ISTTT Tutorial

TRANSPORT PLANNING

THE UNIVERSITY OF SYDNEY
BUSINESS SCHOOL

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ITLS Sydney

OVERVIEW

1. Introduction
2. Transport model system
3. Data
4. Travel behaviour
5. Trip choice
6. Destination choice
7. Mode choice
8. Departure time choice
9. Route choice
10. Traffic simulation
11. Where is the field going?

INTRODUCTION

1

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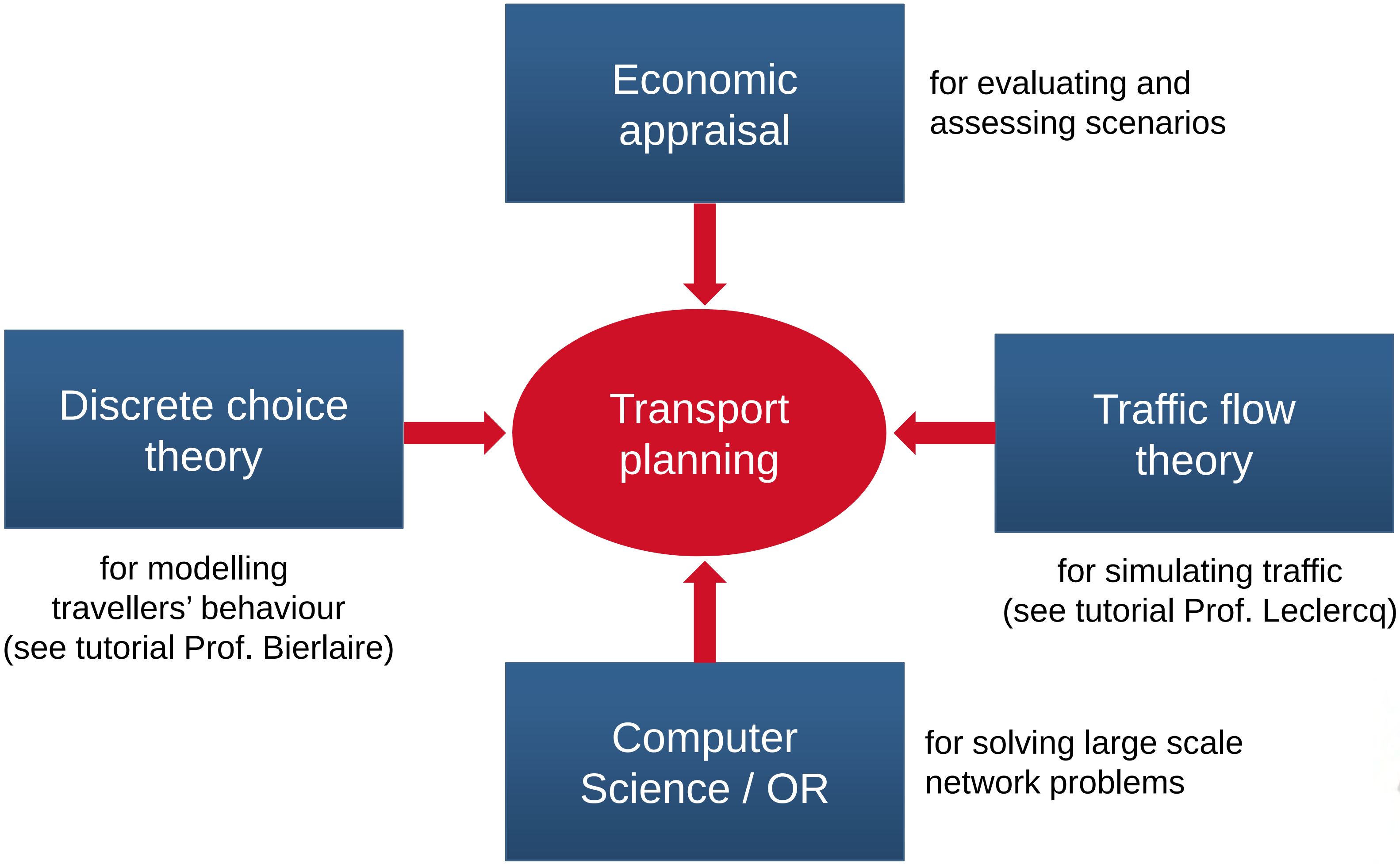
What is transport planning?

INTRODUCTION

Recommended reading

› Ortúzar, J.de D., and Willumsen, L.G. (2011) *Modelling Transport*, 4^{th} edition, Wiley.

Multi-disciplinary



Strategic transport planning

- This tutorial will focus on strategic (long term) transport planning models
- Used for infrastructure decisions:
  - Forecasting effects of building a new road or extending current roads
  - Forecasting effects of new public transport services
- Used for demand and mobility management:
  - Forecasting effects of introducing road pricing
  - Forecasting effects of parking regimes
- Used for traffic management:
  - Forecasting effects of ramp metering
  - Forecasting Effects of route guidance

Economic appraisal

› Cost-benefit analysis

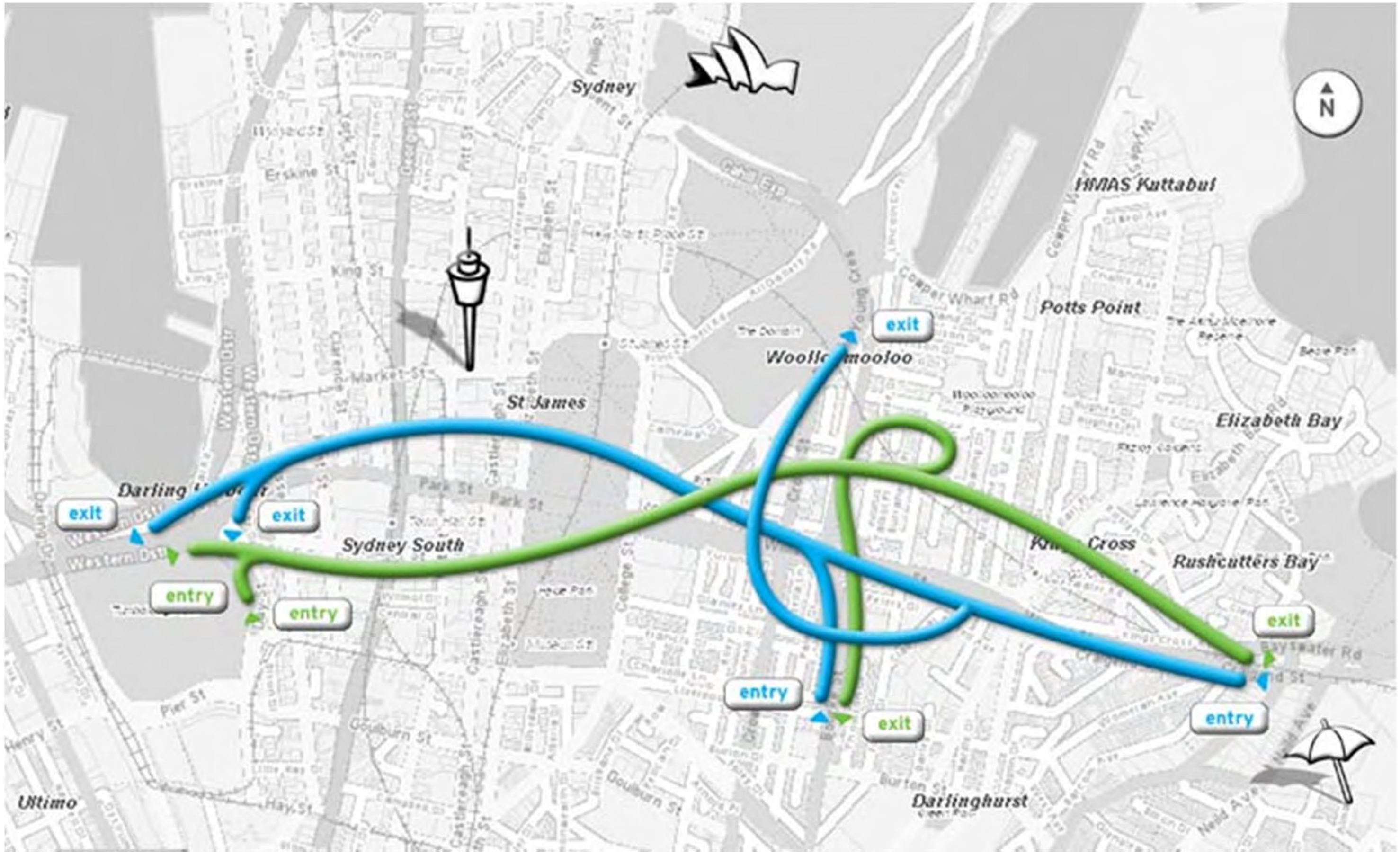
› Environmental impact assessment

› Projects are evaluated based on costs and benefits, e.g.

- Construction costs
- Maintenance costs
- Toll revenues
- Travel times
- Travel time reliability
- Health impacts (noise, emissions of NO_x and PM_{10})
- Climate impacts (emissions of CO_2)
- Employment impacts
- Safety impacts
- Agglomeration impacts

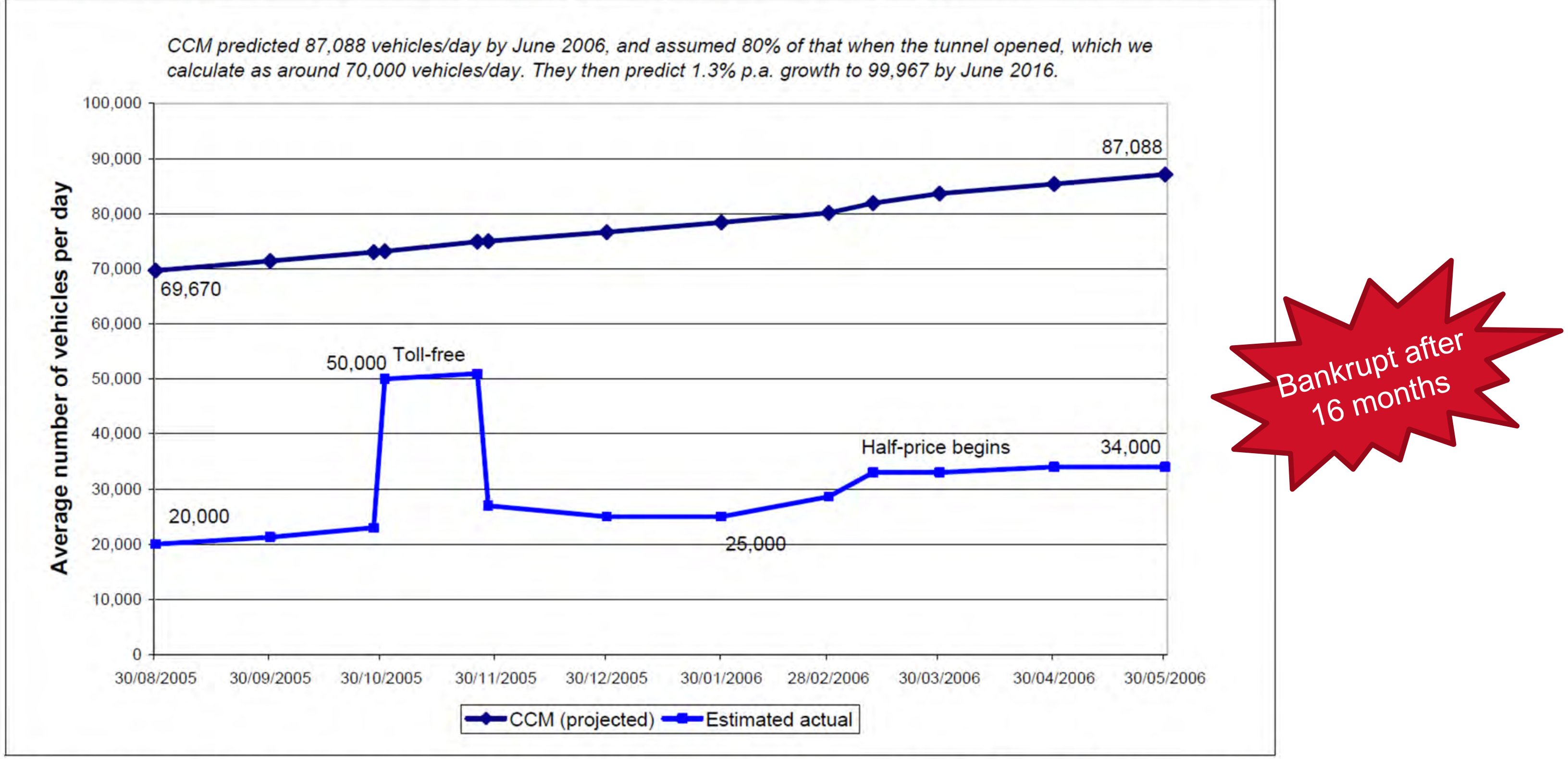
Why good forecasting models are important…

Sydney Cross City Tunnel (completed 2005, costs: $680mln)



Why good forecasting models are important…

Exhibit 2.5: Estimated actual patronage compared to CCM's projections - nine months



Source: Audit Office research. Information on CCM projected patronage obtained from RTA documents. Estimated actual patronage based on research plus CCM statements where available.

Tools

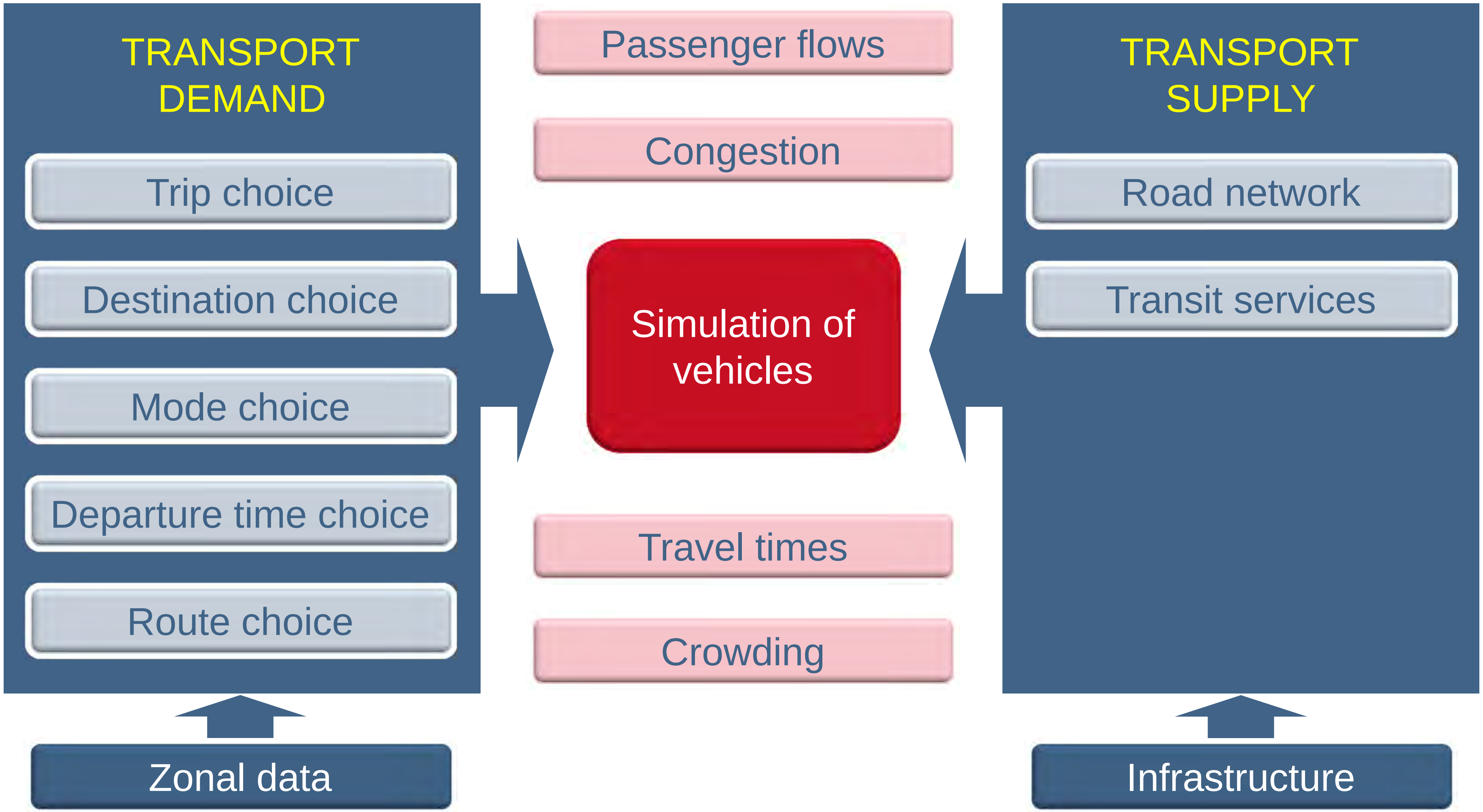
› A lot of software exists for strategic transport planning purposes, such as
  - TransCAD (USA)
  - OmniTRANS (The Netherlands)
  - VISUM (Germany)
  - Cube (UK)
  - EMME (Canada)

› In addition, microscopic traffic simulation software exists, such as
  - VISSIM (Germany)
  - Paramics (UK)
  - AIMSUN (Spain)

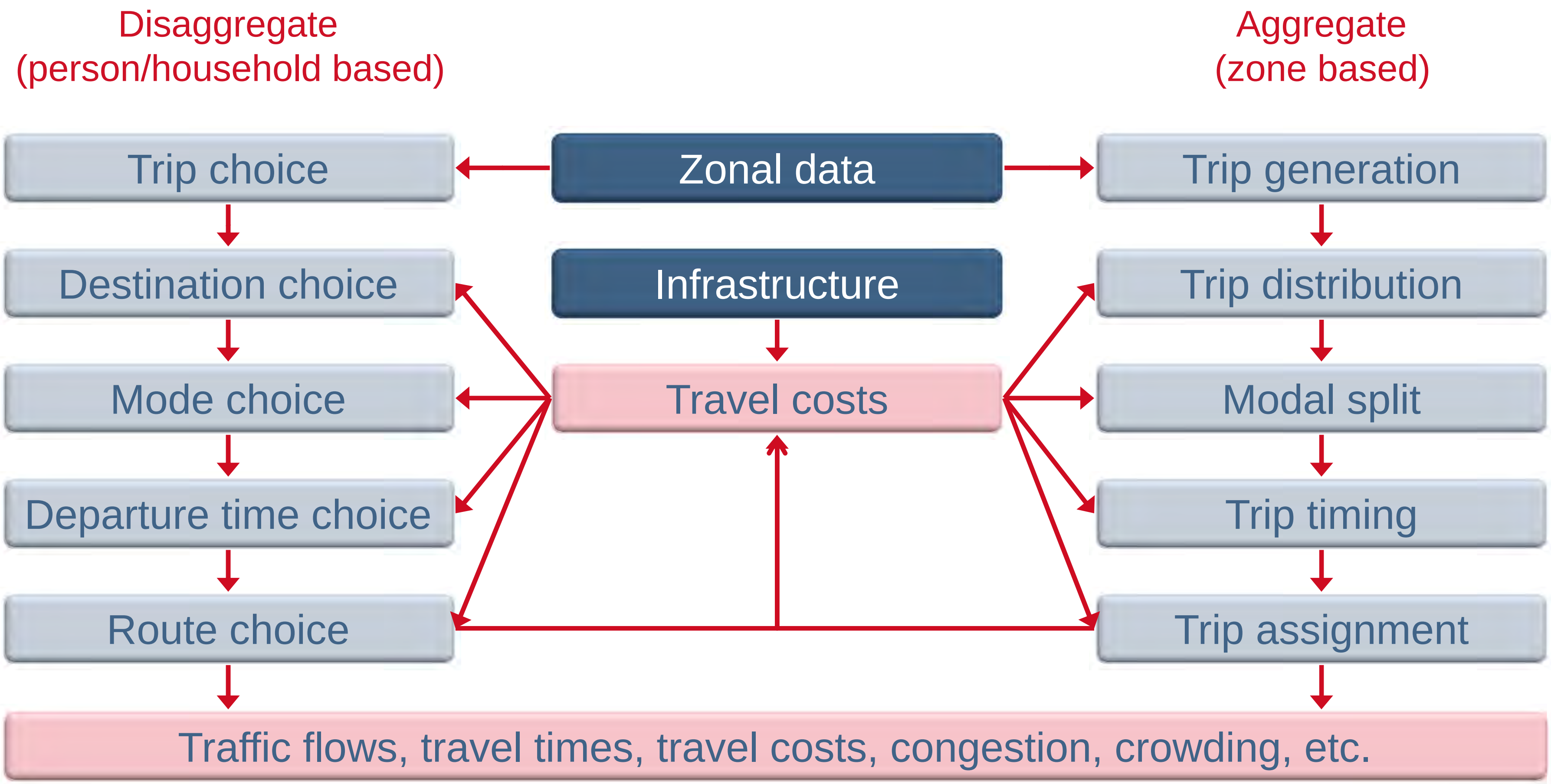
TRANSPORT MODEL SYSTEM

2

TRANSPORT MODEL SYSTEM



Aggregate vs. disaggregate modelling



TRANSPORT MODEL SYSTEM

1. trip choice	Do I want to go shopping?
2. destination choice	Where shall I go shopping?
3. mode choice	Do I take the car or bus?
4. depart. time choice	When do I depart?
5. route choice	Do I go through the city centre?

