MODELLING CROSSING BEHAVIOR AND ACCIDENT RISK OF PEDESTRIANS

HEARTS - WP7

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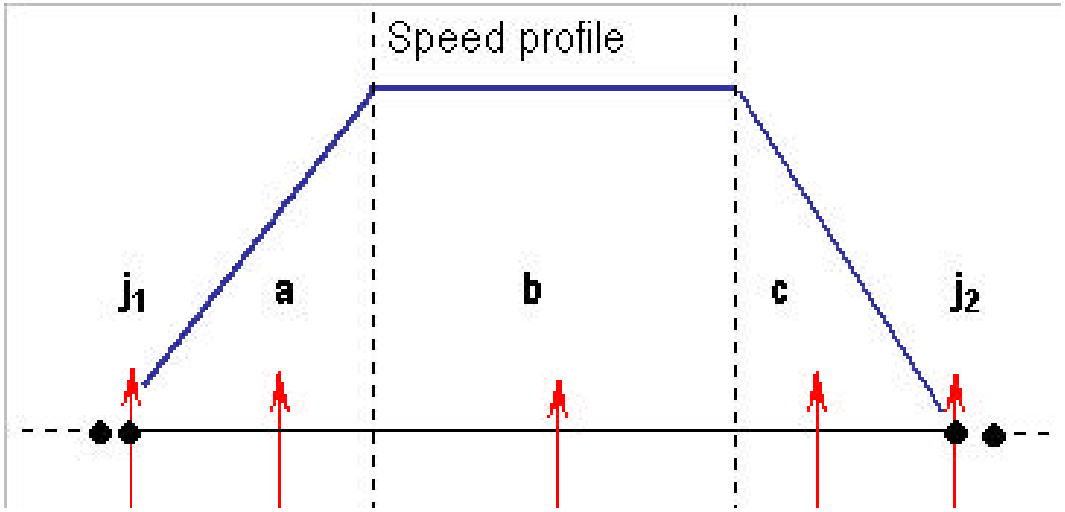
Crossing behavior model



- **Level 1:** Junction or mid-block
- **Level 2.1:** Which junction
- **Level 2.2:** Which interval at mid-block

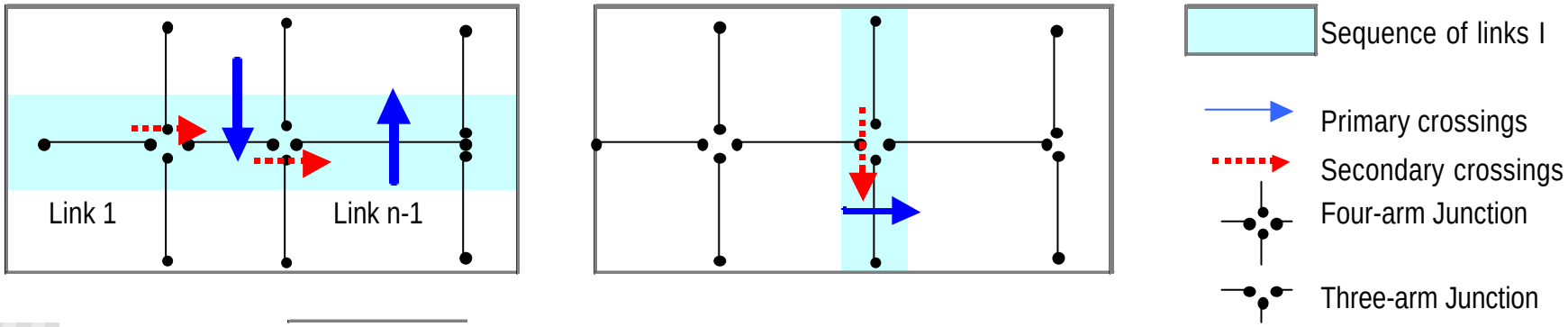
- For a single link or along a trip

Purpose of the analysis

- Express modeling process in an algorithm
- Identify number and location of crossings along a trip
- Calculate crossing probabilities and the related risk along a trip

