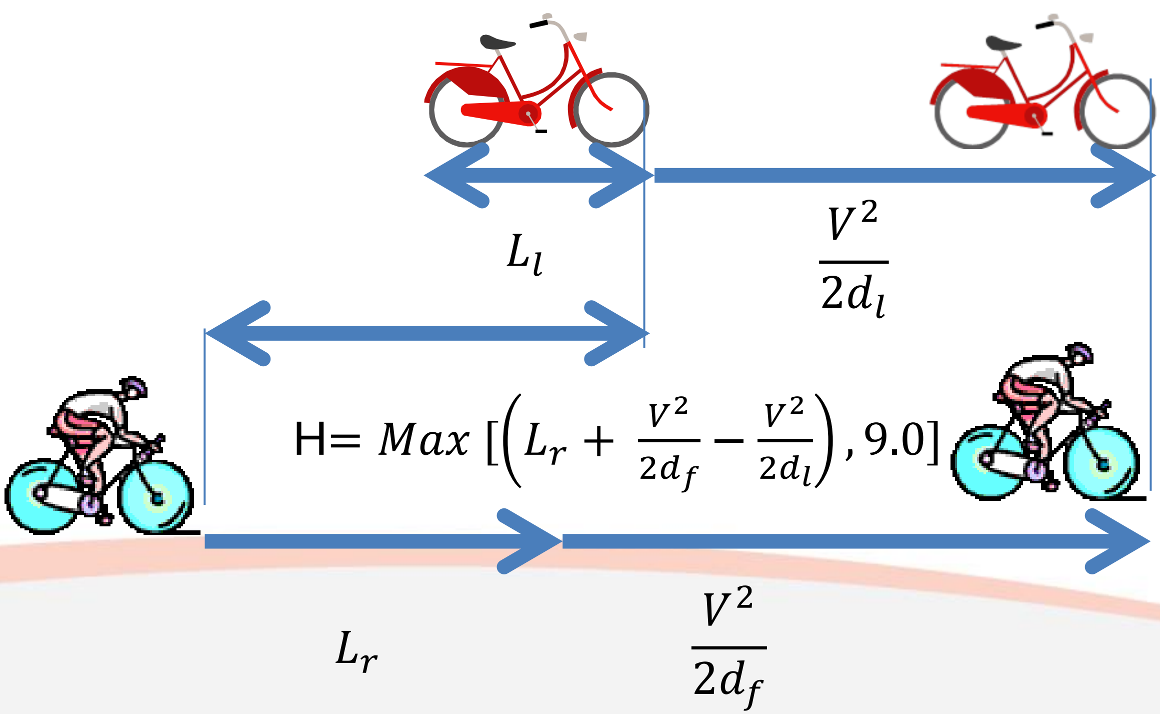


$$H = L_r + L_l + \frac{V^2}{2d_f} - \frac{V^2}{2d_l}$$

Bicycle headways

Raksuntorn (2002)

- Assumes influence when within 70 ft (21 metres)
- Data suggests no correlation with difference in braking distances, and 95% headways greater than 9 feet, but model formulation as follows:



Bicycle following model

General Motors model of form

$$a_t(t+\delta t) = \frac{\alpha_0}{h(t)}[V_l(t) - V_f(t)]$$

Raksuntorn's (2002) model:

$$V_f(t+\delta t) = 0.98.V_f(t) + 0.02h(t) + 0.51(V_l(t) - V_f(t))$$

GM model overestimates distance headway and underestimates following velocity

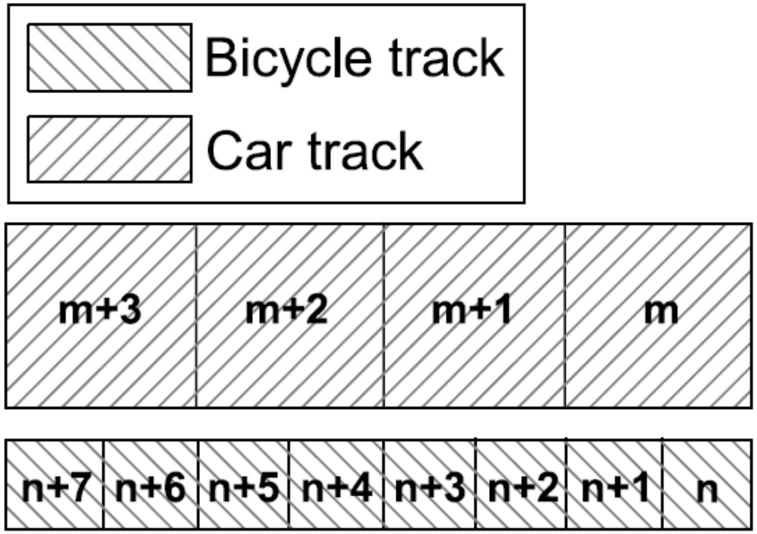
Arrivals, gaps, stopped distances

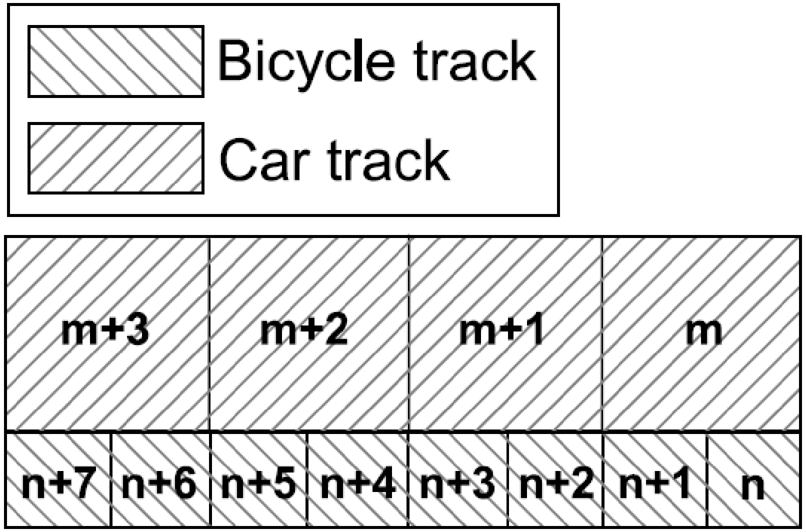
- exponential, gamma or Weibull
- Probability of car turning right across gap in bicycle traffic
- Lateral (0.72 to 2.87 feet car to bicycle) and longitudinal stopped distances (4.2-4.4 feet bicycle to bicycle)

Cellular automata models

(after Vasic and Ruskin, 2012)

	Car	Bicycle
v_{MAX}	3	2
Cell size	7.5 metres	3.75 metres
1 sec time step gives	81 kph (50 mph)	27 kph (17 mph)





Formulation of CA

1. Vehicle motion: each vehicle is advanced v_i cells along the track per unit time
2. Acceleration: if $v_i < v_{Li}$ and $v_i < d_i$, $v_i \rightarrow v_i + 1$.
3. Slowing (due to cars ahead): if $v_i < v_{Li}$, $v_i \rightarrow d_i$
4. Randomisation: if $v_i > 0$, with probability P_R, $v_i \rightarrow v_i - 1$.

Where

v_i is the velocity of the i^{th} vehicle,

$v_{Li} = min(v_{max}, d_i)$

v_{MAX} is the maximum velocity,

d_i is the number of free cells between the i^{th} vehicle and the vehicle ahead

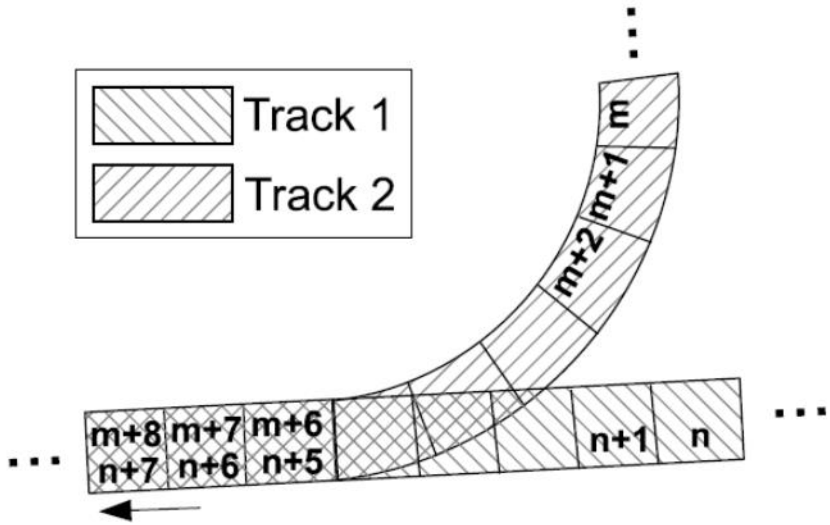
P_R is the randomisation parameter (assumed to be 0.1)

Rule 1 updates position, Rules 2-3 update speed

(From After Nagel and Schreckenberg, 1992)

Modification for conflict: $v_{Li} = \min(v_{max}, d_i, v^T_L(d^T_i), v^C_L(d^C_i), v^B_L(d^B_i))$

i.e. limiting value on speed includes, maximum speed, distance to vehicle in front, speed limit imposed by distance to turn, or distance to conflict, presence of bicycle in adjacent track



Some conclusions

- There is great variability in cycle users and drivers reactions to each other
- PCU factor for cycle traffic will likely vary by type of user and volume of cycle traffic
- Start and end lost times different for cycle traffic (quicker to respond and more variable response)
- Cycle following rules need more research
- More on cycle rider gap acceptance
- More on cycle to cycle proximity longitudinally and laterally

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