› Each step can be described by a different (behavioural) mathematical model

DATA

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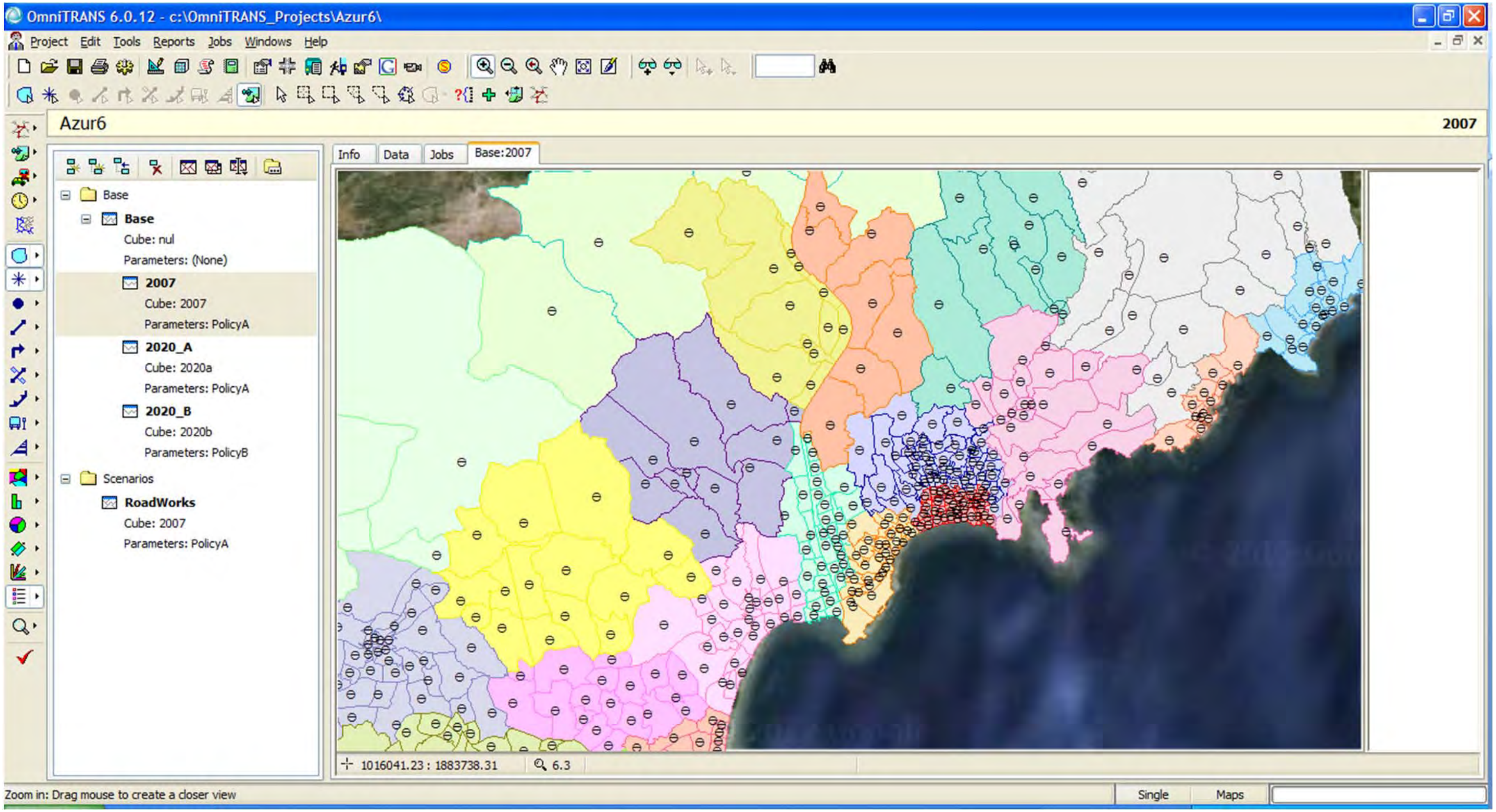
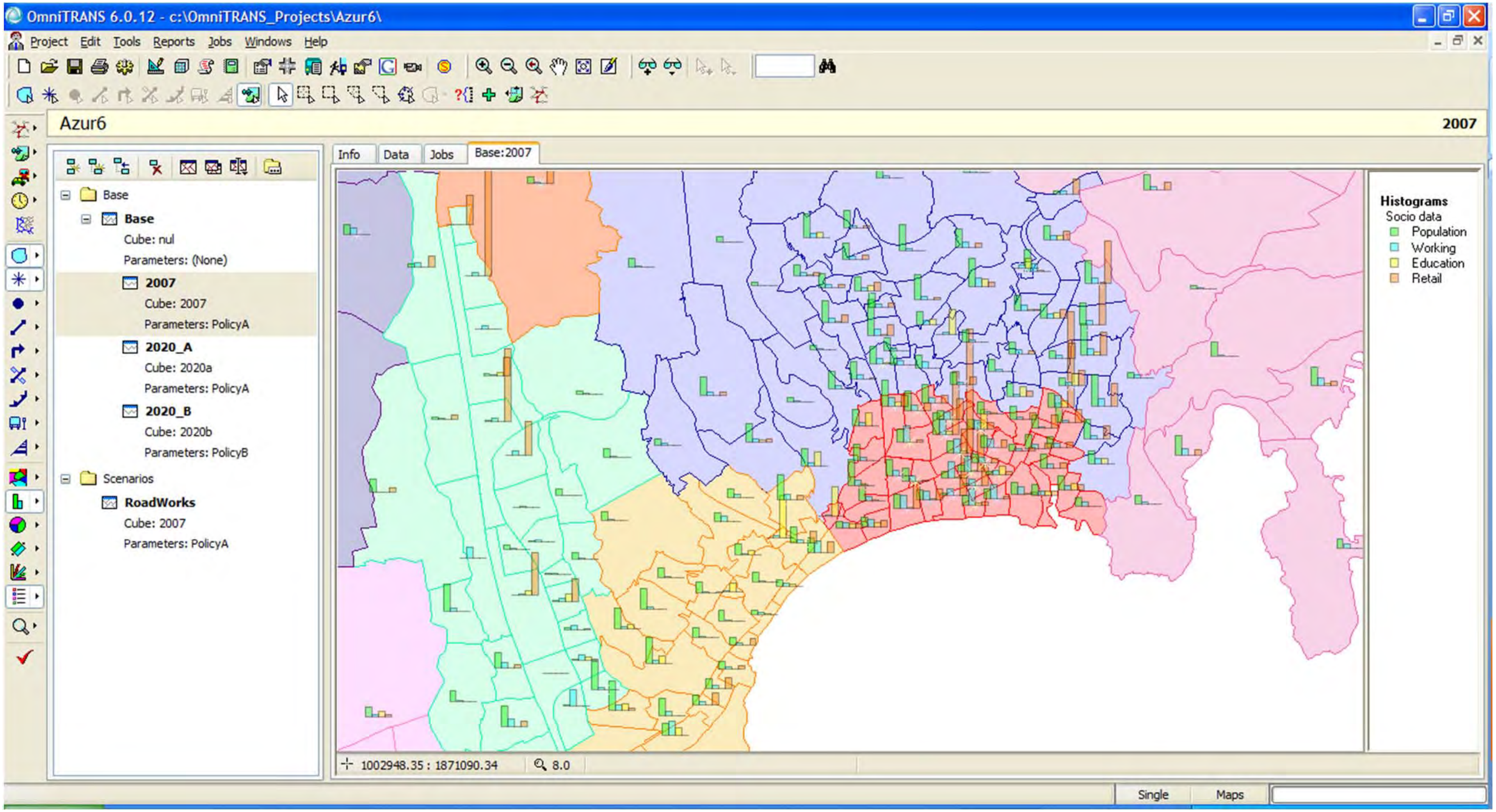
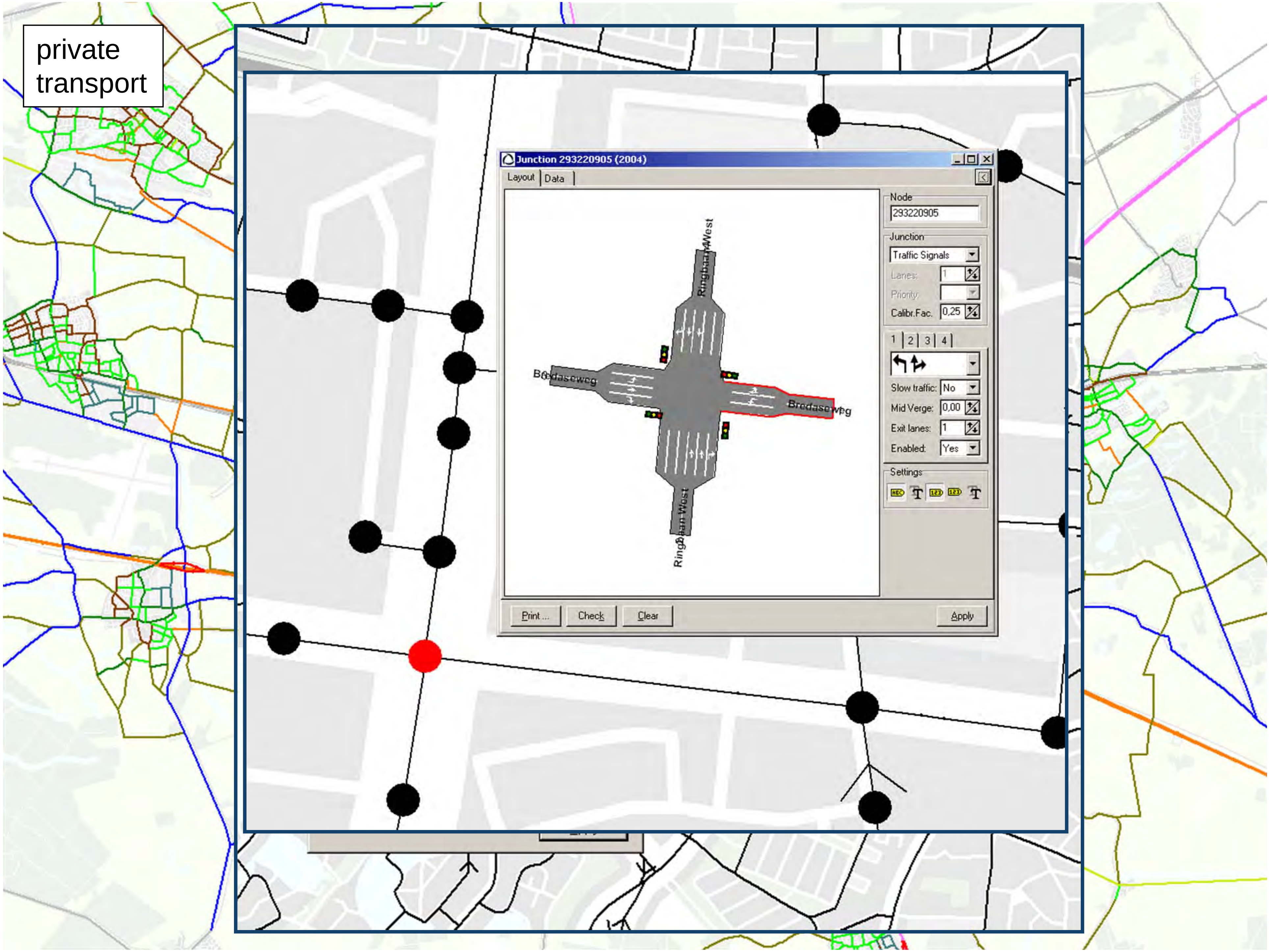
Zones and centroids



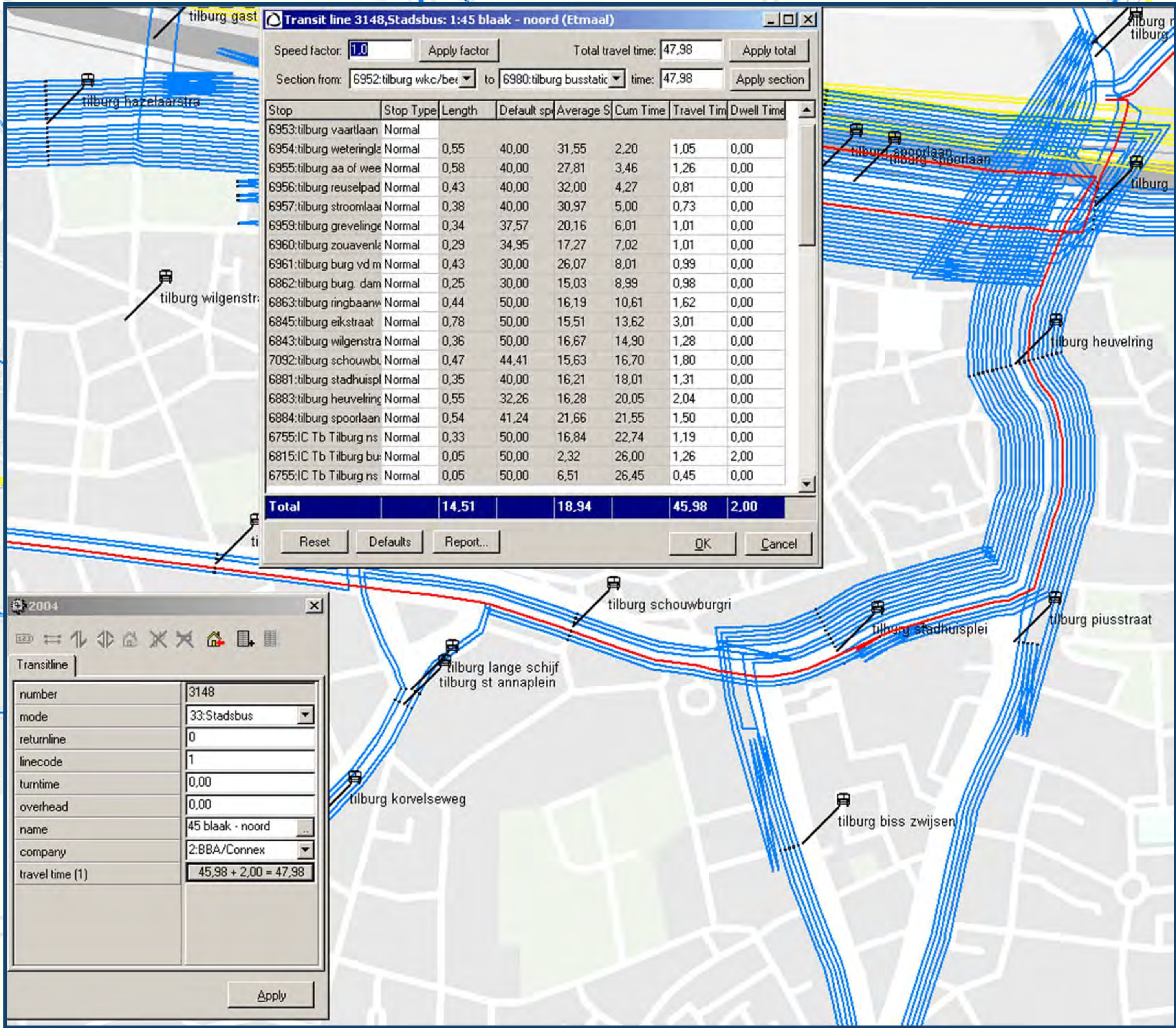
Zonal data (residents, jobs, education, retail)

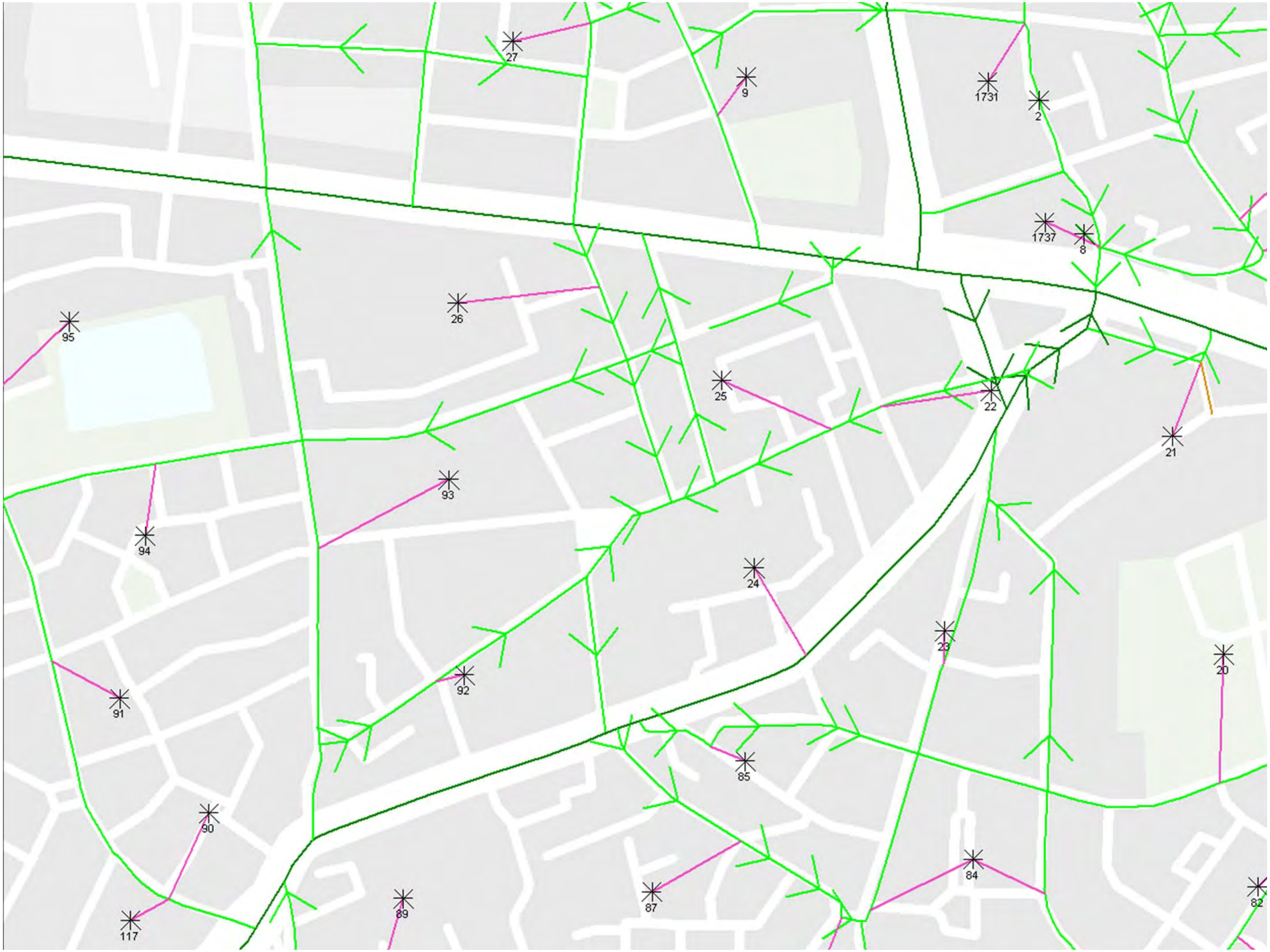


private transport



public transport

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DATA

Household travel surveys

SECTION A: PERSON DETAILS

→ SHOWCARD 2
Q1 Before asking you about your travel, which of these activities apply to you at the moment? More than one category can apply.

Student: Full-time ☐ 1
Part-time ☐ 2
Work: Full-time ☐ 3
Part-time ☐ 4
Casual ☐ 5
Unpaid voluntary work ☐ 6
Unemployed and looking for work ☐ 7
Keeping house ☐ 8
Aged pensioner ☐ 9
Other pensioner ☐ 10
Retired ☐ 11
Other (SPECIFY) ____ ☐ 98

Q2 CHECK Q1: IS THE RESPONDENT A STUDENT? (Q1 CODED 1 OR 2)
YES ☐ 1
NO ☐ 2 → Q6

Q3 What school or educational institution do you attend?
Name: ____
And what is the address?
PRINT FULL DETAILS OF ADDRESS
Street Name: ____
Suburb: ____
Cnr/Opp/Nr Street: ____ (Circle One)
Building Name: ____

RECORD AUTOM
Q4 Is it a secondary ... a university or sc
Secondary school
TAFE/Other Colleg
University
Other (SPECIFY)

Q5 Is it government
Government
Private

Q6 CHECK Q1: DOES THE RESP (Q1 CODED 3, 4,
YES
NO

Q7 Do you have mor
Yes
No

Q8 I'd now like to as main job, that is t usually work the

Q9 What is your occ
PROBE FULLY

Q10 What are the mai your (main) job?
PROBE FULLY

SECTION B: TRIP DETAILS

Q28 I'm now going to ask about your travel on Travel Day. That is from 4am on (SPECIFY TRAVEL DAY) till 4am on (SPECIFY FOLLOWING DAY).
By travel I mean, for example, walking to a friend's place, catching a bus or anytime you left the house, say, to buy a newspaper.

Q29 IS THE COMPLETED MEMORY JOGGER BEING USED?
YES ☐ 1
NO ☐ 2

Q30 Did you go anywhere at all on your Travel Day?
Yes ☐ 1 → Q32
No ☐ 2

Q31 Don't forget that this includes even walking down the street to buy a newspaper or some milk, or visiting friends. Did you go anywhere at all on your Travel Day?
Yes ☐ 1
No ☐ 2

Q32 Were you home at 4 o'clock in the morning on (SPECIFY TRAVEL DAY)?
Yes ☐ 1 → Q36
No ☐ 2

Q33 Where were you at 4 o'clock in the morning on (SPECIFY TRAVEL DAY)? (If in transit, please describe the previous stop)
Main job address ☐ 1 → Q36
Other job address ☐ 2
Social/Recreational ☐ 3
Hospital/Medical ☐ 4
Public accommodation (e.g. hotel/motel) ☐ 5
Transport interchange ☐ 6
Other private dwelling ☐ 7
Other (SPECIFY) ☐ 8

Q34 What is the address of this place? (If in transit, what is the address of the previous stop?) PRINT FULL DETAILS OF ADDRESS
INSIDE STUDY REGION
Street No: ____
Street Name: ____
Suburb: ____
Cnr/Opp/Nr Street: ____ (Circle One)
Building Name: ____
Employer's Name: ____ (If Q33 = 2 "Other job address")
OUTSIDE STUDY REGION
Suburb/Town: ____
State: ____
Postcode: ____
Overseas: ____

Q35 Did you return to the area covered by the map any stage during Travel Day?
SHOW MAP
Yes ☐ 1
No ☐ 2 →

Q36 CHECK: DID THE RESPONDENT GO ANYWHE AT ALL ON TRAVEL DAY? (Q30 CODED 1 OR Q31 CODED 1)
YES ☐ 1
NO ☐ 2 →

Q37 CHECK Q9 AND Q10: IS THE RESPONDENT IN THE SPECIAL OCCUPATION GROUP?
YES ☐ 1
→ DON'T COLLECT WORK TRIP DATA
NO ☐ 2
Office

SECTION C: DEMOGRAPHICS

→ SHOWCARD 8
Q72 Looking at Card 8, what is your personal Gross Income? That is, before tax or anything else is taken out.