Symbols and definitions

- Primary and secondary crossings

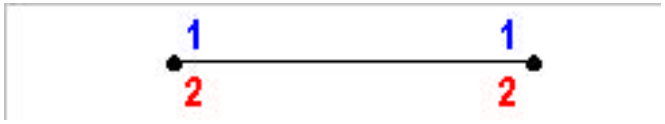


Along a sequence of links on the same direction

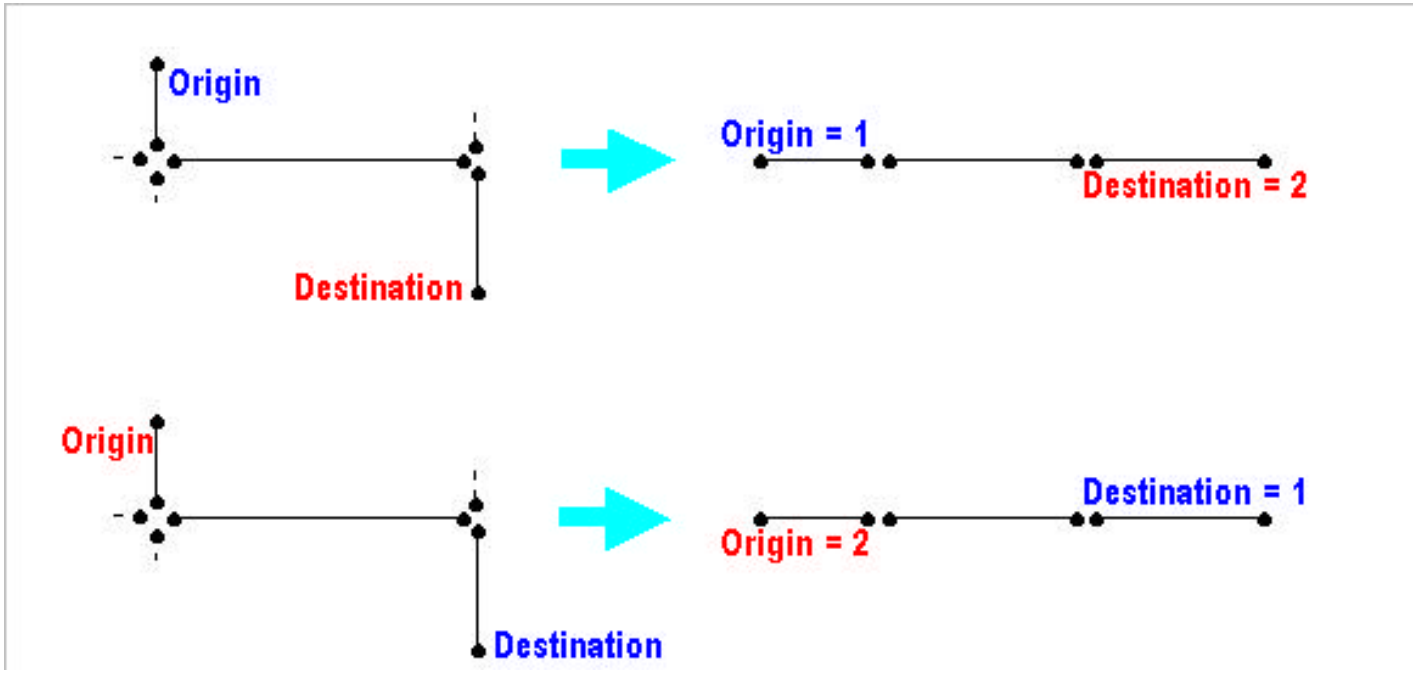
- Crossing probabilities only for primary crossings
- P=1 for secondary crossings