			Code
A.	Negative income		1
B.	Nil income		2
C.	$1-$149 /week	$1-$7,799 /year	3
D.	$150-$249 /week	$7,800-$12,999 /year	4
E.	$250-$399 /week	$13,000-$20,799 /year	5
F.	$400-$599 /week	$20,800-$31,199 /year	6
G.	$600-$799 /week	$31,200-$41,599 /year	7
H.	$800-$999 /week	$41,600-$51,999 /year	8
I.	$1,000-$1,299 /week	$52,000-$67,599 /year	9
J.	$1,300-$1,599 /week	$67,600-$83,199 /year	10
K.	$1,600-$1,999 /week	$83,200-$103,999 /year	11
L.	$2,000 or more/week	$104,000 or more/year	12

Q73 Do you currently hold a licence to drive ....?
(a) A Car — Yes: Full ☐ 1, Provisional ☐ 2, Learners ☐ 3; No ☐ 4
(b) A Motorcycle — Yes: Full ☐ 5, Provisional ☐ 6, Learners ☐ 7; No ☐ 8
(c) A Truck — Yes: Full ☐ 9, Provisional ☐ 10, Learners ☐ 11; No ☐ 12
(d) Other (SPECIFY) ☐ 98

Q74 CHECK Q73: DOES RESPONDENT CURRENTLY HOLD A DRIVER'S LICENCE?
YES ☐ 1 → Q76
NO ☐ 2

Q75 Why didn't you hold a driver's licence on Travel Day?
No car available ☐ 1
Not yet applied ☐ 2
Under age ☐ 3
Advanced age ☐ 4
Medical condition ☐ 5
Physical condition ☐ 6
Licence suspended/cancelled ☐ 7
Not interested in having a licence ☐ 8
Other (SPECIFY) ☐ 98

Q76 On (SPECIFY TRAVEL DAY) did you have any difficulty using any form of transport, including walking, because of a physical condition or disability?
PROMPT: This could be a short or long term condition
Yes ☐ 1
No ☐ 2 → Q79

→ SHOWCARD 9
Q77 Looking at Card 9, on (SPECIFY TRAVEL DAY) were you unable to use any of these because of this condition? That is, you couldn't use them at all.
TICK CODES IN COLUMN Q77 BELOW

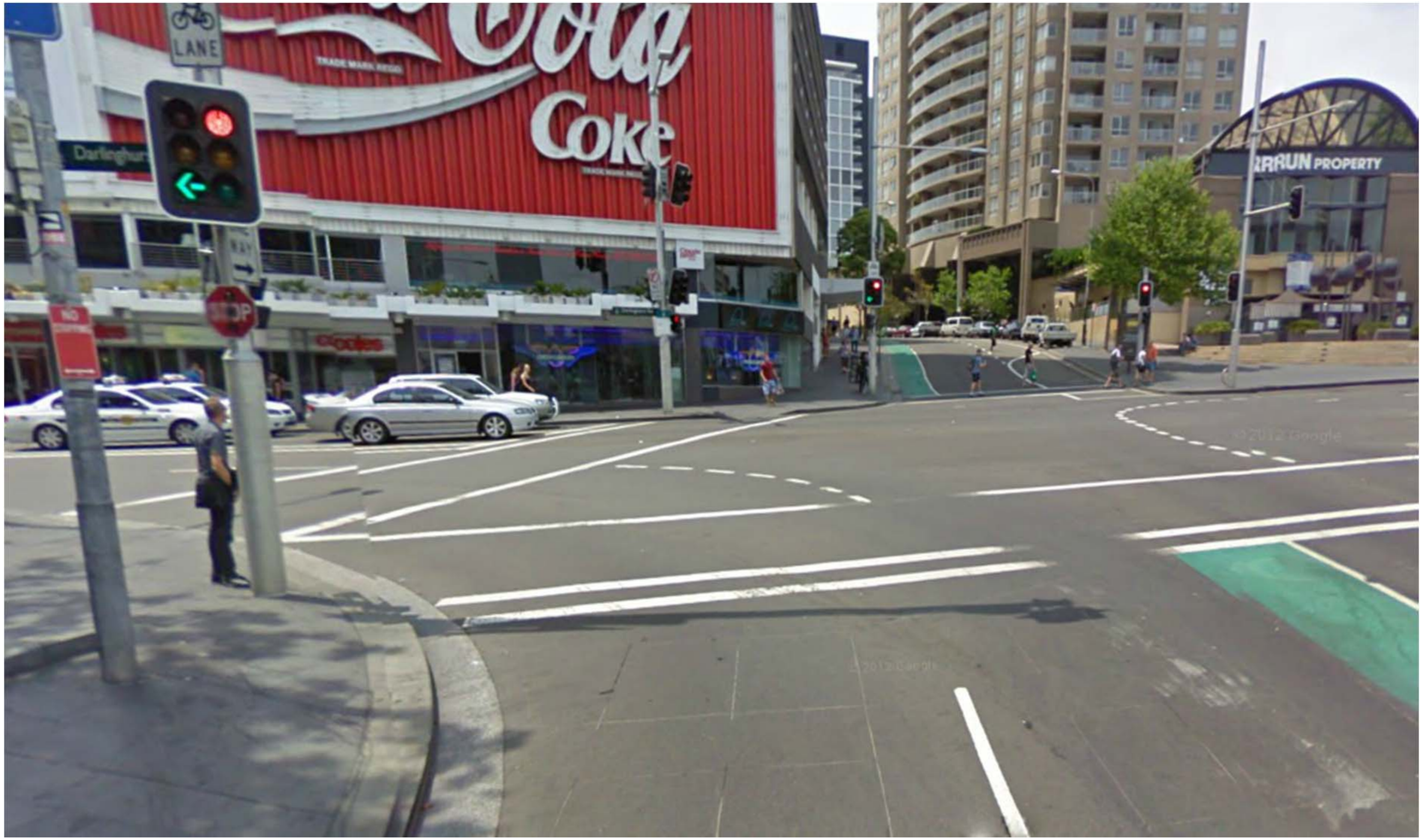
Q78 Still looking at Card 9, on (SPECIFY TRAVEL DAY) were you restricted from using any of these? That is, you couldn't use them as often as you wanted because of your physical condition.
TICK CODES IN COLUMN Q78 BELOW

	Q77 Prevented	Q78 Restricted
Walking	☐ 1	☐ 1
Car or motorcycle (unmodified) – as driver	☐ 2	☐ 2
– as passenger	☐ 3	☐ 3
Bicycle	☐ 4	☐ 4
Public Transport: Train	☐ 5	☐ 5
Bus	☐ 6	☐ 6
School Bus	☐ 7	☐ 7
Ferry	☐ 8	☐ 8
Monorail	☐ 9	☐ 9
Light rail	☐ 10	☐ 10
Taxi (unmodified)	☐ 11	☐ 11
Aircraft	☐ 12	☐ 12
None of these	☐ 13	☐ 13

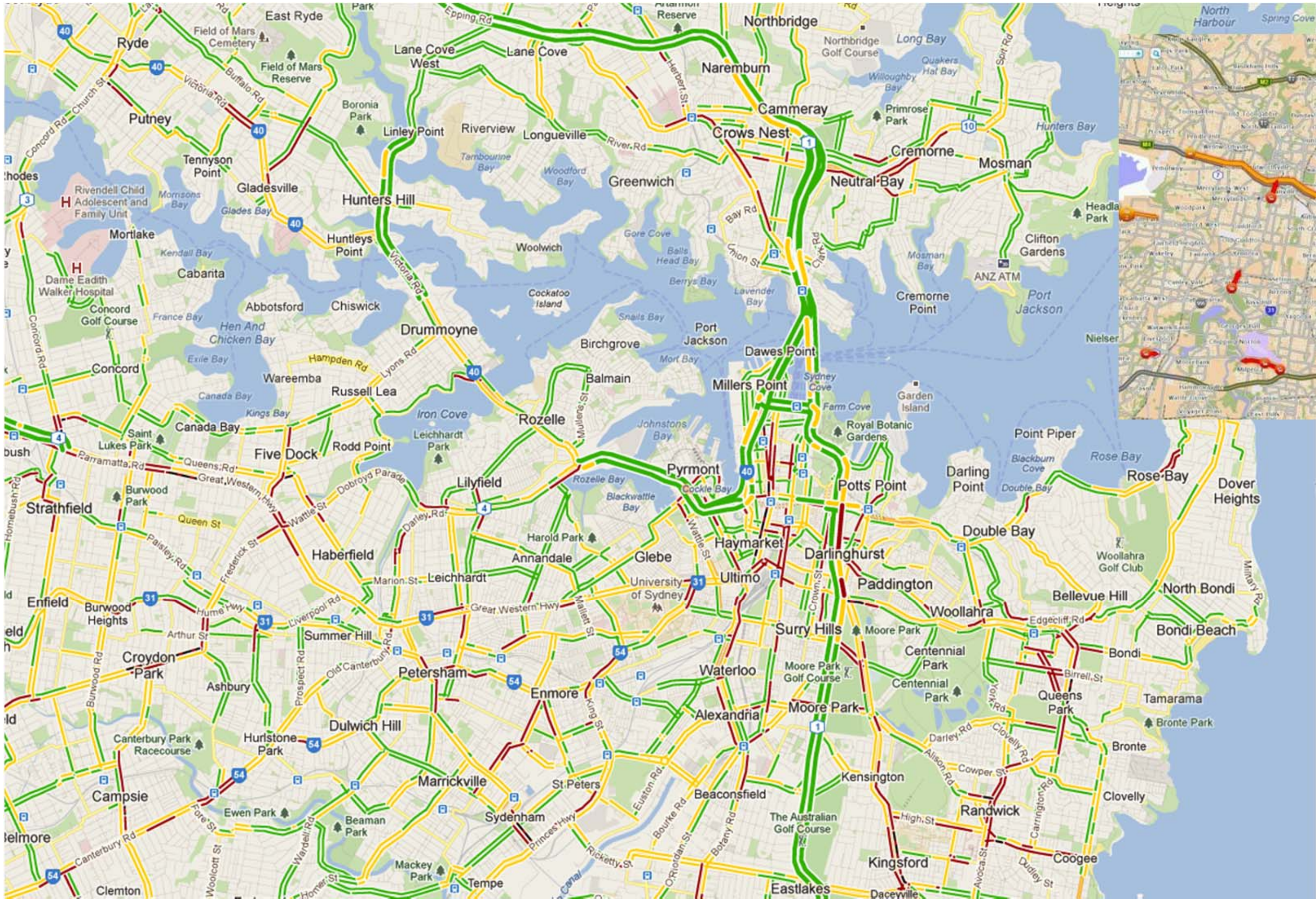
Q79 CHECK Q25: IS THIS INTERVIEW BEING CONDUCTED BY PROXY? (Q25 CODED 1)
YES ☐ 1 → Q90
NO ☐ 2

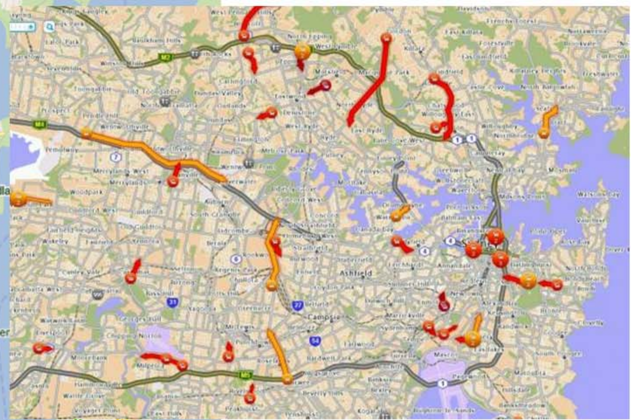
Traffic counts (from induction loop detectors) I

Traffic counts (from induction loop detectors) II



Speeds and travel times (from TomTom, Navteq, Google)





BEHAVIOUR

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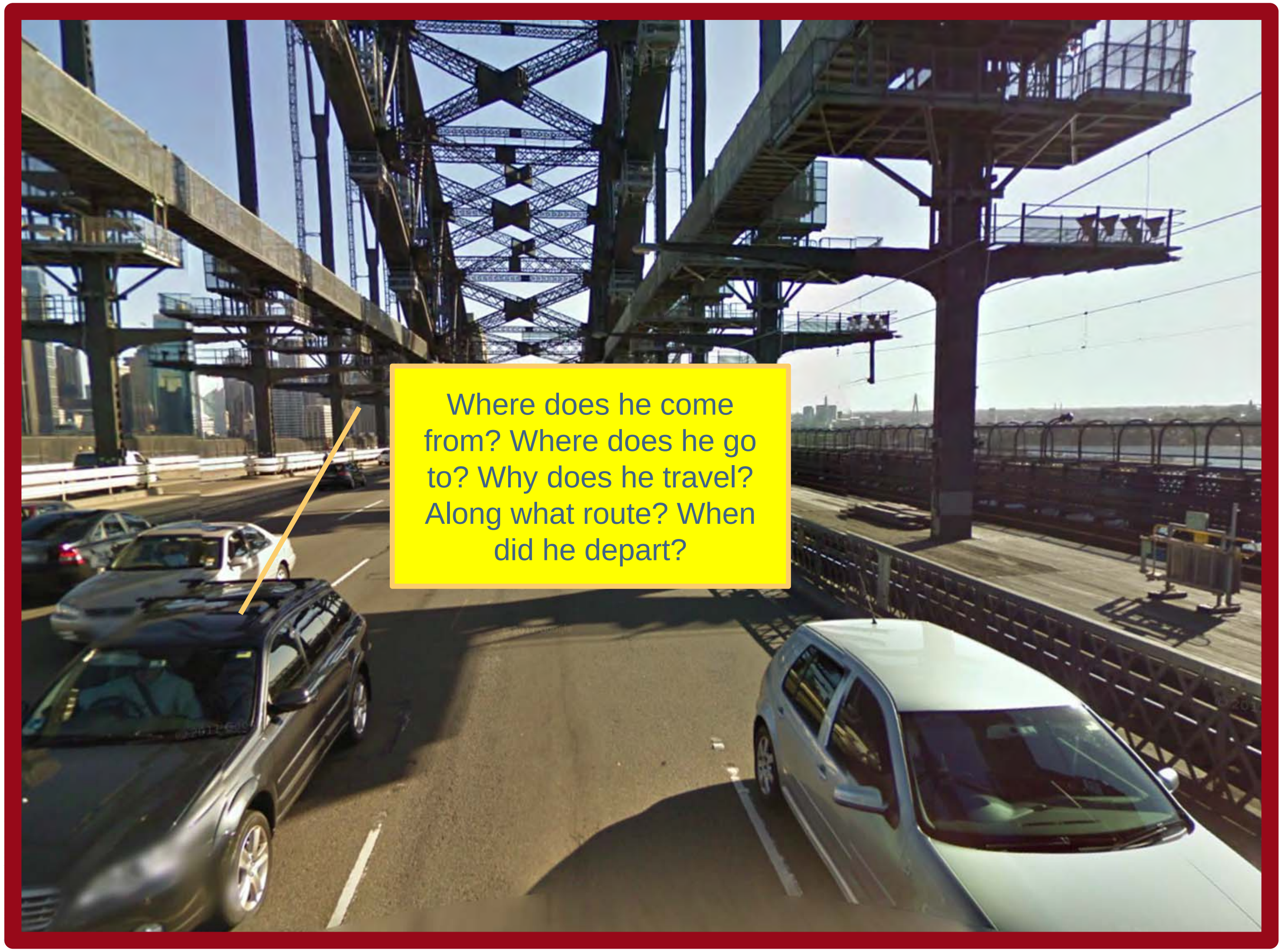
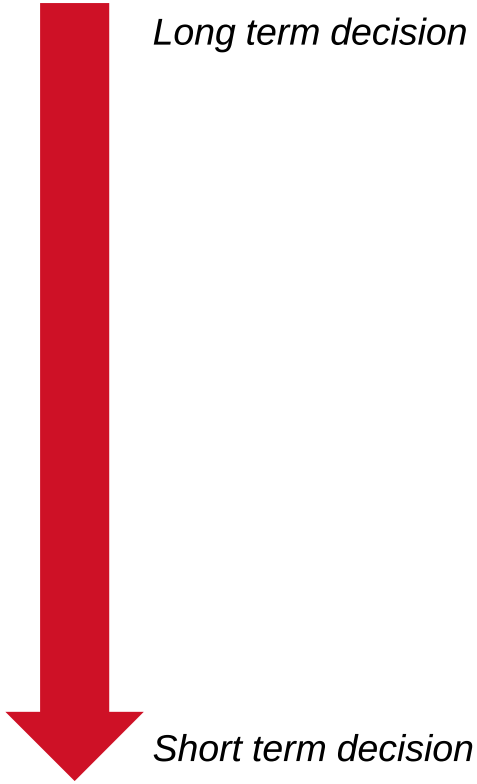
What are we modelling?



Travel behaviour

› People make choices that affect travel:
  - Residential location choice (where do I want to live?)
  - Work location choice (where do I want to work?)
  - Car ownership choice (do I want to own a car?)
  - Activity choice (what do I want to do?)
  - Trip choice (do I make a trip?)
  - Destination choice (where do I want to go?)
  - Mode choice (how I do I travel?)
  - Route choice (along which route do I travel?)
  - Departure time choice (when do I depart?)
  - Speed choice (how fast do I want to drive?)
  - …



OD matrices I

› The aim of demand models is to capture travel behaviour and determine origin-destination (OD) matrices, which describe the number of trips from origin zone to destination zone

› There exists a separate OD matrix for each

- Trip purpose
- Mode
- Time period
- User group

› Example: there are 50 trips from zone 2 to zone 4

	1	2	3	4	5
1					
2				50	
3					
4					
5					

OD matrices II

- Assume 3,000 zones (e.g., the Sydney model)
- Assume further the following
  - 5 trip purposes (work, business, education, shopping, leisure)
  - 6 transport modes (walk, bike, car driver, car passenger, train, BTM)
  - 3 time periods (AM peak, PM peak, rest of day)
  - 18 user groups (car/no-car, low/medium/high income, 3 age groups)
- Then there would be 5 x 6 x 3 x 18 = 1,620 OD matrices
- Each OD matrix contains 9 million cells
- This means 1,620 x 9 million = 14,580 million values
- Most of these values are zero or very small, i.e. they are sparse matrices

TRIP CHOICE

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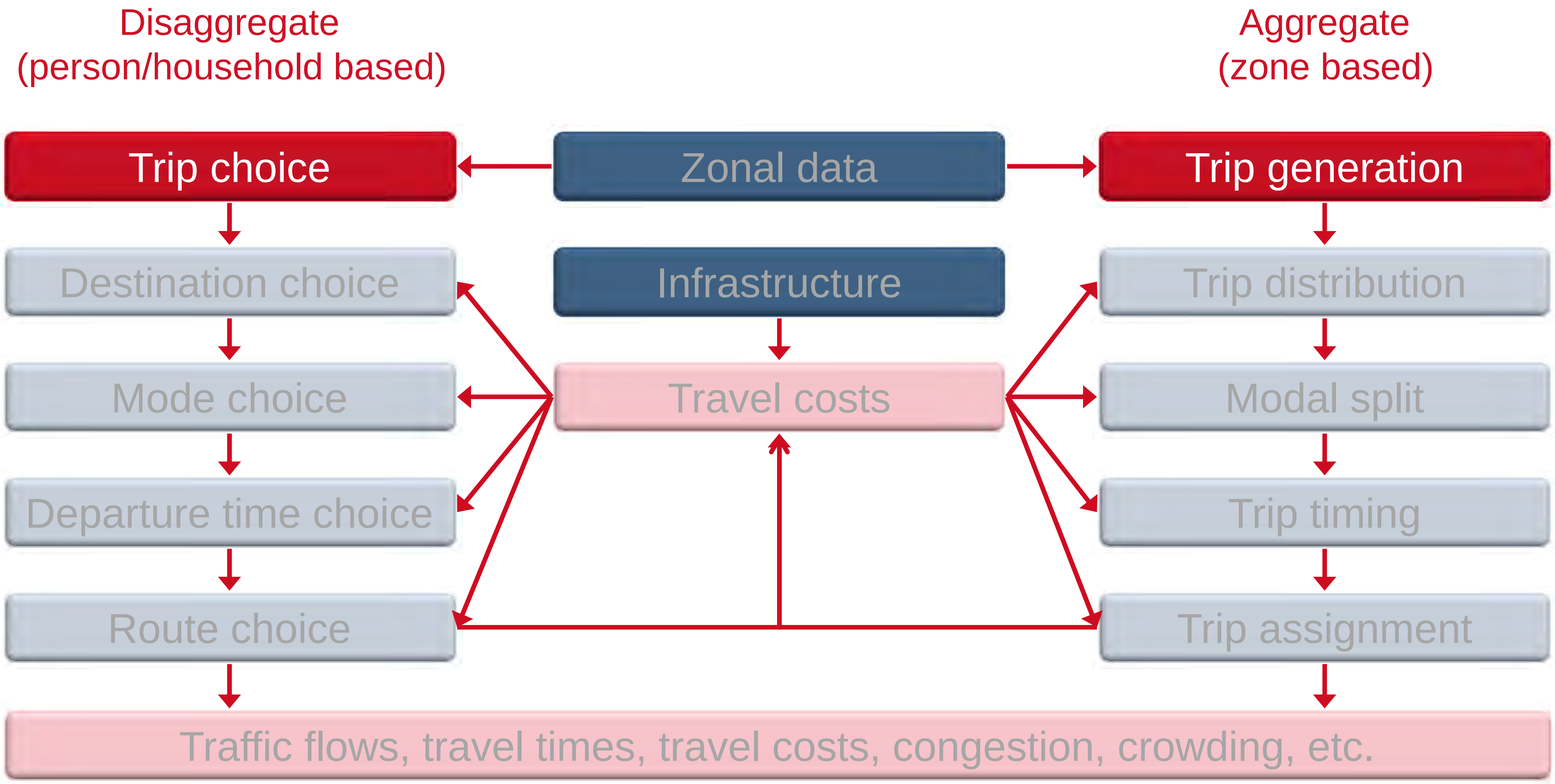
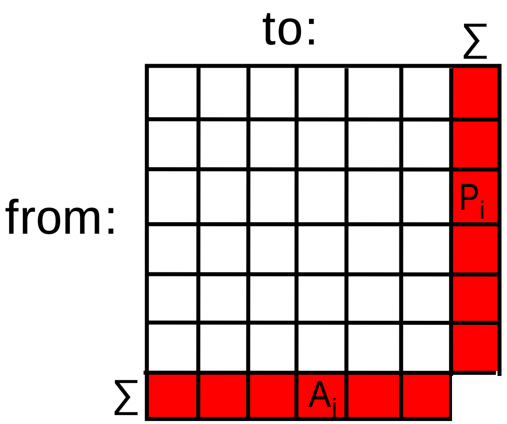
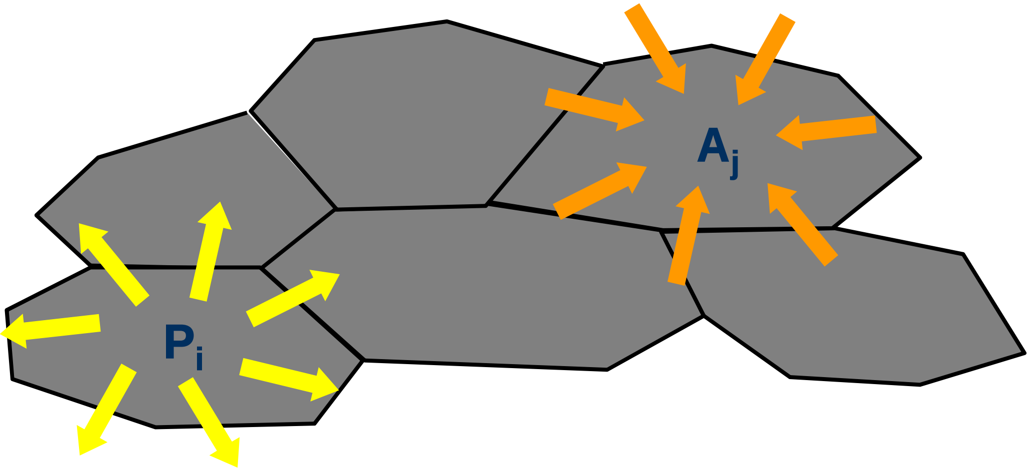
Disaggregate vs. aggregate demand modelling



Production and attraction

- Trip productions represent the row totals of the OD matrix
- Trip attractions represent the column totals of the OD matrix





Models

- Example aggregate model (linear regression):

$$\text{production} = \alpha_1 \cdot \text{population} + \alpha_2 \cdot \text{avg\_income} + \alpha_3 \cdot \text{accessibility} + \ldots$$

- Example disaggregate model (logit model) for each household:

$$V_{stay} = 0$$

$$V_{go} = \alpha_1 \cdot \text{householdsize} + \alpha_2 \cdot \text{income} + \alpha_3 \cdot \text{numberofcars} + \ldots$$

$$\Pr(\text{another trip}) = \frac{\exp(V_{go})}{\exp(V_{stay}) + \exp(V_{go})}$$

DESTINATION CHOICE

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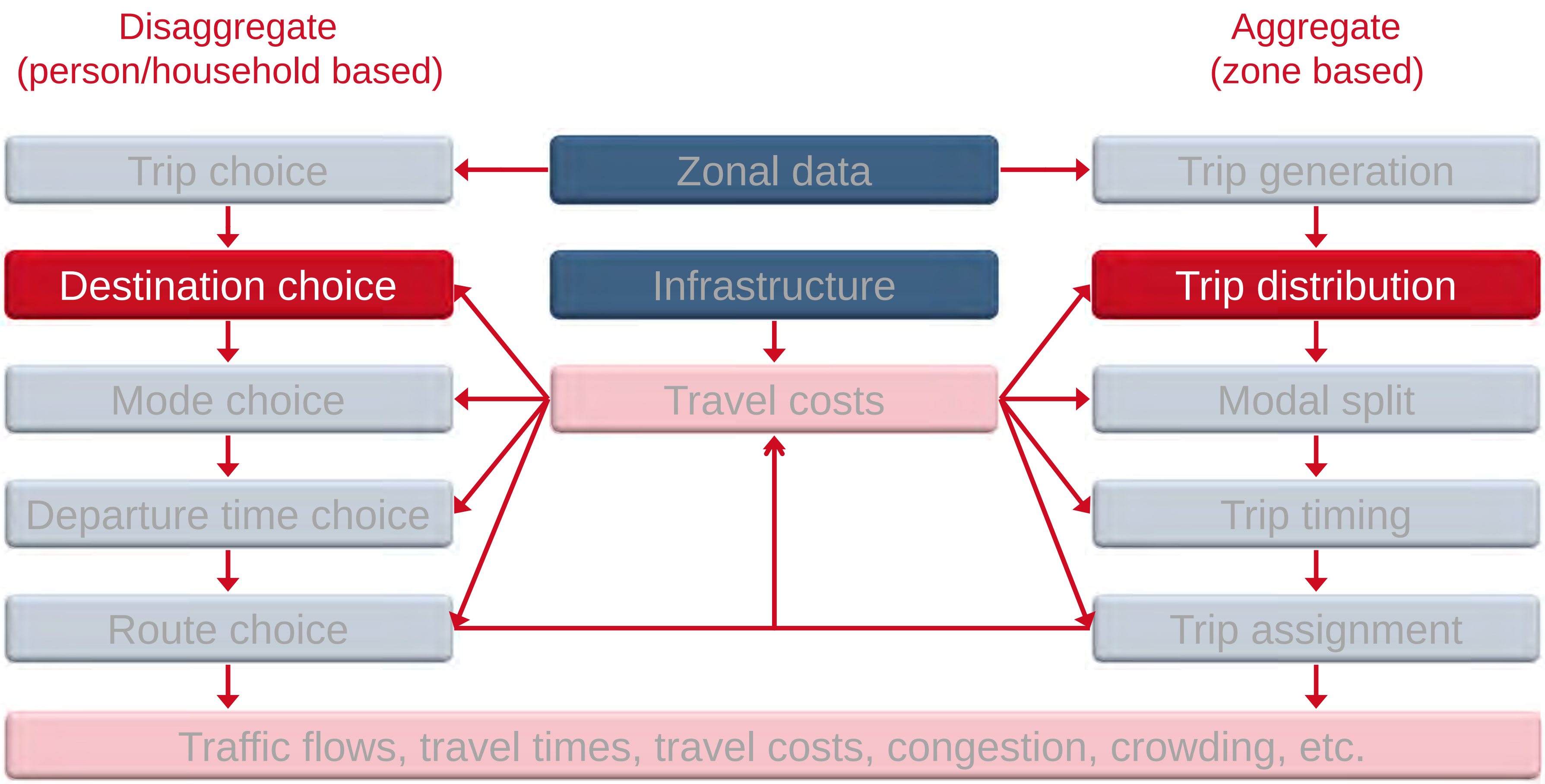
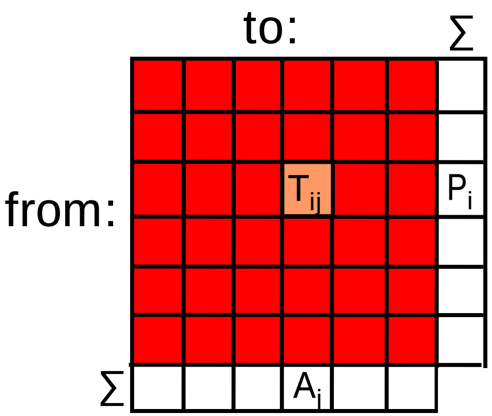
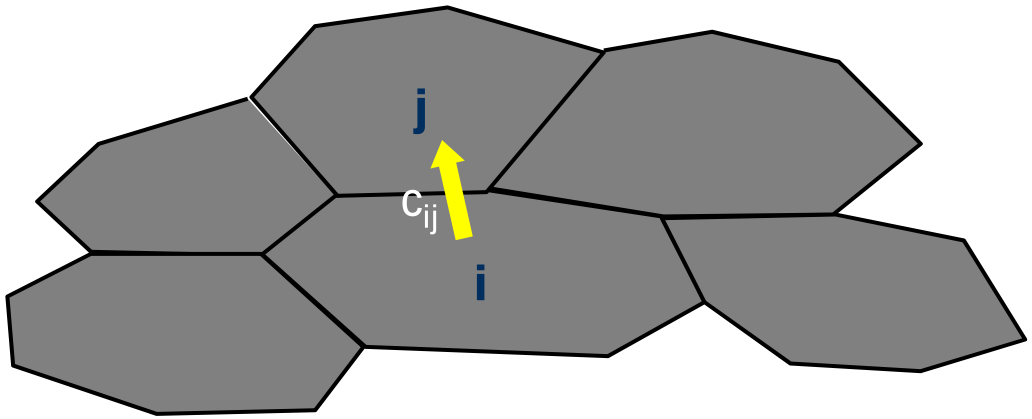
Disaggregate vs. aggregate demand modelling



OD matrix

› Based on trip productions (P) and attractions (A), and the generalised costs (c) between each OD pair, find the most likely trip matrix (T)





Models

› Example aggregate model (gravity model):

$$T_{ij} = a_i b_j P_i A_j f(c_{ij})$$

› Example disaggregate model (logit model) for each household:

$$V_{destination\_1} = K_1 + \alpha_1 \cdot \text{retailspace} + \alpha_2 \cdot \text{traveldistance} + \alpha_3 \cdot \text{travelcost} \cdot \text{income} + \ldots$$

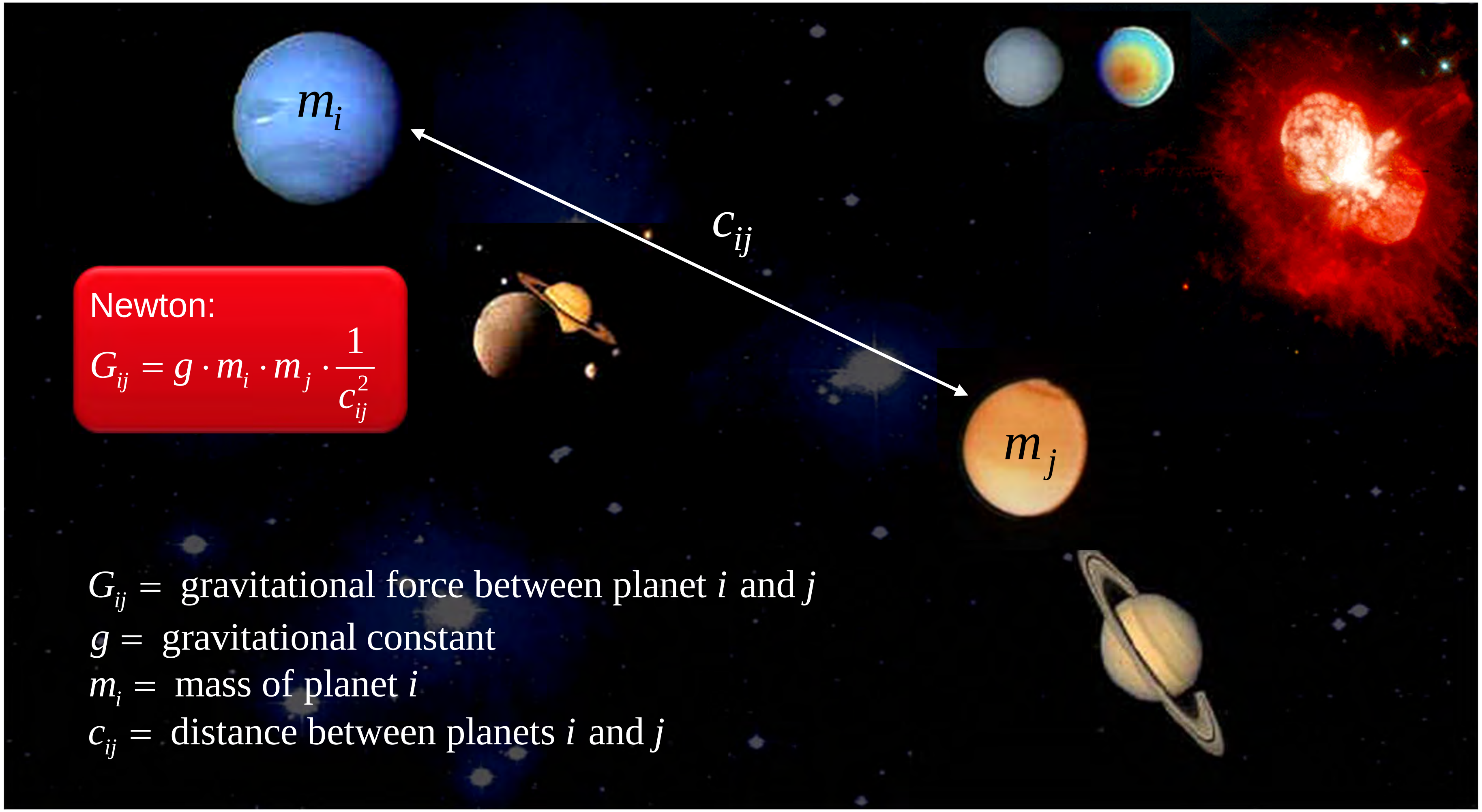
$$V_{destination\_2} = K_2 + \alpha_1 \cdot \text{retailspace} + \alpha_2 \cdot \text{traveldistance} + \alpha_3 \cdot \text{travelcost} \cdot \text{income} + \ldots$$

$$\vdots$$

$$V_{destination\_D} = \alpha_1 \cdot \text{retailspace} + \alpha_2 \cdot \text{traveldistance} + \alpha_3 \cdot \text{travelcost} \cdot \text{income} + \ldots$$

$$\Pr(\text{destination } d) = \frac{\exp(V_{destination\_d})}{\exp(V_{destination\_1}) + \exp(V_{destination\_2}) + \ldots + \exp(V_{destination\_D})}$$

The gravity model I



Newton:

$$G_{ij} = g \cdot m_i \cdot m_j \cdot \frac{1}{c_{ij}^2}$$

$G_{ij} =$ gravitational force between planet i and j

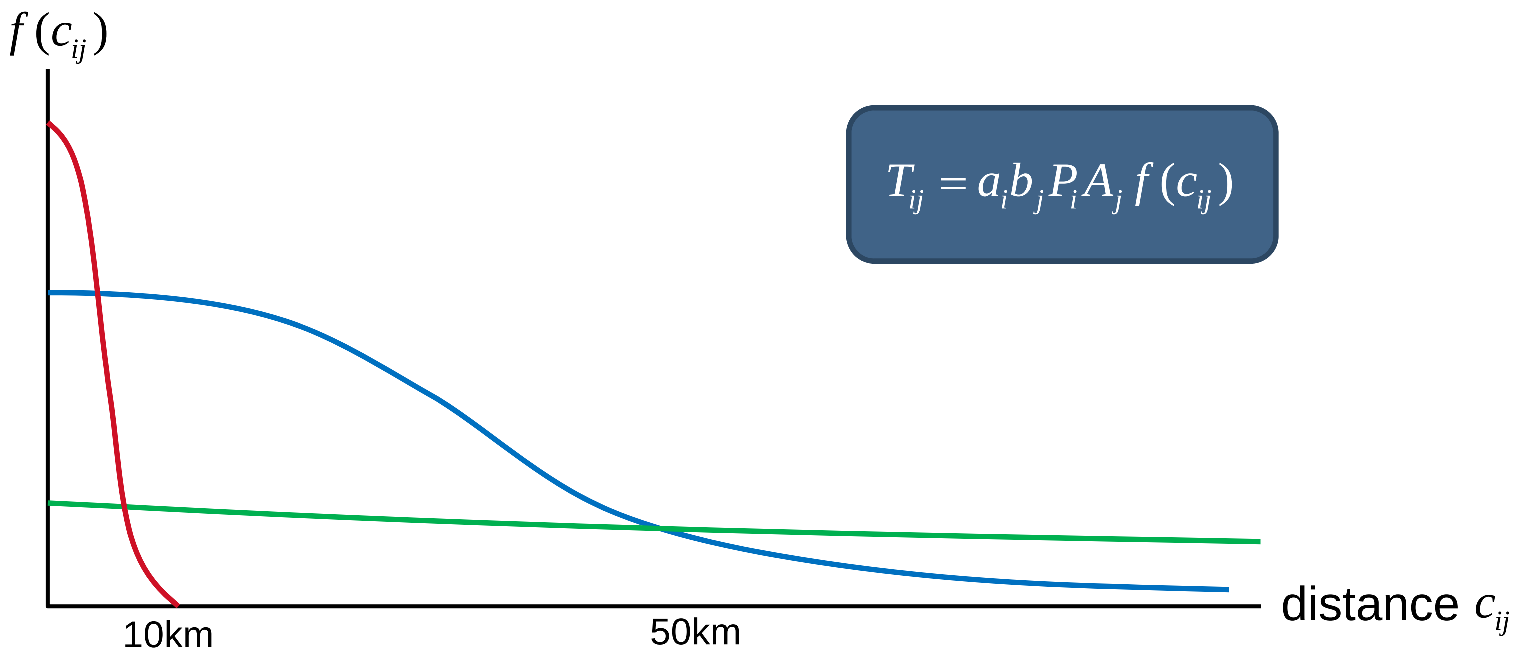
$g =$ gravitational constant

$m_i =$ mass of planet i

$c_{ij} =$ distance between planets i and j

The gravity model II

- Function $f(c_{ij})$ is called the deterrence function
- It describes the relative willingness to make a trip as a function of the generalised travel cost (time, cost, and/or distance)



MODE CHOICE

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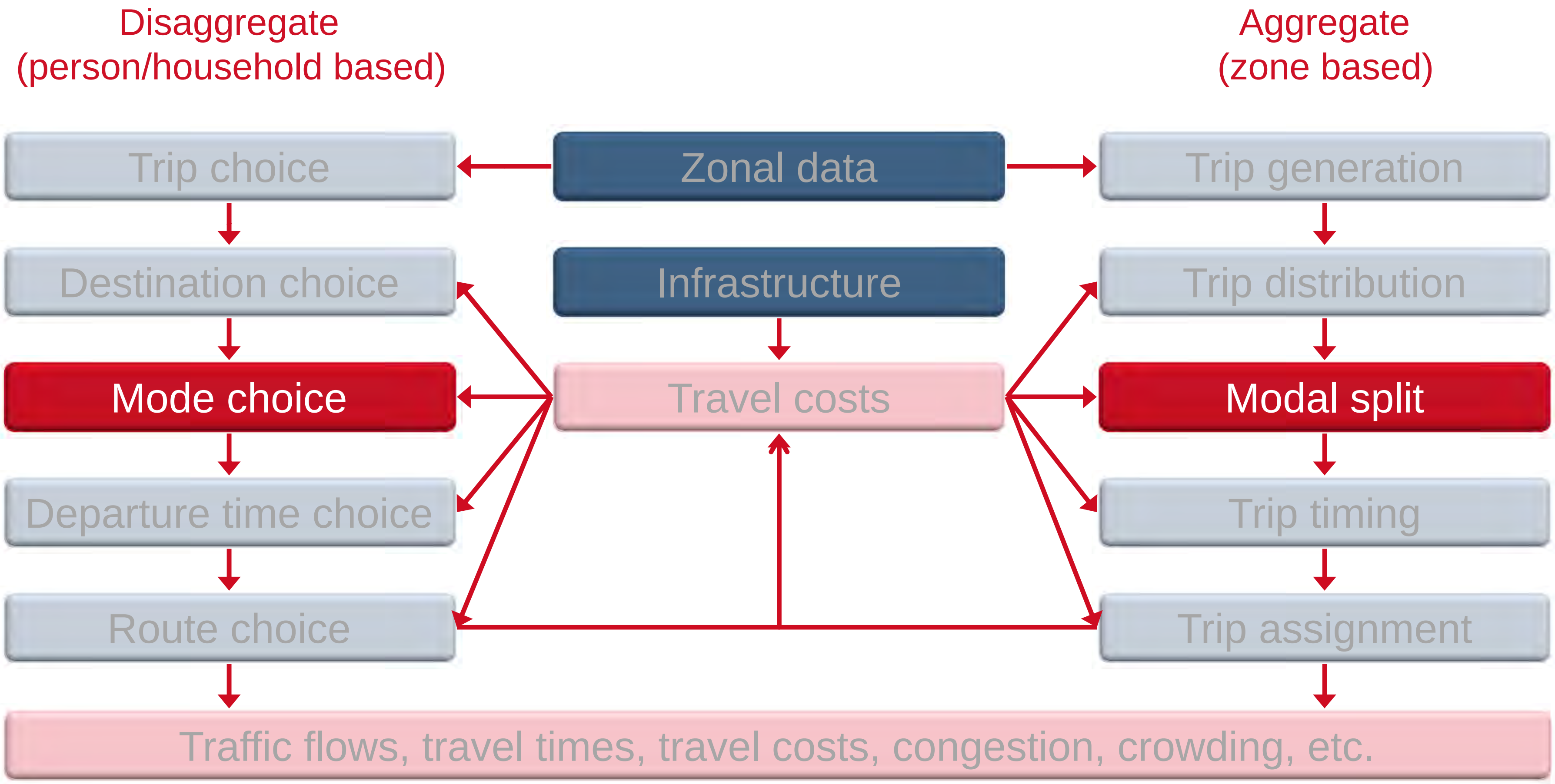
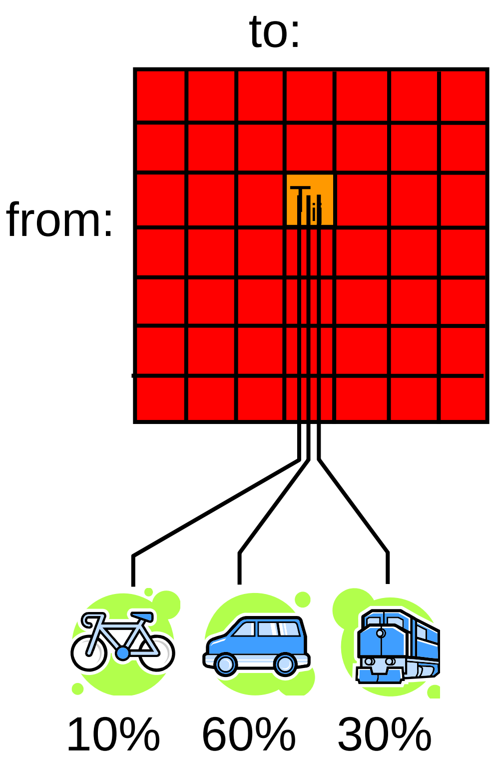
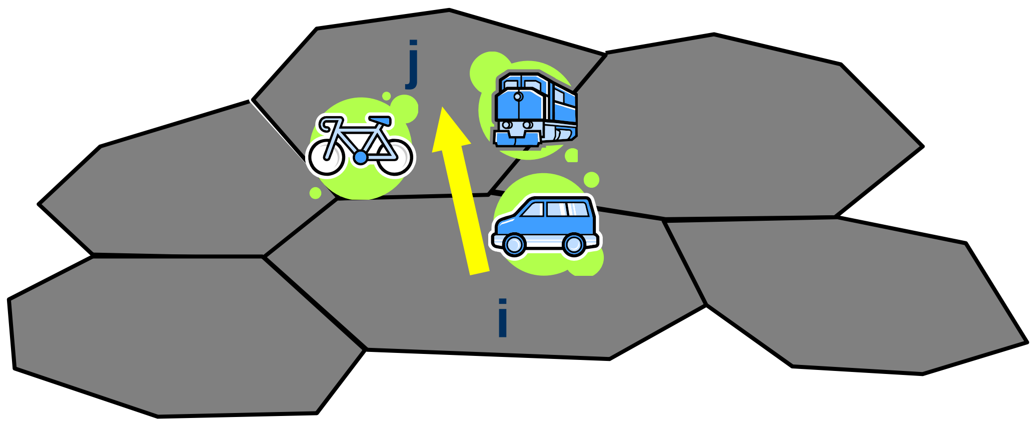
Disaggregate vs. aggregate demand modelling