Symbols and definitions

- Position 1: Above the link
  Position 2: Bellow the link



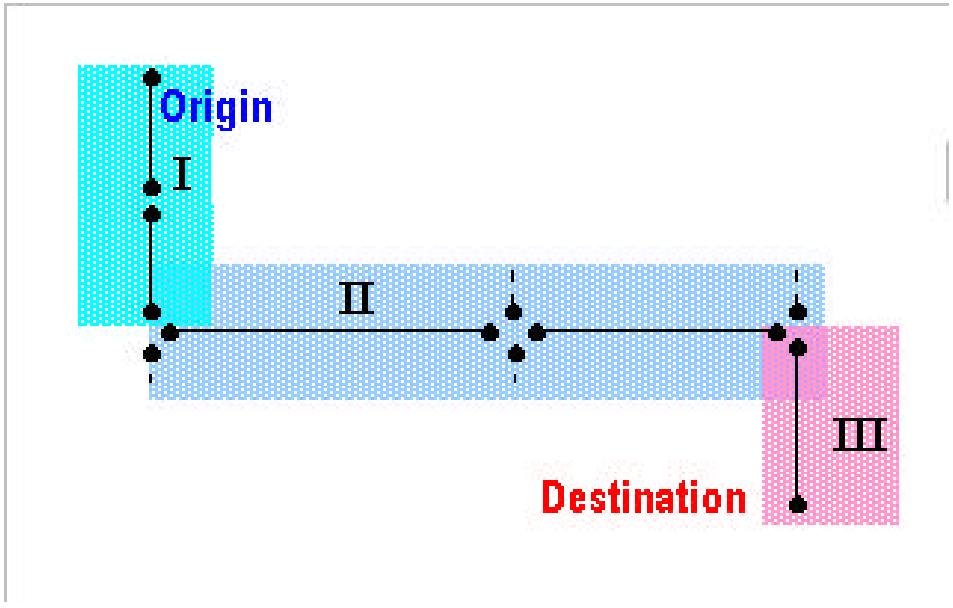
- For a trip: identify position of origin and destination



Symbols and definitions

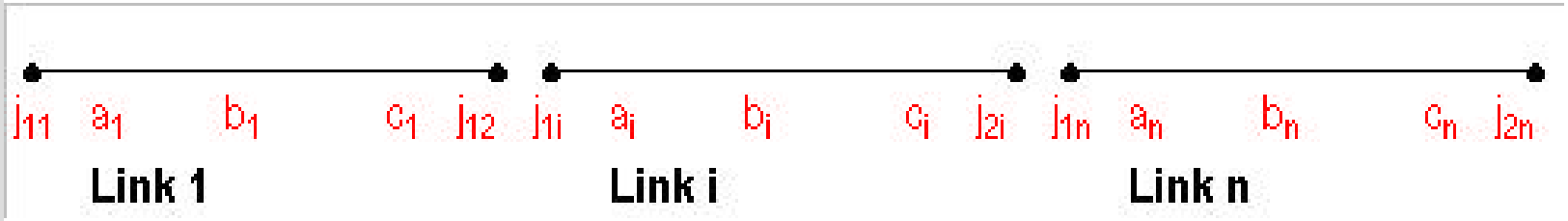
- For a pedestrian trip:

  Identify sequences of links on the same direction

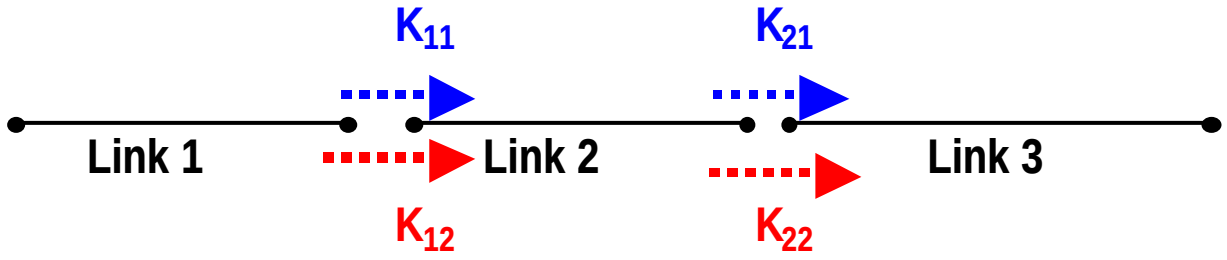


Symbols and definitions

- For a sequence of links I on the same direction
- Primary crossing options ÓP=1

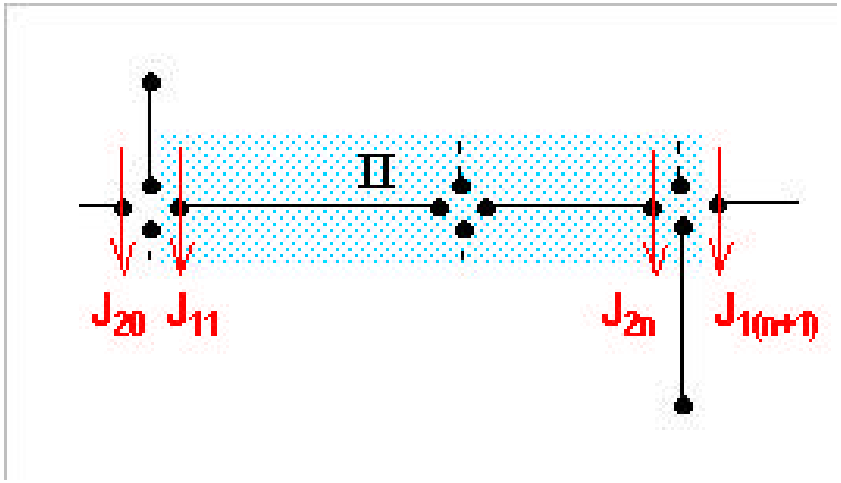


- Secondary crossing options $ÓP_K=1$



Additional crossing options

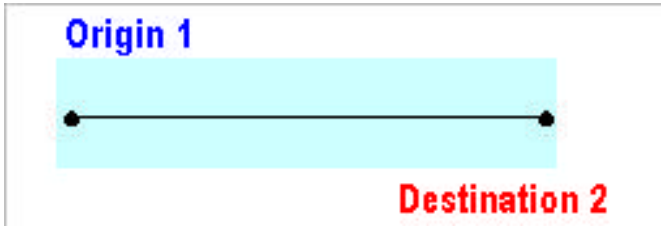
- For a sequence of n links I
- j_{20} : Junction 2 of the last link of sequence I-1
- $j_{1(n+1)}$: Junction 1 of the first link of sequence I+1



Algorithm for number and location of crossings

1. IF no change of direction THEN

1.1

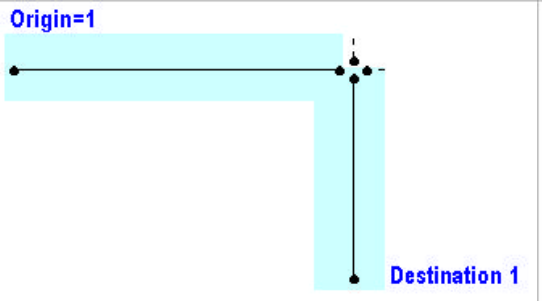


1.2

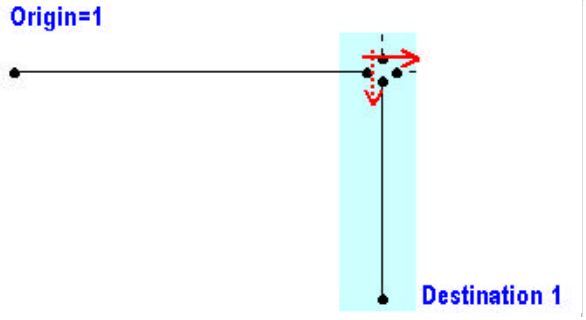
Algorithm for number and location of crossings