MODE CHOICE

OD matrix per mode





Models

› Example disaggregate model (logit model) for each household:

$$V_{car} = K_{car} + \alpha_1 \cdot \text{traveltime} + \alpha_2 \cdot \text{toll} + \alpha_3 \cdot \text{carownership} + \ldots$$

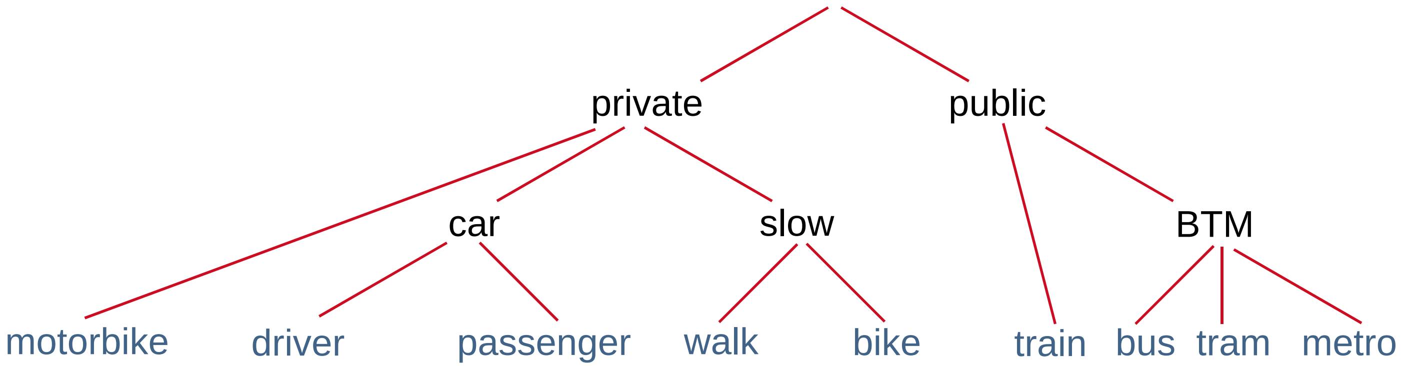
$$V_{train} = K_{train} + \alpha_4 \cdot \text{invehicletime} + \alpha_5 \cdot \text{waitingtime} + \alpha_6 \cdot \text{fare} + \alpha_7 \cdot \text{income} + \ldots$$

$$V_{BTM} = K_{BTM} + \alpha_4 \cdot \text{invehicletime} + \alpha_5 \cdot \text{waitingtime} + \alpha_6 \cdot \text{fare} + \alpha_7 \cdot \text{income} + \ldots$$

$$V_{bike} = \alpha_8 \cdot \text{traveldistance}$$

$$\Pr(\text{car}) = \frac{\exp(V_{car})}{\exp(V_{car}) + \exp(V_{train}) + \exp(V_{BTM}) + \exp(V_{bike})}$$

Nested logit model



DEPARTURE TIME CHOICE

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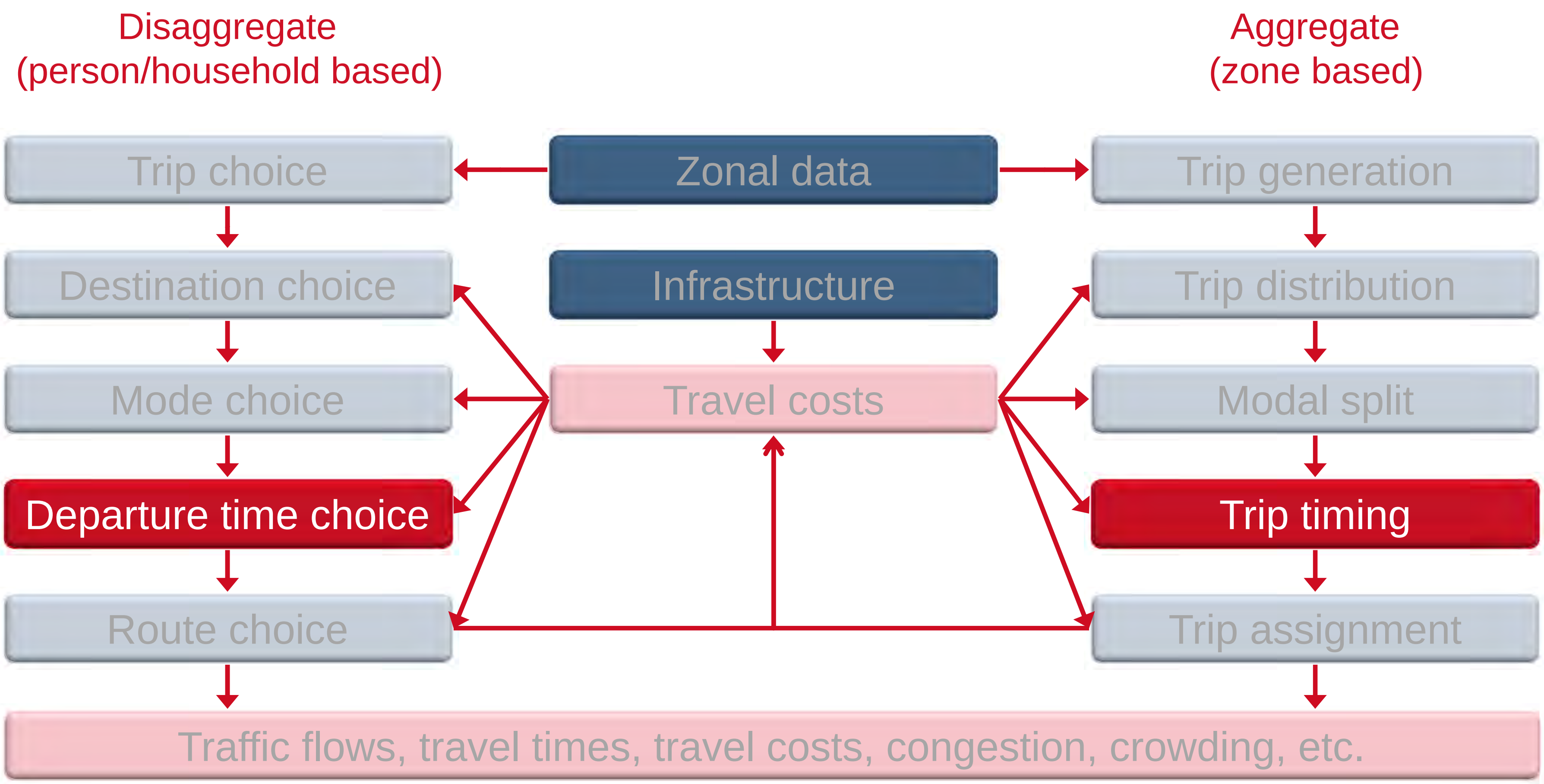
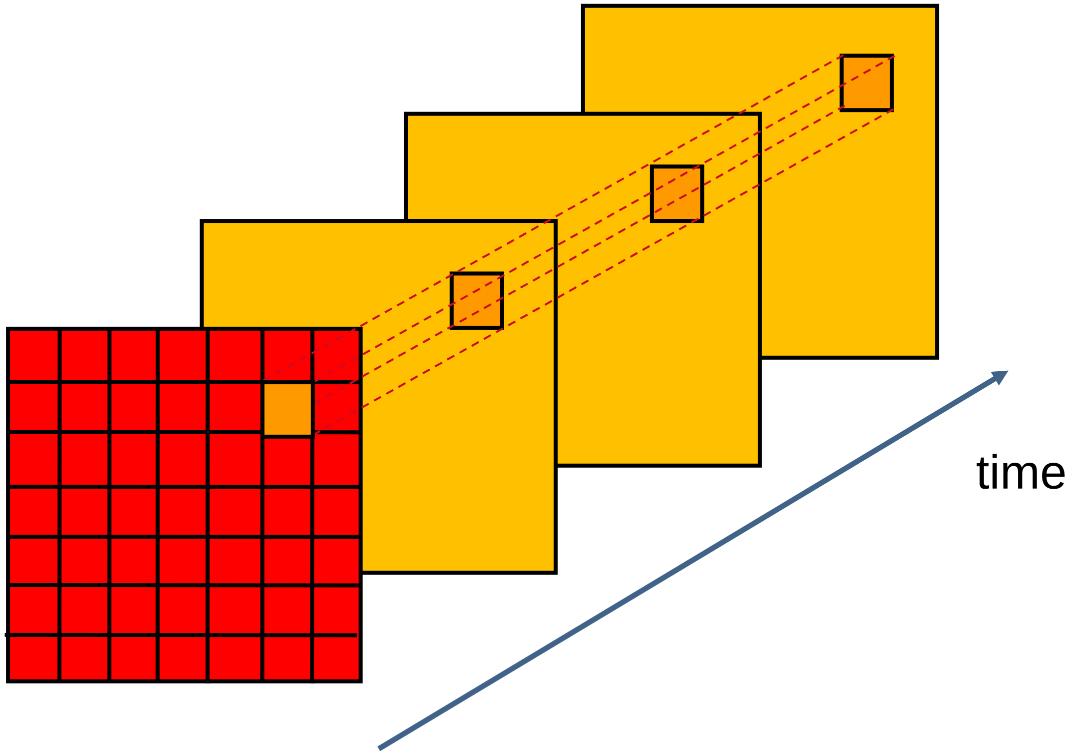
Disaggregate vs. aggregate demand modelling



OD matrix per mode per time period

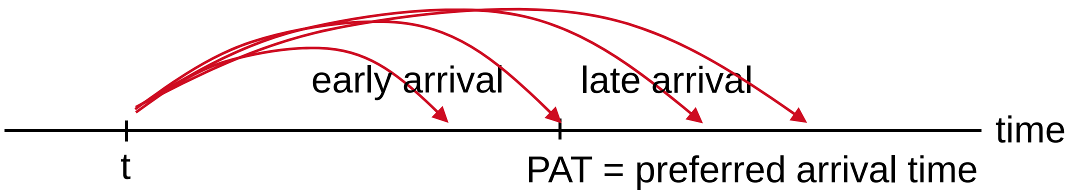


Models

› Example disaggregate model (logit model) for each household:

$$V_{period\_1} = \alpha_1 \cdot \text{traveltime} + \alpha_2 \cdot \text{toll} + \alpha_3 \cdot \text{early\_arrival} + \alpha_4 \cdot \text{late\_arrival} + \ldots$$
$$V_{period\_2} = \alpha_1 \cdot \text{traveltime} + \alpha_2 \cdot \text{toll} + \alpha_3 \cdot \text{early\_arrival} + \alpha_4 \cdot \text{late\_arrival} + \ldots$$
$$\vdots$$
$$V_{period\_T} = \alpha_1 \cdot \text{traveltime} + \alpha_2 \cdot \text{toll} + \alpha_3 \cdot \text{early\_arrival} + \alpha_4 \cdot \text{late\_arrival} + \ldots$$

$$\Pr(\text{period } t) = \frac{\exp(V_{period\_t})}{\exp(V_{period\_1}) + \exp(V_{period\_2}) + \ldots + \exp(V_{period\_T})}$$



ROUTE CHOICE

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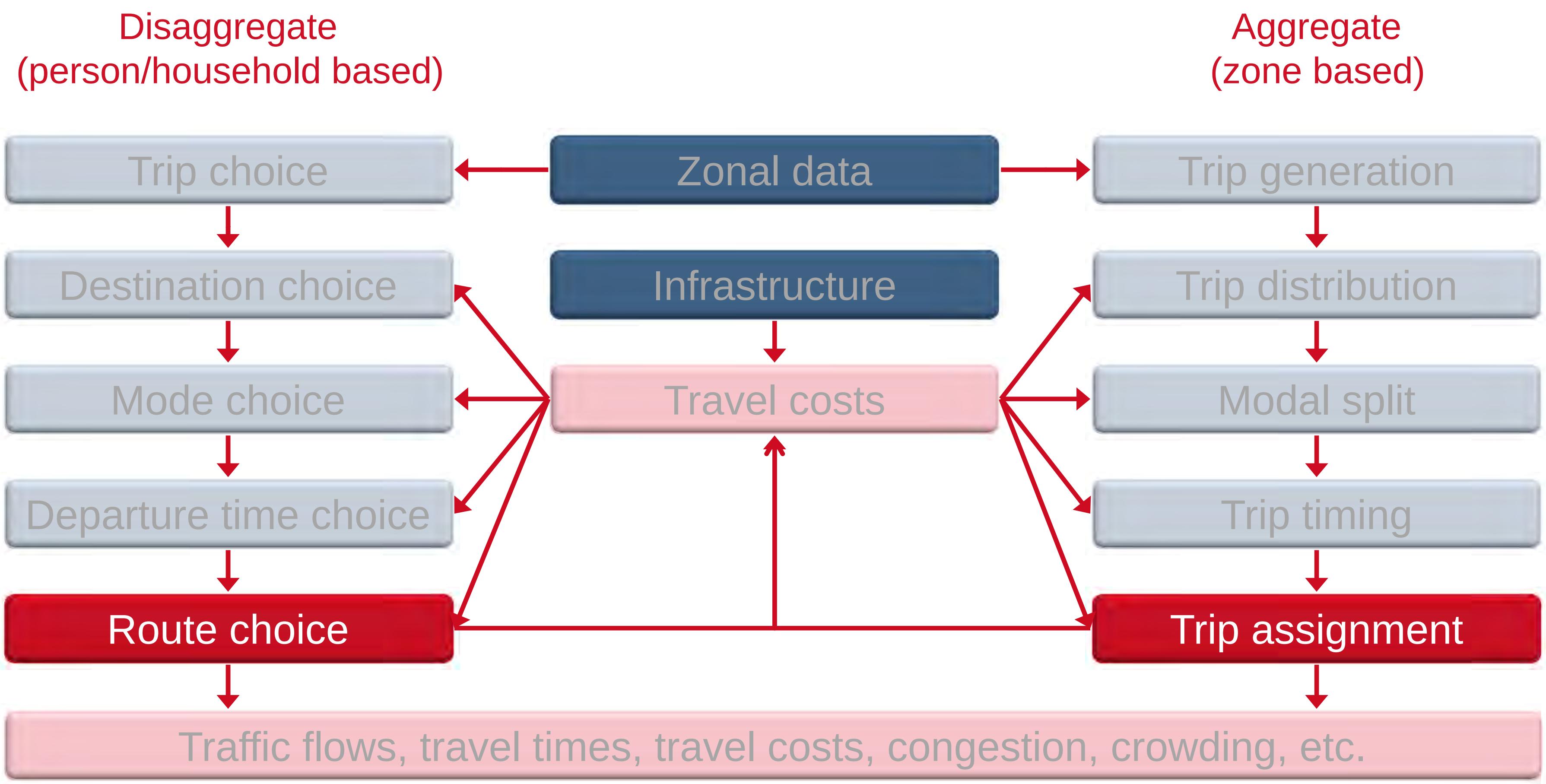
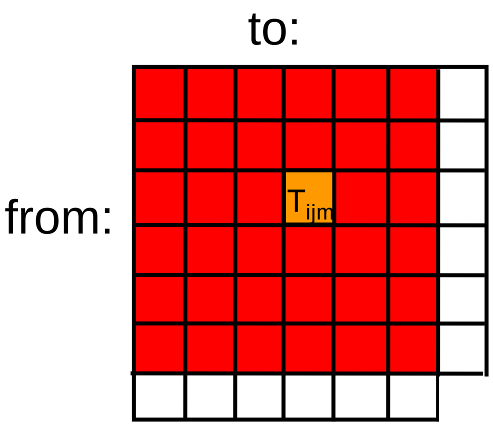
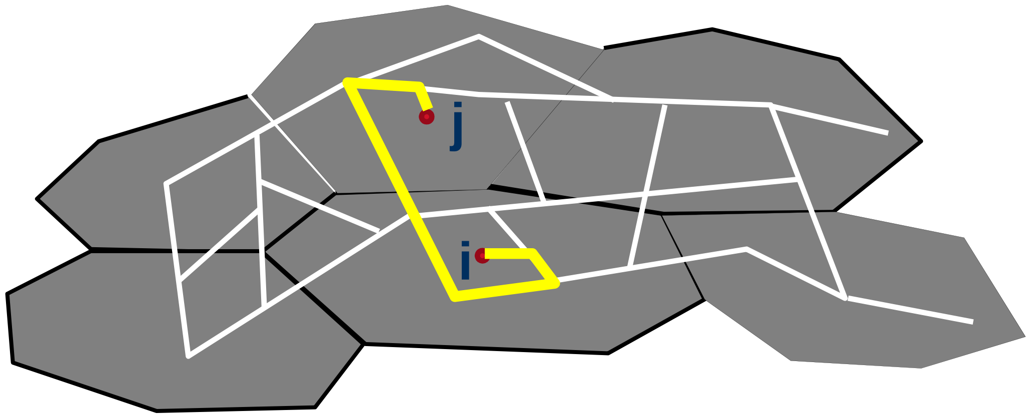
Disaggregate vs. aggregate demand modelling



Assign the OD matrix to the network





› Assume that travellers choose the shortest, fastest or cheapest route / transit line.