2. IF one change of direction THEN

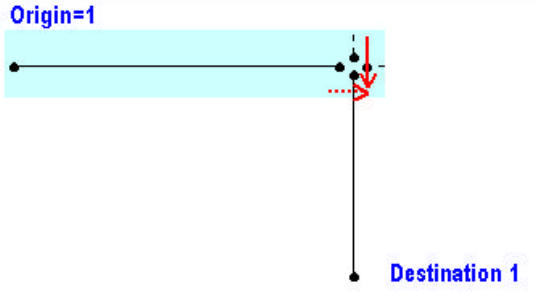
2.1 **A**



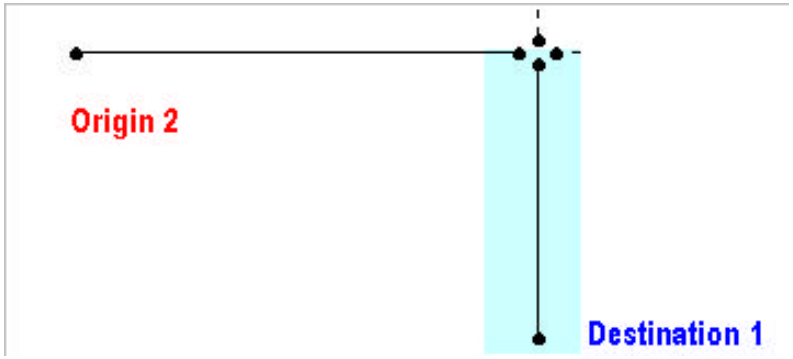
B



C



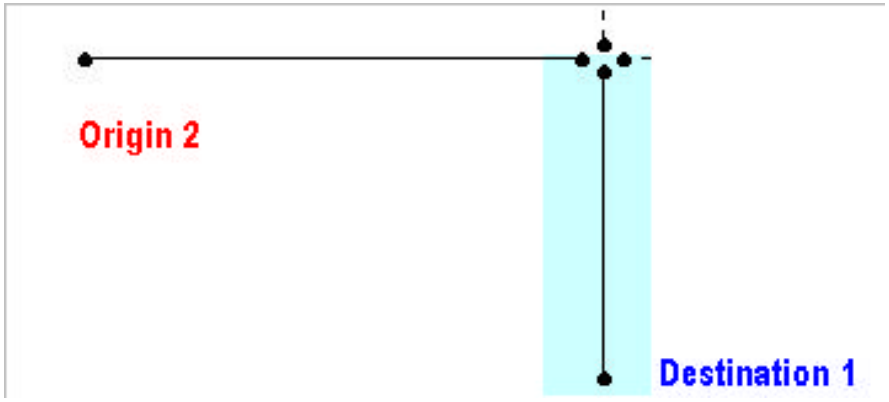
2.2



Algorithm for number and location of crossings

2. IF one change of direction THEN

2.3



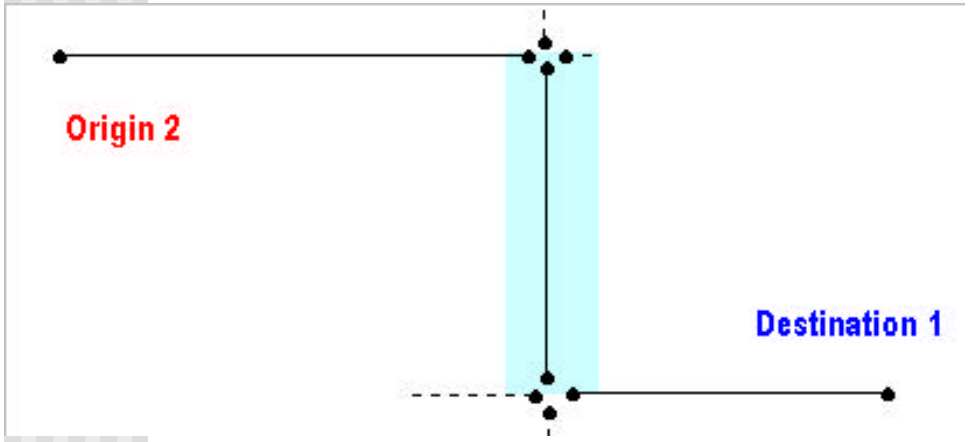
2.4

Algorithm for number and location of crossings

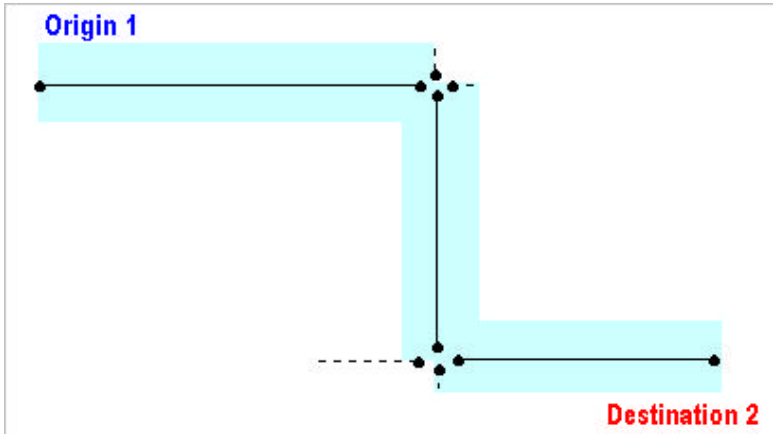
3. IF two changes of direction THEN

3.2 IF Left-Right or Right-Left

3.2.1



3.2.2 .A



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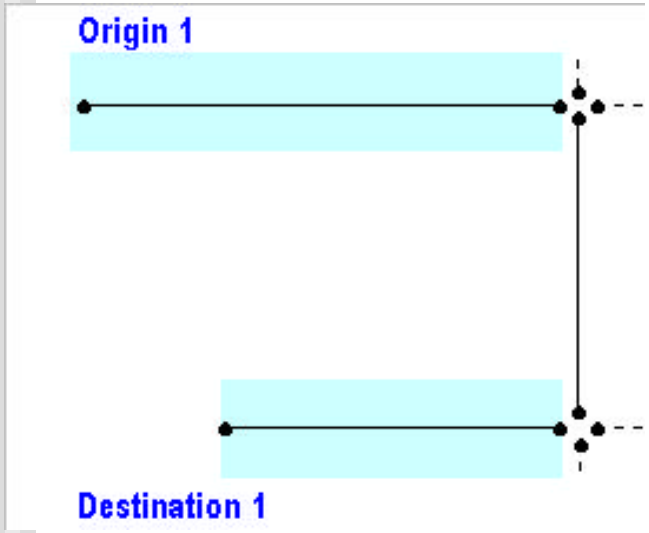
Algorithm for number and location of crossings