Models

› Example disaggregate model (logit model) for each household:

$$V_{route\_1} = \alpha_1 \cdot \text{traveltime} + \alpha_2 \cdot \text{toll} + \alpha_3 \cdot \text{motorway} \cdot \text{gender} + \ldots$$
$$V_{route\_2} = \alpha_1 \cdot \text{traveltime} + \alpha_2 \cdot \text{toll} + \alpha_3 \cdot \text{motorway} \cdot \text{gender} + \ldots$$
$$\vdots$$
$$V_{route\_R} = \alpha_1 \cdot \text{traveltime} + \alpha_2 \cdot \text{toll} + \alpha_3 \cdot \text{motorway} \cdot \text{gender} + \ldots$$

$$\Pr(\text{route } r) = \frac{\exp(V_{route\_r})}{\exp(V_{route\_1}) + \exp(V_{route\_2}) + \ldots + \exp(V_{route\_R})}$$

Traffic assignment model types

› Different assumptions on route choice lead to different assignment model types

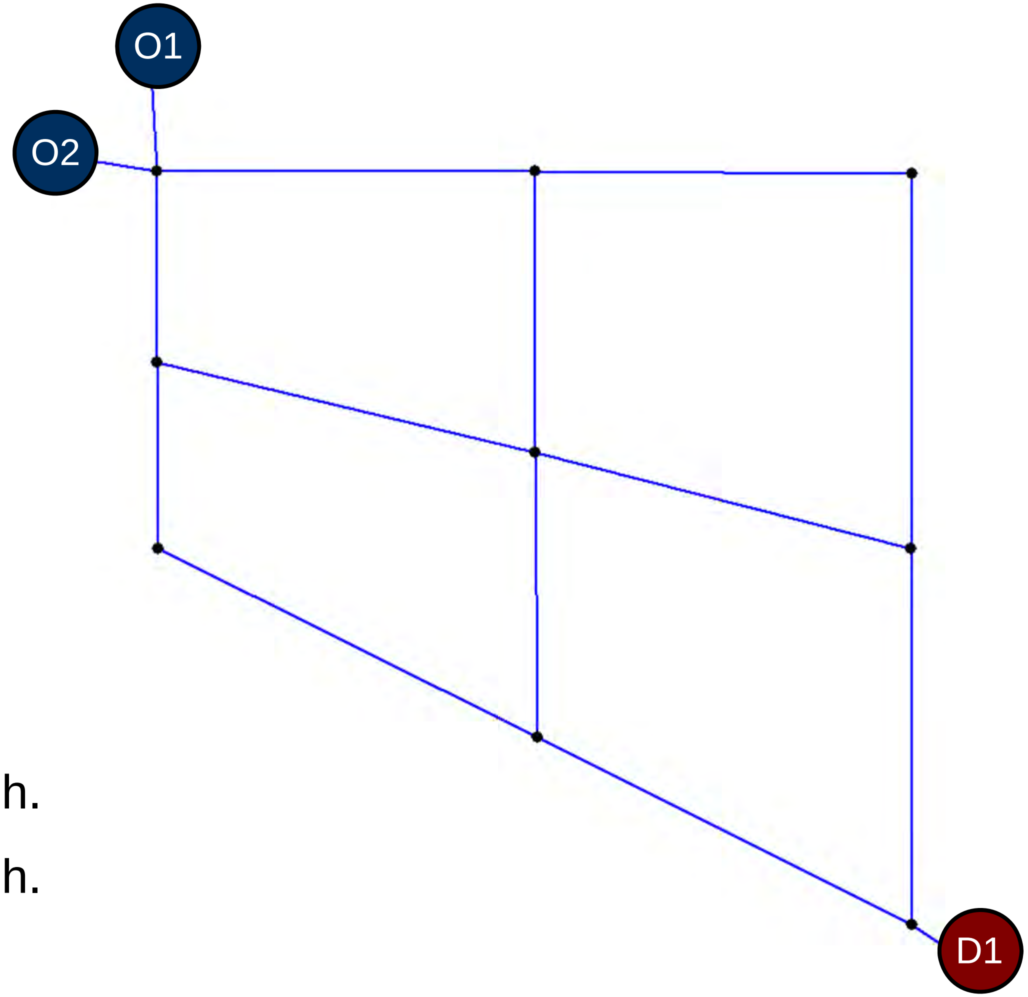
› Traffic assignment type 1: All-or-nothing (AON) assignment
  - Assumes all travellers take the fastest route without considering congestion

› Traffic assignment type 2: Stochastic assignment
  - Assumes all travellers take the perceived fastest route without considering congestion

› Traffic assignment type 3: User equilibrium (UE) assignment
  - Assumes all travellers take the fastest route taking congestion into account

› Traffic assignment type 4: Stochastic user equilibrium (SUE) assignment
  - Assumes all travellers take the perceived fastest route taking congestion into account

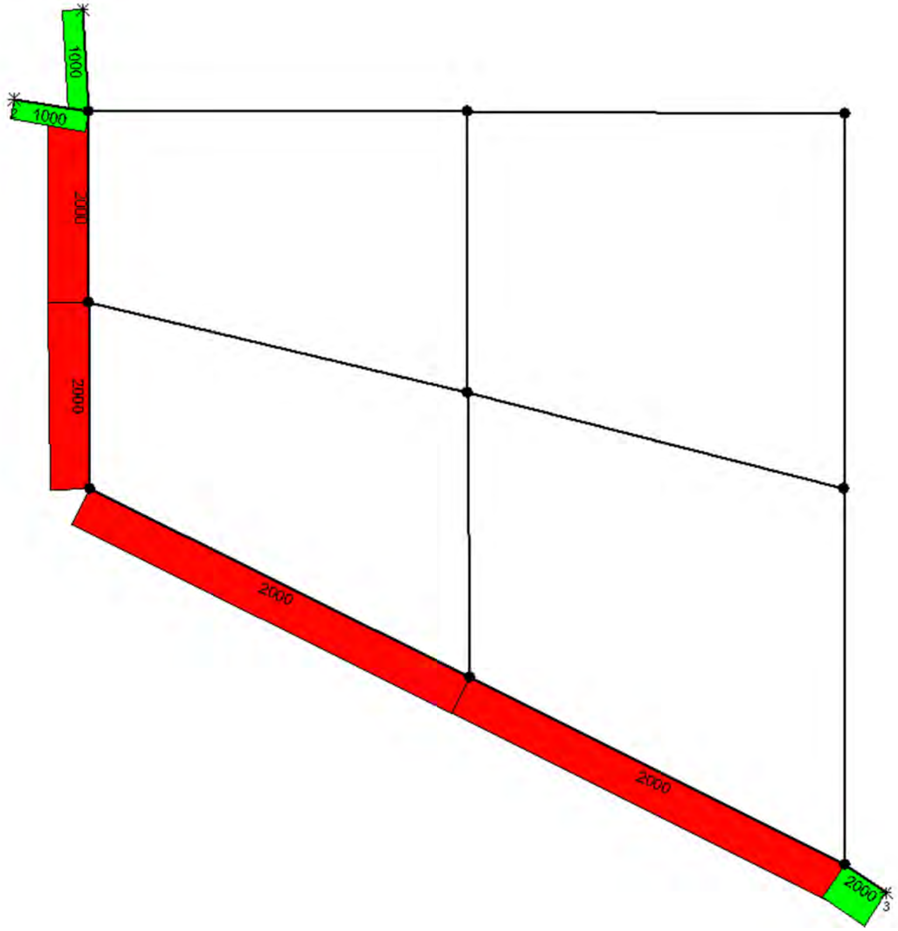
Simple example



- Two OD pairs
- Travel demand (O1,D1) is 1,000 veh.
- Travel demand (O2,D1) is 1,000 veh.

All-or-nothing (AON) assignment

- Assign all traffic to the fastest routes (not taking congestion into account)
- Most simple assignment technique



high speed

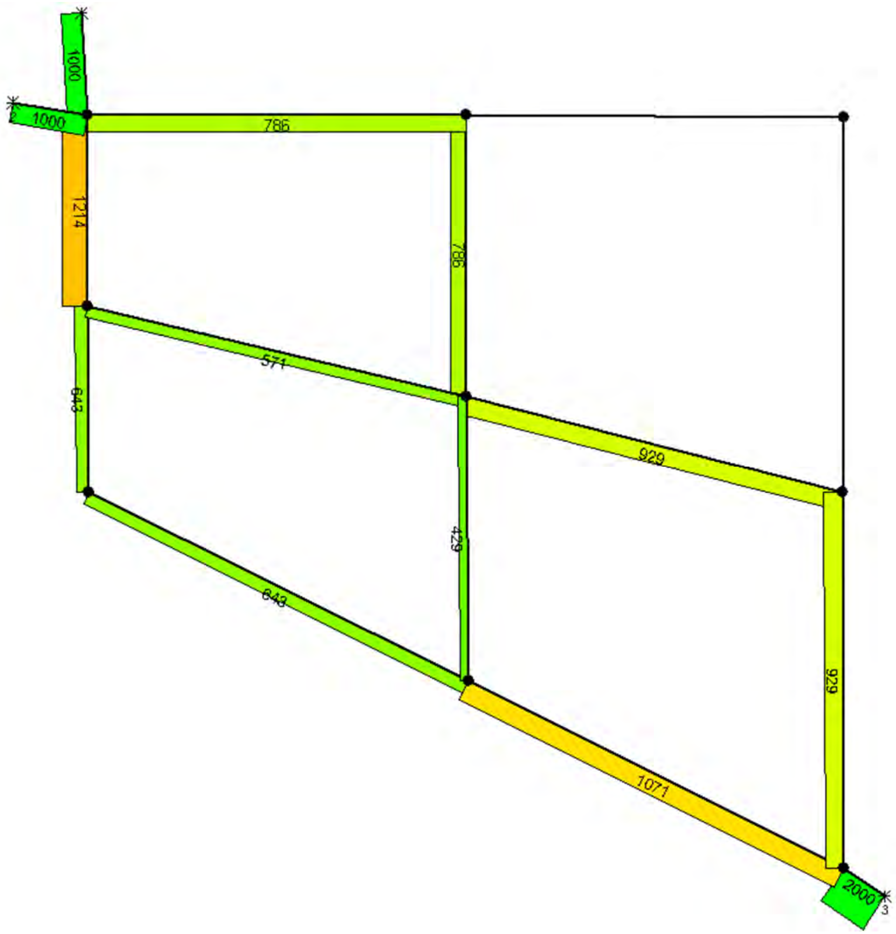
low speed

User equilibrium (UE) assignment

- › Assign all traffic according to the actual fastest route (taking congestion into account)
- › More realistic, assuming travellers learn which routes are congested
- › Requires more computation time (iterative simulations)

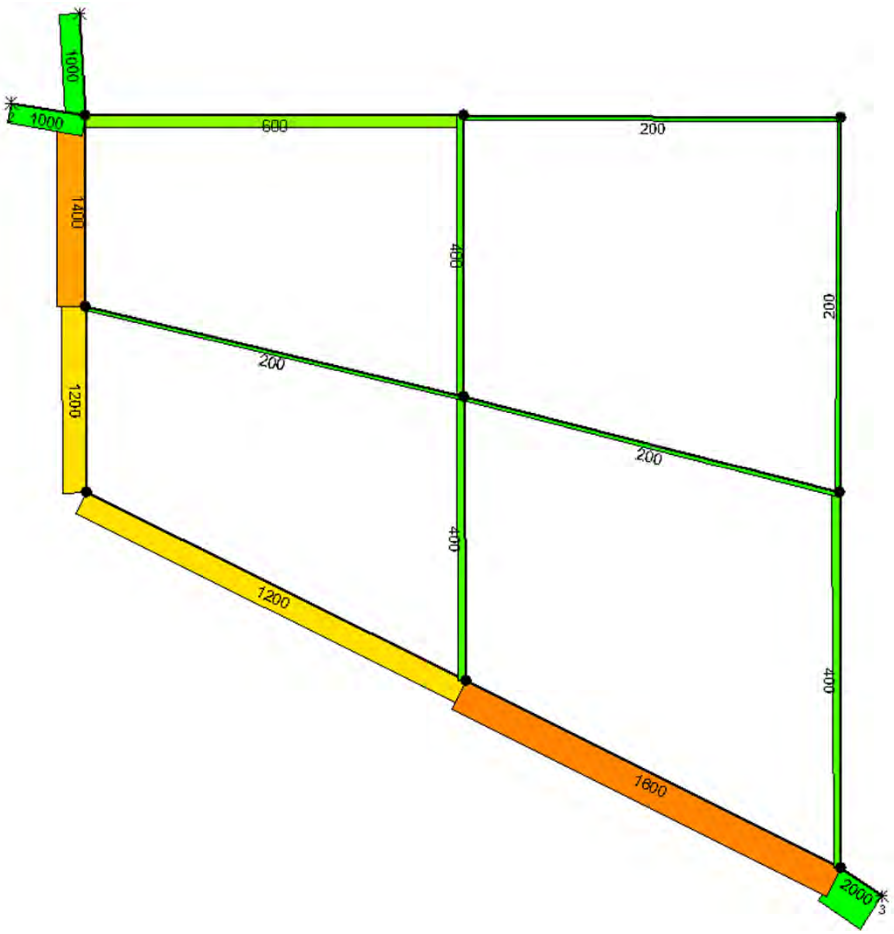
high speed

low speed



Stochastic (user equilibrium) assignment

- Assign all traffic to the perceived fastest routes according to the logit model (with or without congestion)
- Does not assume perfect knowledge of travellers

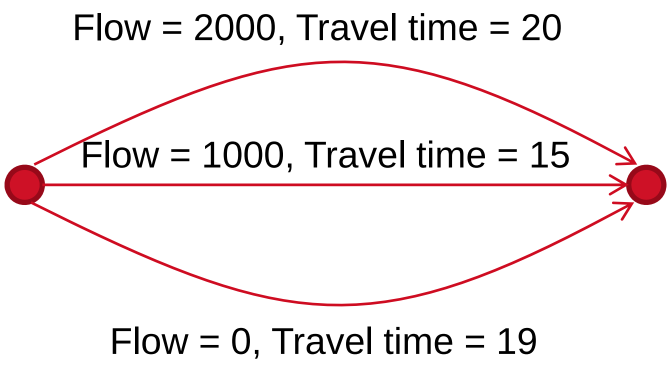


high speed

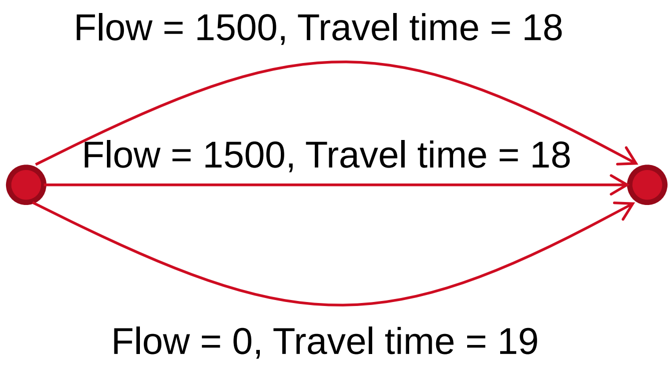
low speed

User equilibrium

- Can be found by applying Wardrop's first principle (Wardrop, 1952):
  - In a user equilibrium, for each OD pair, all used routes have equal travel time, which is no greater than the travel time on any unused route



No user equilibrium



User equilibrium

Model formulation

› If generalised travel cost only depends on current link flow (separable, symmetric):

- Optimisation problem (see Beckmann et al., 1956)

$$\min_{q\in\Omega} \sum_a \int_{w=0}^{q_a} c_a(w)dw \qquad \Omega = \left\{ q \mid q_a = \sum_p \delta_{ap} f_p, \sum_p f_p = D^{rs},\ f_p \geq 0 \right\}$$

› Otherwise:

- Variational inequality problem (see e.g. Dafermos and Sparrow, 1969)

$$\sum_a c_a(q^*)\left(q_a - q_a^*\right) \geq 0, \quad \forall q \in \Omega \qquad \Omega = \left\{ q \mid q_a = \sum_p \delta_{ap} f_p, \sum_p f_p = D^{rs},\ f_p \geq 0 \right\}$$

TRAFFIC SIMULATION

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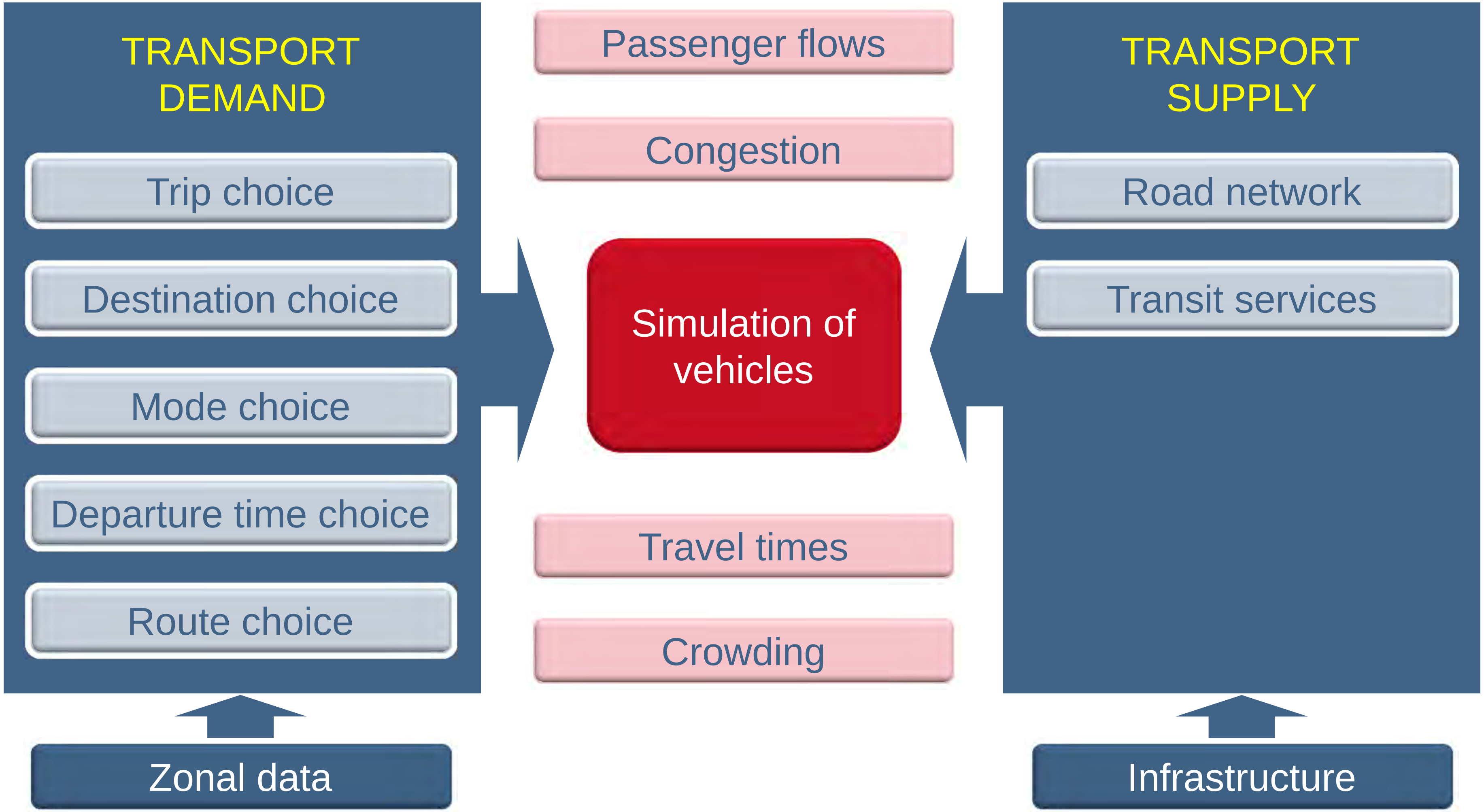
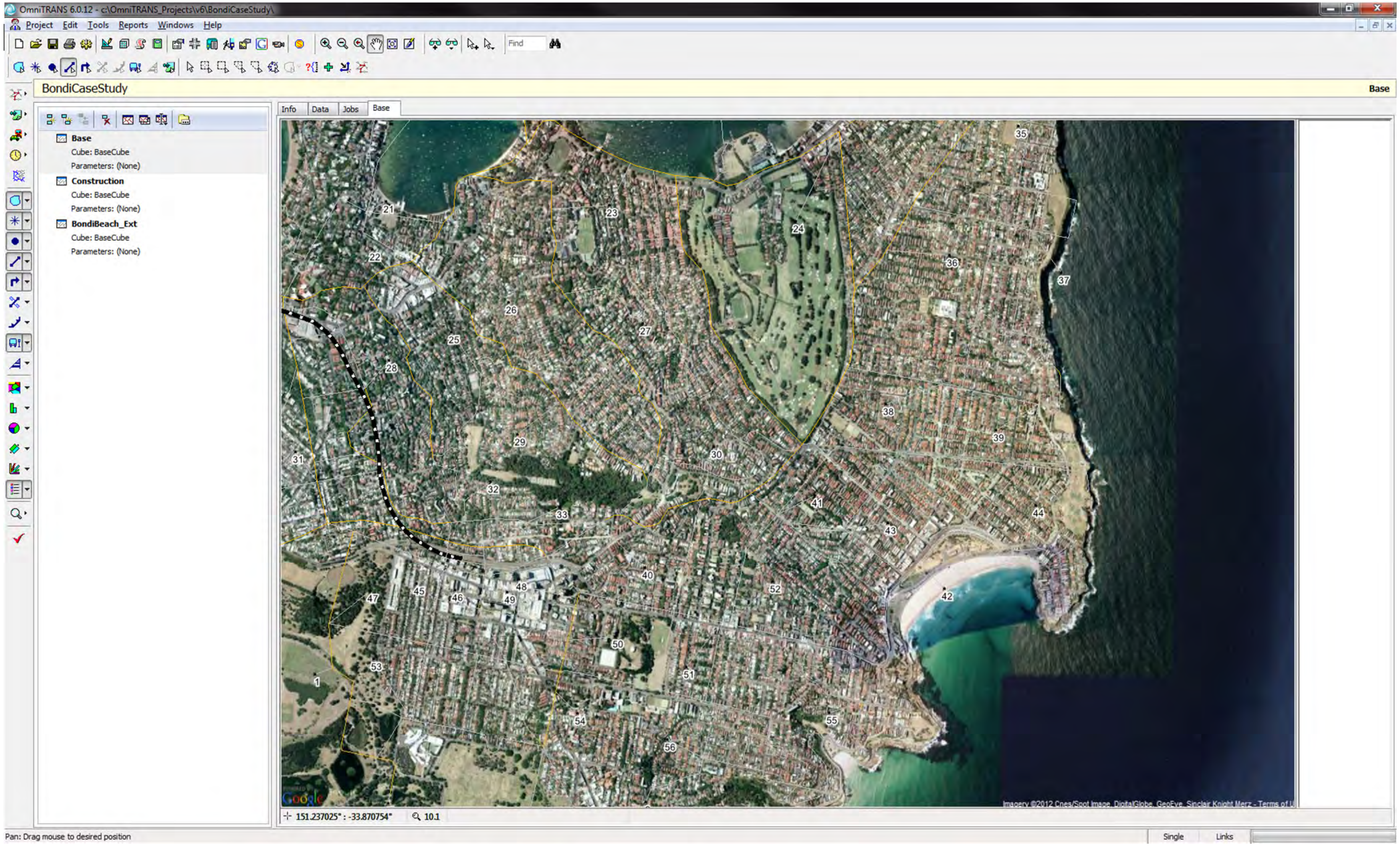
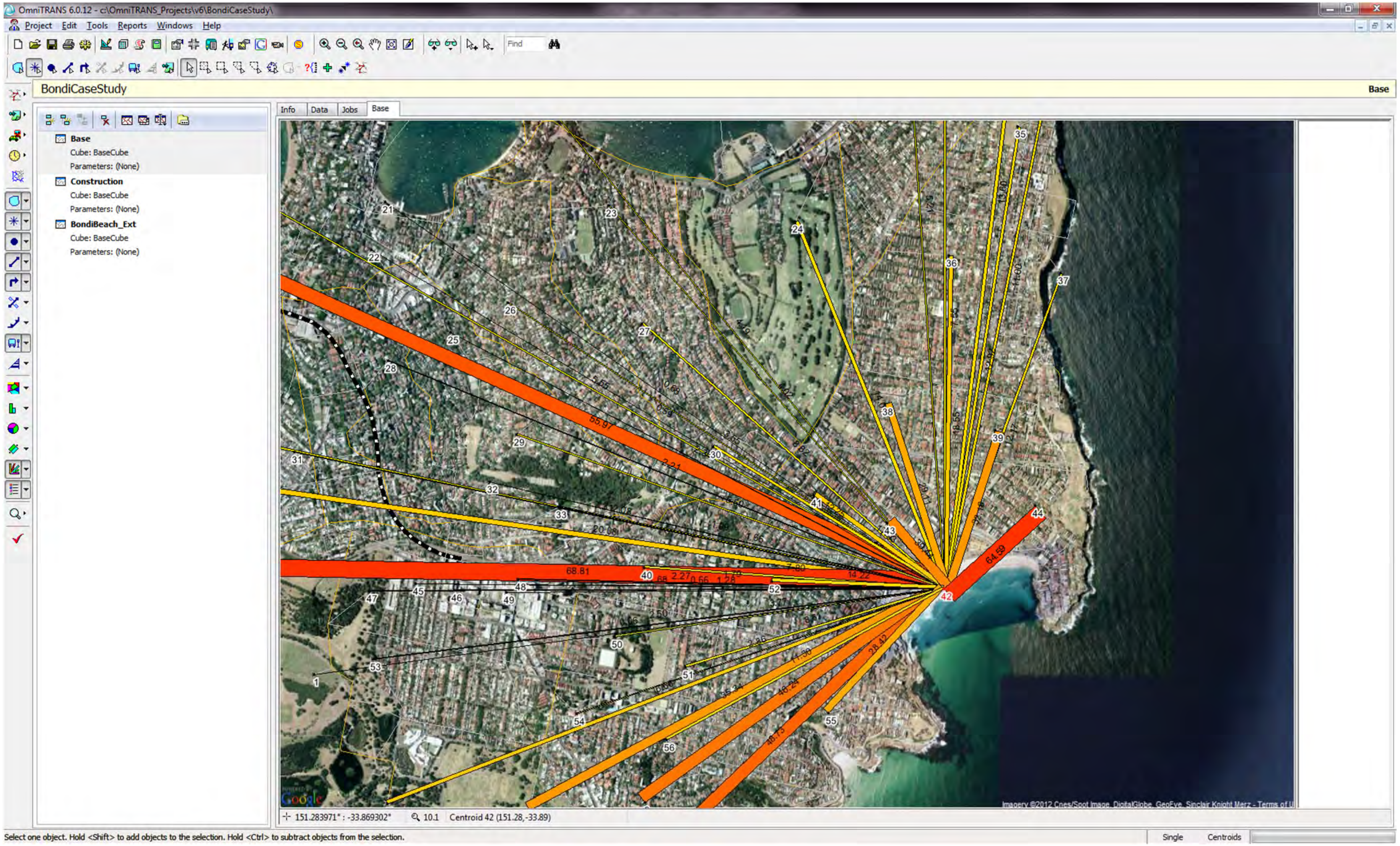
TRAFFIC SIMULATION