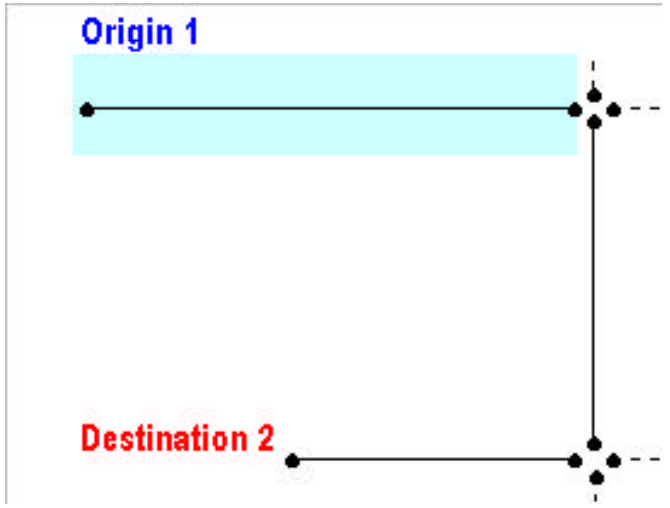
2. IF two changes of direction THEN

2.1 IF Left- Left or Right- Right

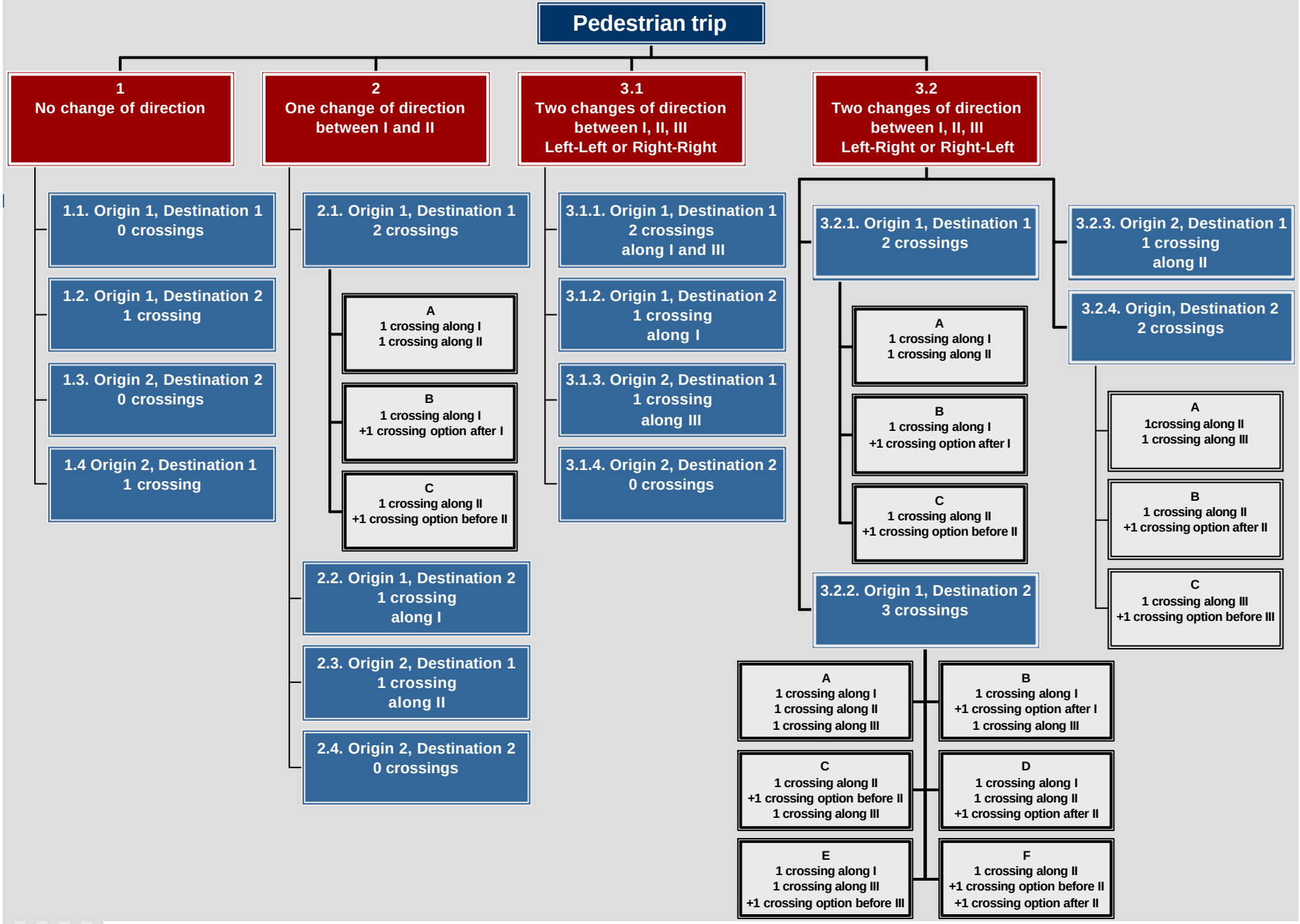
2.1.1



2.1.2



PEDESTRIAN CROSSINGS CONSIDERATION FOR A TRIP



Consideration of primary crossing options

- For each primary crossing on a sequence of n links on the same direction

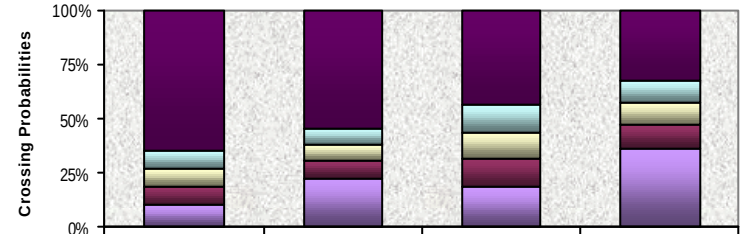
- Junction crossing options $O_J = n * 2$,
  For Level 1 and 2.1: $O \{j_{1i}, j_{2i}\}, i = 1, \ldots, n$
- Mid - block crossing options $O_m = n * 3$
  For Level 1: $O \{B_i, C_i, D_i, F_i\}, i = 1, \ldots, n$
  For Level 2.2: $Om \{a_i, b_i, c_i\}, i = 1, \ldots, n$

- Additional junction options

Models sensitivity

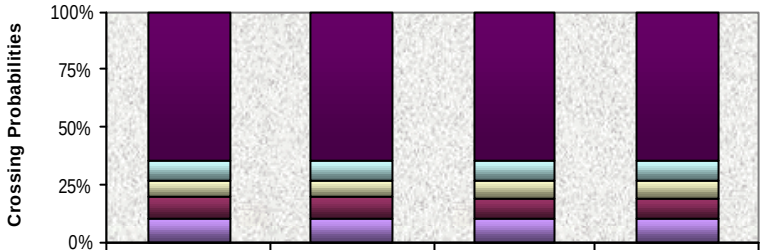
- Examined sensitivity of 15 variables

Sensitivity to Crosswalk



	Junction 1:yes Junction 2:no	Junction 1:yes Junction 2:yes	Junction 1:no Junction 2:no	Junction 1:no Junction 2:yes
Junction 2	64,6%	54,5%	43,4%	32,1%
C	8,6%	7,7%	13,0%	10,6%
B	7,9%	7,0%	12,0%	9,8%
A	8,9%	7,9%	13,4%	10,9%
Junction 1	10,0%	22,9%	18,2%	36,6%

Sensitivity to Cycle Length



	45 sec	60 sec	90 sec	120 sec
Junction 2	64,6%	64,6%	64,6%	64,6%
C	8,8%	8,7%	8,6%	8,6%
B	7,1%	7,6%	7,9%	8,1%
A	9,5%	9,1%	8,9%	8,8%
Junction 1	10,0%	10,0%	10,0%	10,0%