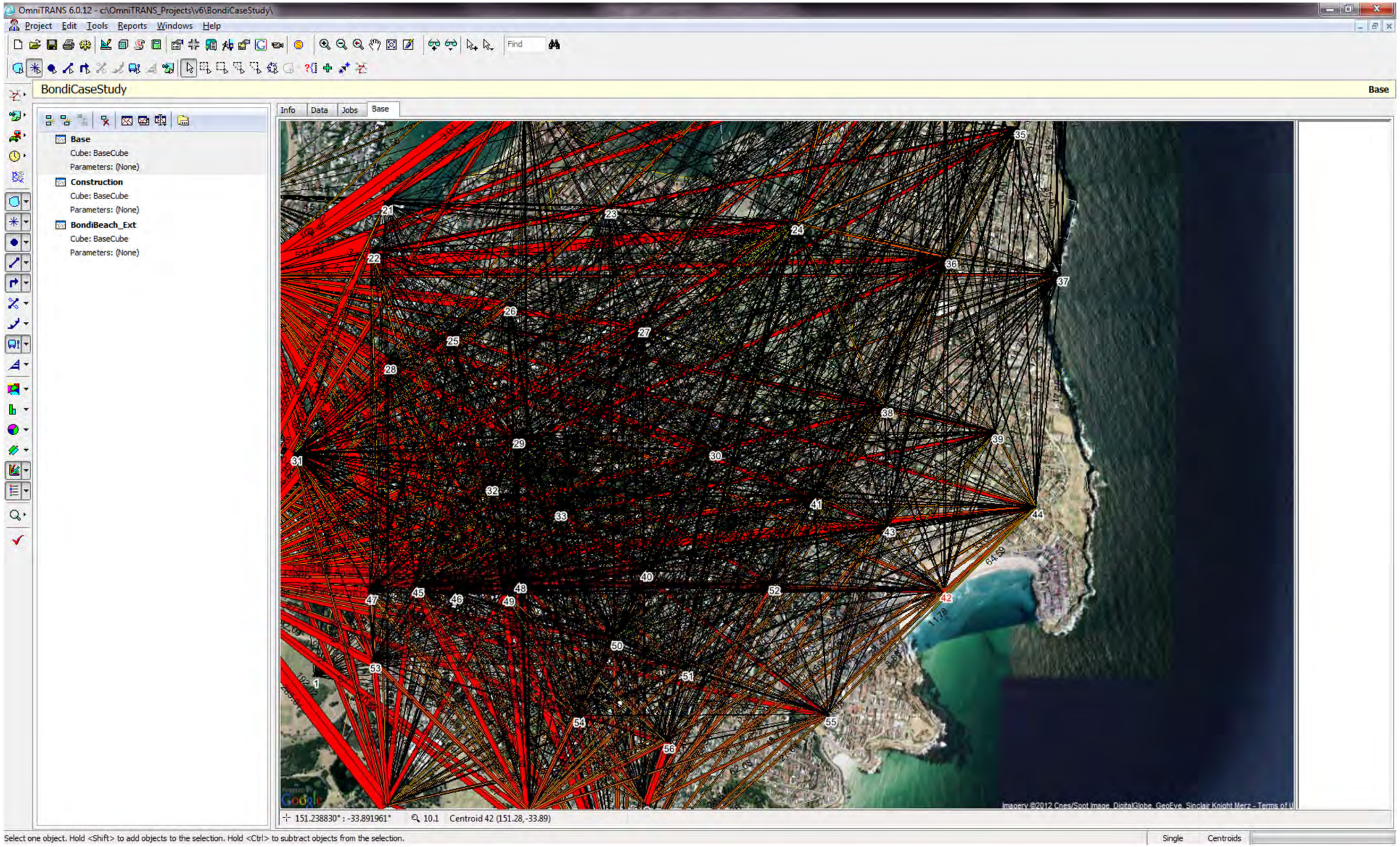
TRAFFIC SIMULATION



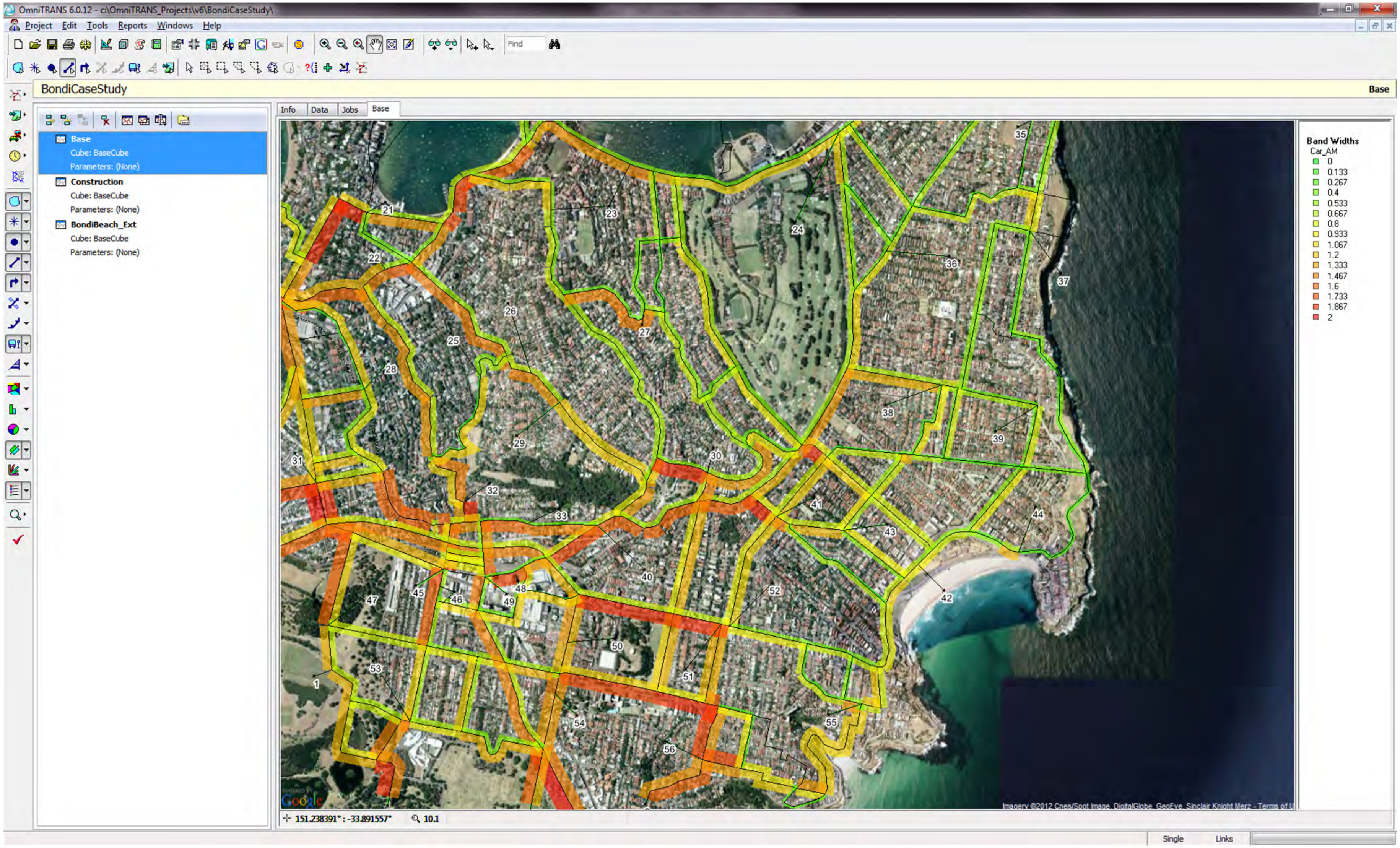
TRAFFIC SIMULATION



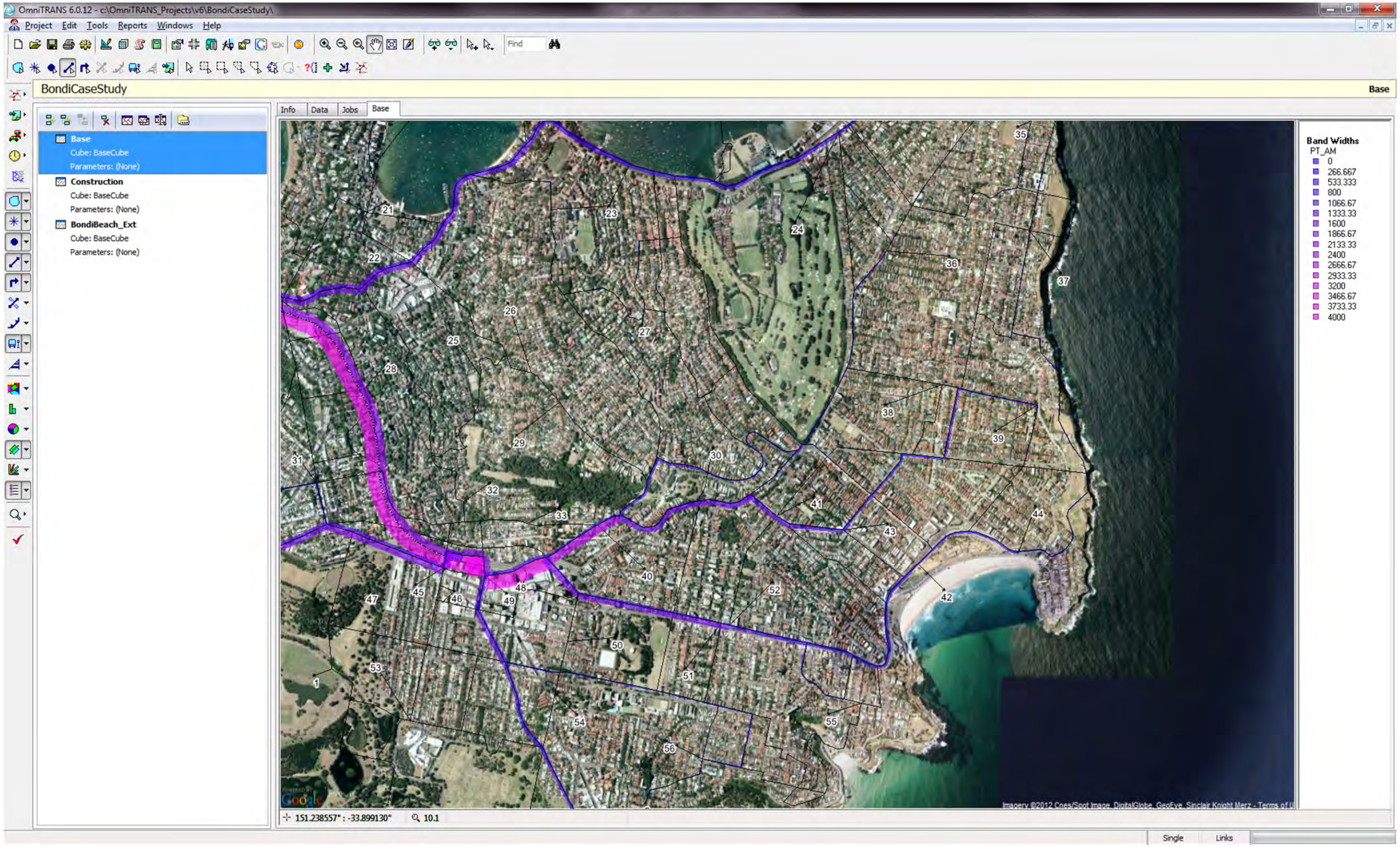
TRAFFIC SIMULATION



TRAFFIC SIMULATION



TRAFFIC SIMULATION



Static versus dynamic traffic simulation

› Traditional strategic transport models adopt static traffic simulation procedures:

- Considers a single time period (i.e., morning peak)
- Assumes a stationary travel demand
- Assumes instantaneous flow propagation
- Developed in the 1950s
- Still widely used by governments all over the world
- Do not forecast queues and delays very well

› Traffic is dynamic by nature, therefore dynamic traffic simulation procedures yield more realistic results:

- Considers several time intervals (i.e. 24 x 5 min.)
- Assume time-varying demand
- Assumes dynamic flow propagation with queuing and spillback

Micro, meso, and macro

- Macroscopic models
  - Consider traffic flow rates (like water)
  - Uses the fundamental diagram as input
  - Deterministic network loading procedure
  - Mostly used on large networks
- Microscopic models
  - Consider each individual vehicle separately
  - Uses behavioural rules as input (car following, lane changing, etc)
  - Stochastic network loading procedure
  - Mostly used on small portions of the network
- Mesoscopic models
  - Considers individual or packets of vehicles
  - Uses an input mix of fundamental diagram and behavioural rules
  - Mostly used for medium sized networks
- Hybrid models

  Different portions of the network are simulated macroscopically, mesoscopically, or microscopically

Micro, meso, and macro

Demand models

macroscopic
aggregate gravity models

mesoscopic
disaggregate choice models

microscopic
disaggregate activity-based models

Supply models

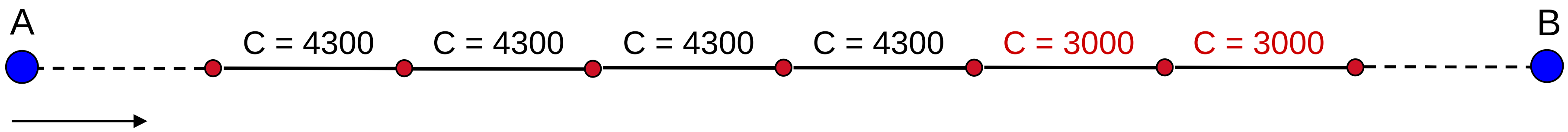
macroscopic
static and dynamic assignment models

mesoscopic
dynamic assignment models

microscopic
dynamic simulation models

Example

- Consider the following route from A to B with a travel demand of 4000 veh/h



- What are the speeds on each link?
- What is the travel time from A to B?
- Where are the queues?

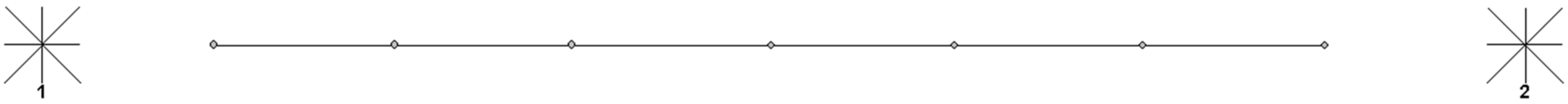
Example

100% speed

0%

› Outcome of a macroscopic dynamic network loading model (Yperman, 2007)

Flow (veh/h)



› Accurate speeds, travel times, and queues

› These dynamic models are rarely applied for strategic transport planning, as they are too computationally demanding (cannot handle large networks) and time consuming

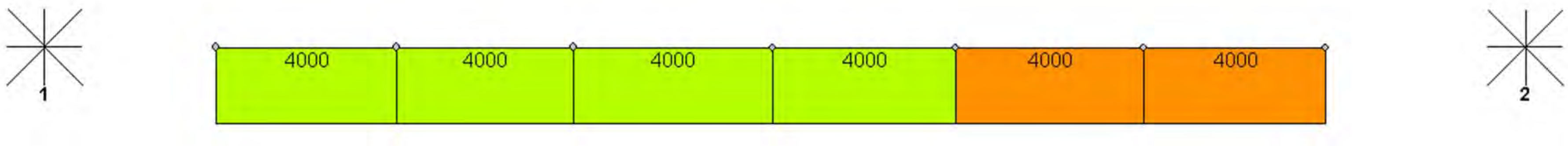
Example

100% speed

0%

- Outcome of a traditional static network loading model (Beckmann et al., 1956)

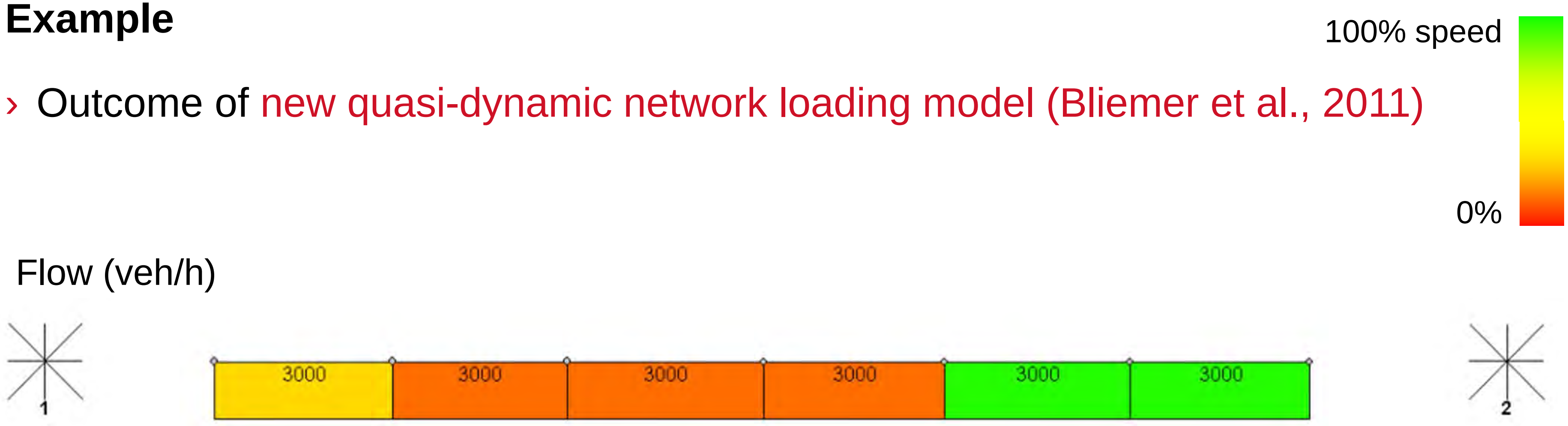
Flow (veh/h)



- Wrong flows, wrong location of the congestion, wrong speeds, wrong travel times
- These models are applied in 99% of the strategic planning studies
- The methods behind these models were established in the 1950s and have not changed much since (Wardrop, 1952; Beckmann et al., 1956; Frank and Wolfe, 1956)

Example

› Outcome of new quasi-dynamic network loading model (Bliemer et al., 2011)



› Correct locations of the queues, good approximations of the speeds and travel times

› Runs on large scale networks

Macroscopic static traffic assignment

› Travel times on road segments are often calculated using the Bureau of Public Roads (BPR) function:

$$c_a(q_a) = \frac{L_a}{\theta_a}\left(1 + \alpha_a\left(\frac{q_a}{C_a}\right)^{\beta_a}\right)$$

$c_a =$ travel time on road segment a (h)

$q_a =$ traffic flow on road segment a (veh/h)

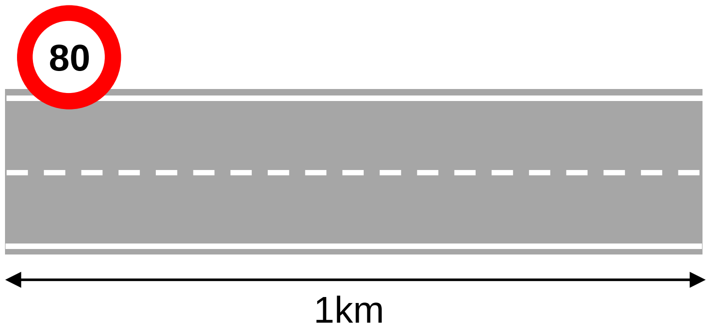
$L_a =$ length of road segment a (km)

$\theta_a =$ maximum speed of road segment a (km/h)

$C_a =$ capacity of road segment a (veh/km)

α_a, β_a parameters

$$c_a(q_a) = \frac{1}{80}\left(1 + 0.15\left(\frac{q_a}{4000}\right)^4\right)$$



Macroscopic static traffic assignment

- Traditional algorithms for finding a static user equilibrium assignment:
  - Frank-Wolfe (1956)
  - Method of successive averages (MSA)
- Faster algorithms have recently be proposed:
  - Origin-based assignment (Bar-Gera, 2002)
  - Projected gradient (Florian et al, 2009)
  - LUCE (Gentile and Noekel, 2009)
  - TAPAS (Bar-Gera, 2010)
  - Etc.