- Finally selected 6 variables

Level 1: Junction or mid block
Level 2.1: Which Junction

- Nested Logit Model

Variable	**Definition**	**Coeff**	B	C	D	F	**J**	**M**	J1	J2
Constant	1	1,0000	2,2079		1,7266	1,3875	2,2332			
Walking distance	m	-0,0112	•	•	•	•			•	•
Crossing distance	m	-0,0089	•	•	•	•			•	•
Start + end MB	1, 0	1,5722						•		
Start MB - end I	1, 0	0,8415						•		
Traffic volume	veh/h	-0,0003	•	•	•	•				
Crosswalk	1, 0	1,0002	•	•	•	•			•	•
Traffic signal	1, 0	0,7502							•	•
Pedestrian signal	1, 0	1,2350							•	•
Voj		0,7585					•			
Vom		0,8342						•		

Level 2.2: Which interval at mid-block

- Level-of-service model

Variable	Definition	Coeff
Constant	1	-2,4778
Nears Traffic Vol	1000 veh/h	-0,1159
Fars Traffic Vol	1000 veh/h	0,2674
Speed	km/h	0,0067
Nears Cros Width	m	-0,2795
Fars Cros width	m	0,4072
Crosswalk	1, 0	-0,2762
Pedestrian signal	1, 0	-0,4930
Signal spacing	m	0,0023

Calculation of primary crossing probabilities

- Nested Logit Model
- Calculate Utilities
  U_o = Ó(variable*coefficient)
- Calculate Inclusive values
  Vo=Ln Ó(e^{Uo})
- Calculate marginal probabilities for “junction or mid-block”
  $P_m = e^{Uo}/e^{Vo}$
- Calculate conditional probabilities for “which junction”
  $Pji = e^{Uji}/e^{Vji}$

Calculation of primary crossing probabilities

- Level-of-service model
- Calculation of crossing difficulty at mid-block
  Do= Ó(variable*coefficient)
- Calculation of relative crossing difficulties RDo in relation to a difficulty of reference RDr
- Calculation of crossing probability of reference Pr
- Conditional crossing probabilities for “which interval at mid-block”
  Po = RDo*Pr

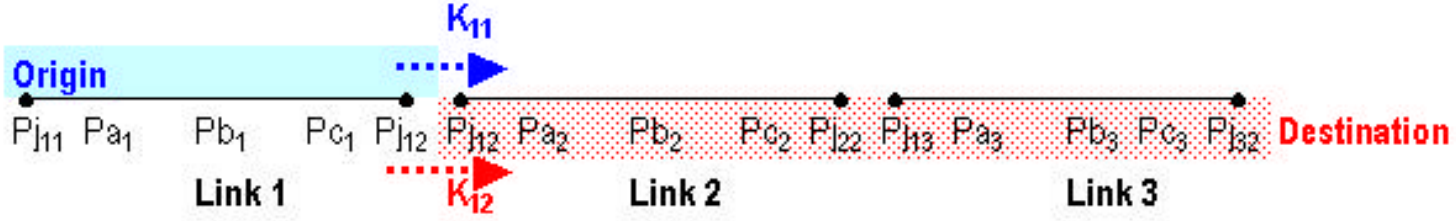
Calculation of primary crossing probabilities

- Final Probabilities =

  (Marginal Probabilities)*(Conditional Probabilities)

Calculation of secondary crossing probabilities

- The side of a secondary crossing depends on whether the primary crossing has been made or not



- $PK_{11} + PK_{12} = 1$

- $PK_{11} = ÓP_{after}$
- $PK_{12} = ÓP_{before}$

Calculation of accident risk along a trip

- P_{oi} the primary crossings probabilities o $\{j_{1i}, a_i, b_i, c_i, j_{2i}\}$, $i=1,..,n$
- $PK_{i(1,2)} = 1$ the secondary crossings probabilities
  (1,2) refers to side of the road
- R_{oi} the risk of a primary crossing option
- $RK_{i(1,2)}$ the risk of a secondary crossing

$$R_{trip} = \sum_{i=1}^{n} (Poi * Roi) + \sum_{i=1}^{n} \left[(\sum_{1}^{i} Poi) * RKi(2,1) + (\sum_{i+1} Poi) * RKi(1,2) \right]$$

Summary

- An algorithm for the estimation of type, number and location of crossings along a trip
- A modeling process providing crossing probabilities for various locations along a trip
- Calculation of accident risk along a trip in relation to crossing behavior

Summary

- A complete and coherent approach to modeling crossing behavior and accident risk
- Models validation within the cities case-studies could allow for further improvement