Macroscopic dynamic traffic assignment

› Adopts a proper link model

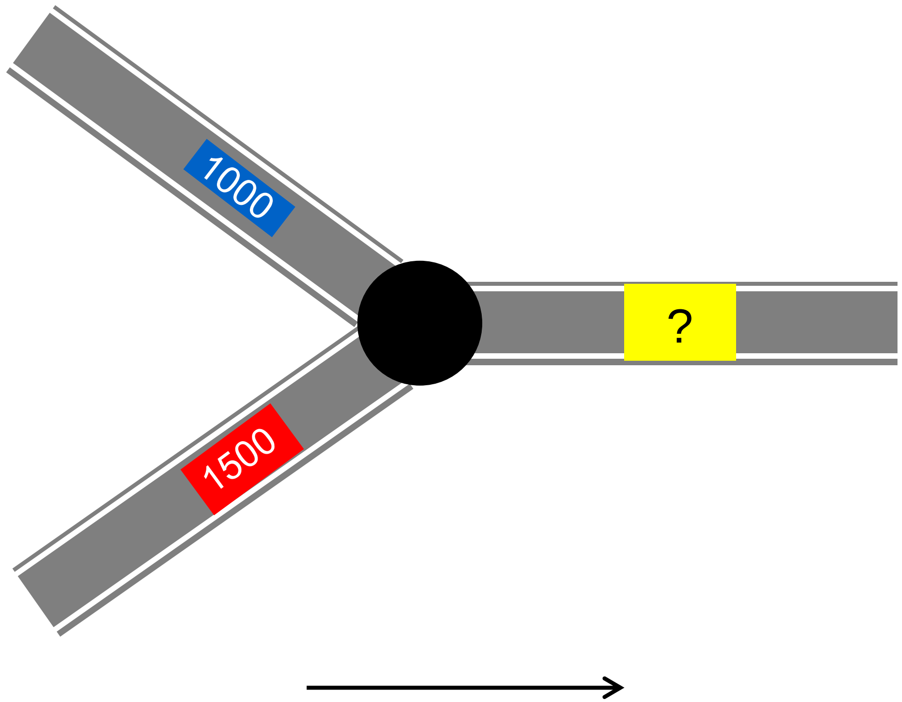
- General macroscopic first or second order link model
- Mostly based on kinematic wave theory (Lighthill and Whittam, 1955; Richards, 1956)
- Uses fundamental diagrams as input
- Can model physical queues and spillback

› Adopts a proper node model

- general macroscopic first order node model (Tampère et al., 2011)

Node model

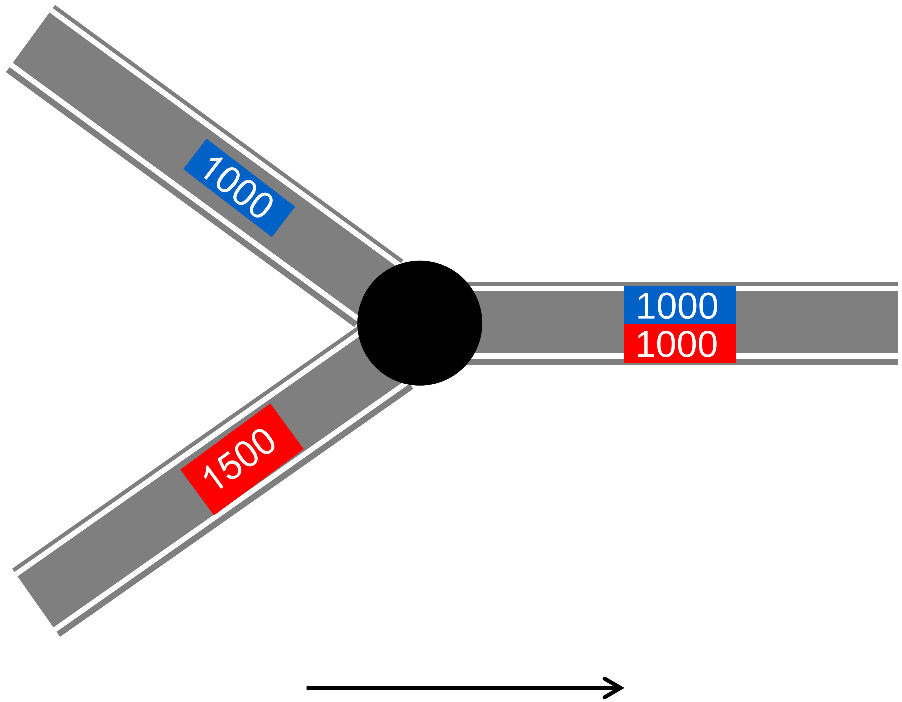
› Consider the following merge:



(capacity = 2000/lane)

Node model

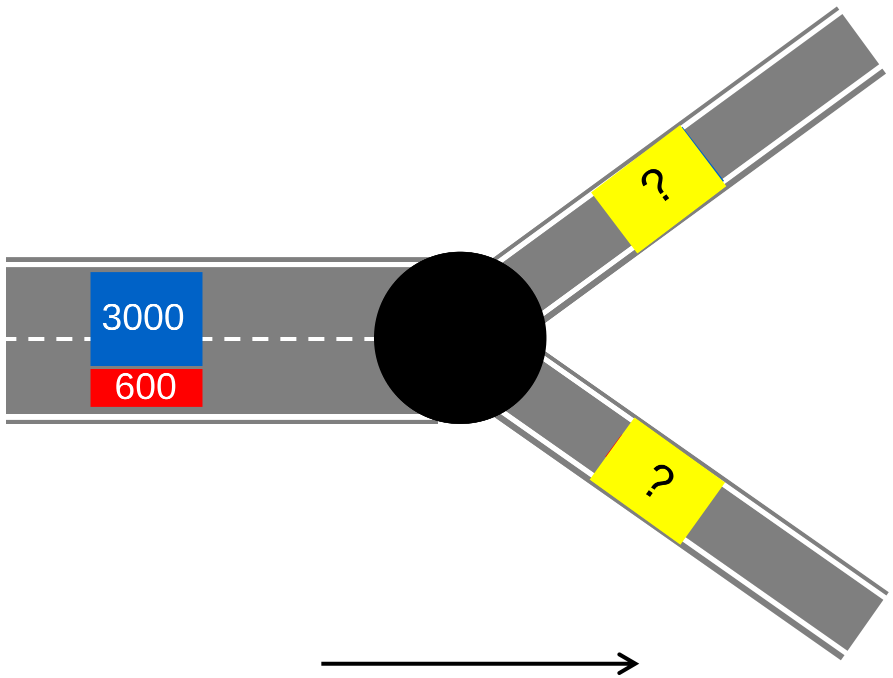
› Consider the following merge:



(capacity = 2000/lane)

Node model

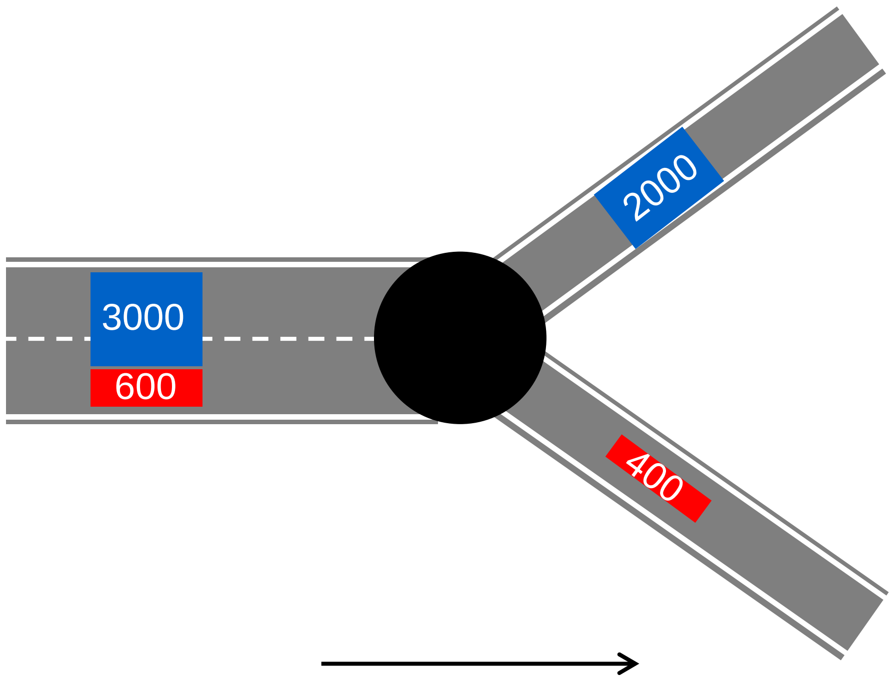
› Consider the following diverge:



(capacity = 2000/lane)

Node model

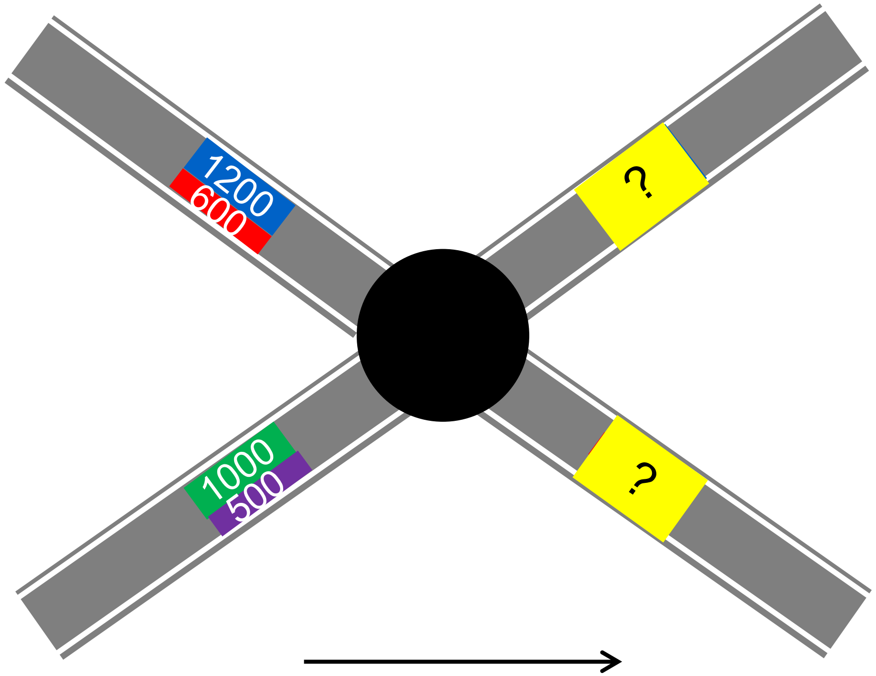
› Consider the following diverge:



(capacity = 2000/lane)

Node model

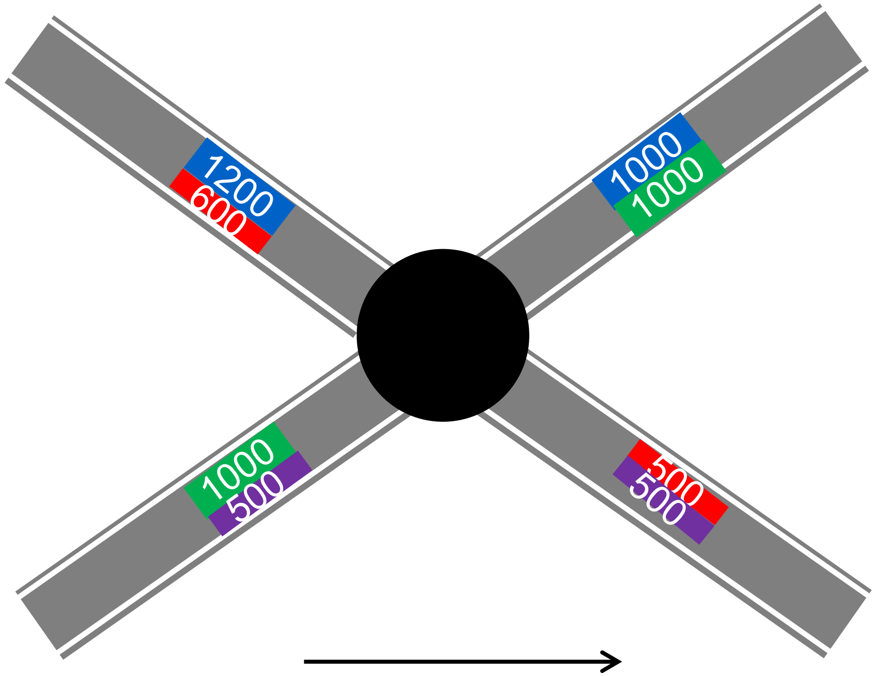
› Consider the following cross-node:



(capacity = 2000/lane)

Node model

› Consider the following cross-node:

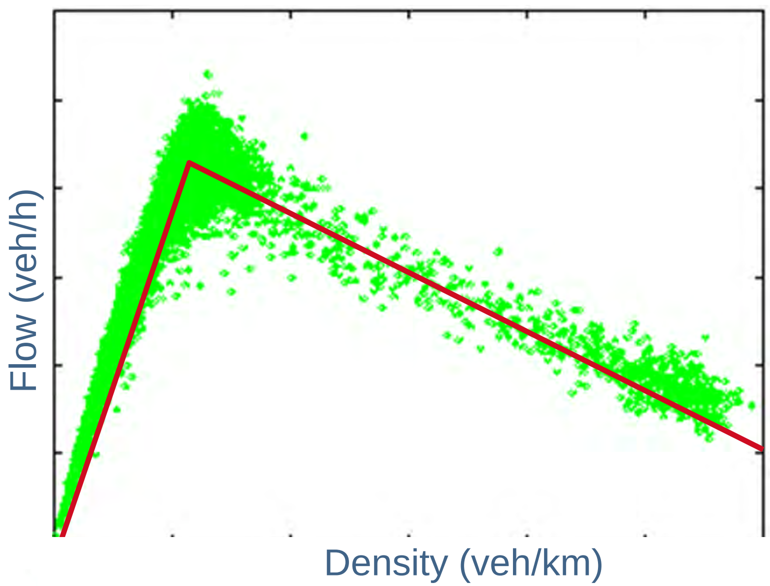


(capacity = 2000/lane)

(Tampère et al., 2011)

Macroscopic dynamic traffic assignment

› Several solution algorithms have been proposed
  - Cell transmission model (Daganzo, 1994, 1995)
  - Link transmission model based on Newell's simplified theory (Yperman, 2007)
  - Generalised link transmission model (Gentile, 2010)

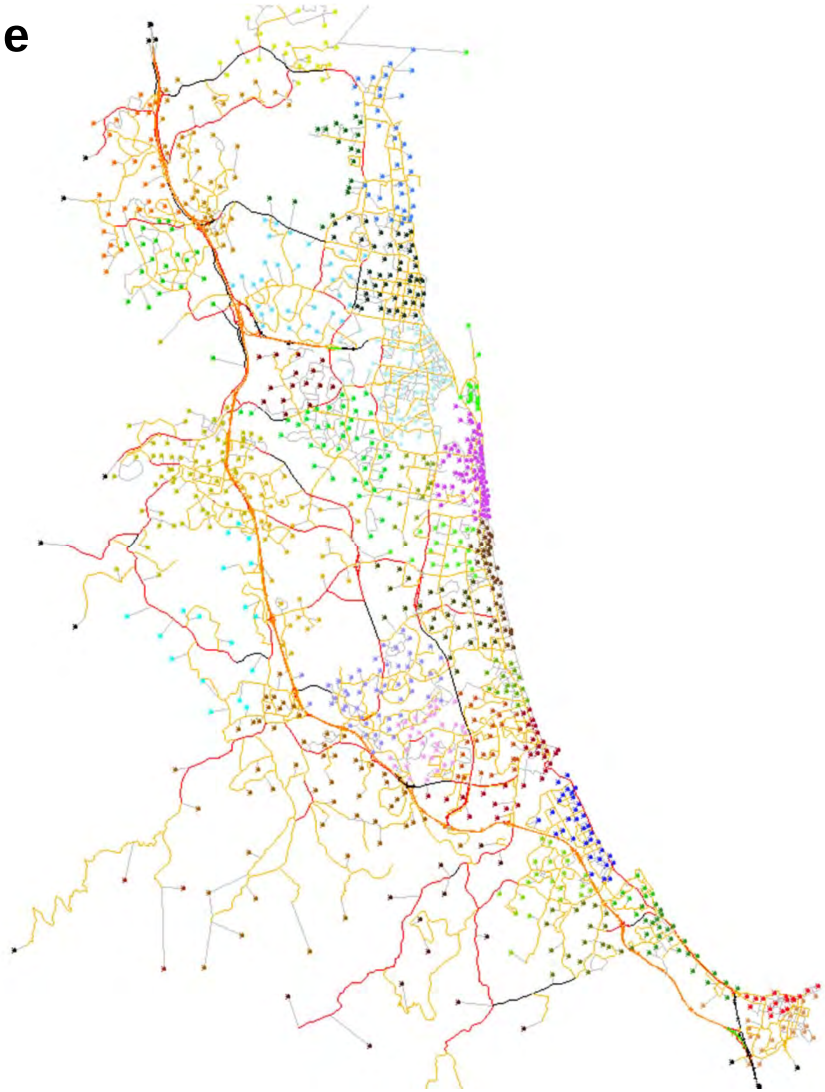


Quasi-dynamic traffic assignment

- Bliemer et al. (2013) have developed a static model that is derived from a dynamic model
- Base model (first order macroscopic model consistent with traffic flow theory)
  - generalised link transmission model (Gentile, 2010)
  - general node model (Tampère et al., 2011)
- Assuming the following static assumptions
  - stationary travel demand during a single time period
  - instantaneous traffic flow propagation in free-flow
- Leads to a novel more realistic static traffic assignment model
  - residual queues and queuing delays
  - capacity constrained link flows
- Work in progress (Bliemer, Raadsen, Smits, Brederode, Wismans, Zhou, Bell)

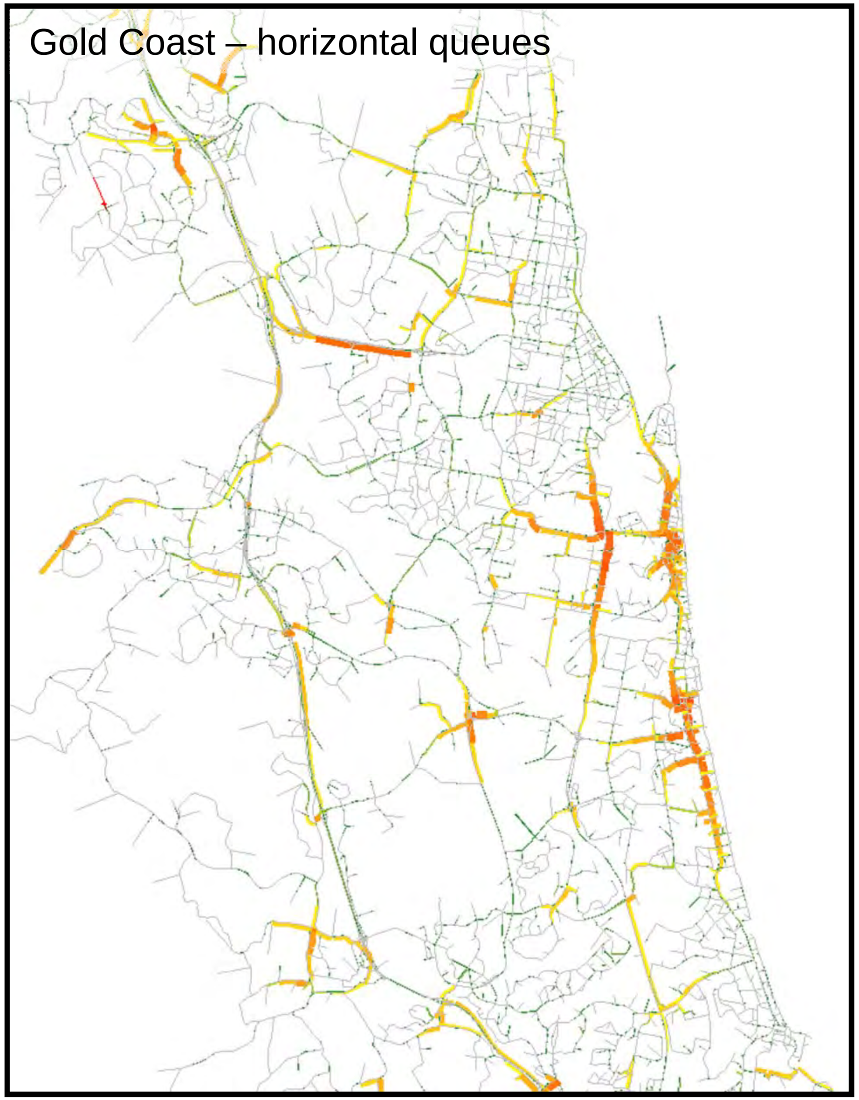
Quasi-dynamic traffic assignment example

› Gold Coast network (medium-sized)
› 1,067 zones
› 9,565 links



Example: Gold Coast

TRAFFIC SIMULATION



WHERE IS THE FIELD GOING?

11

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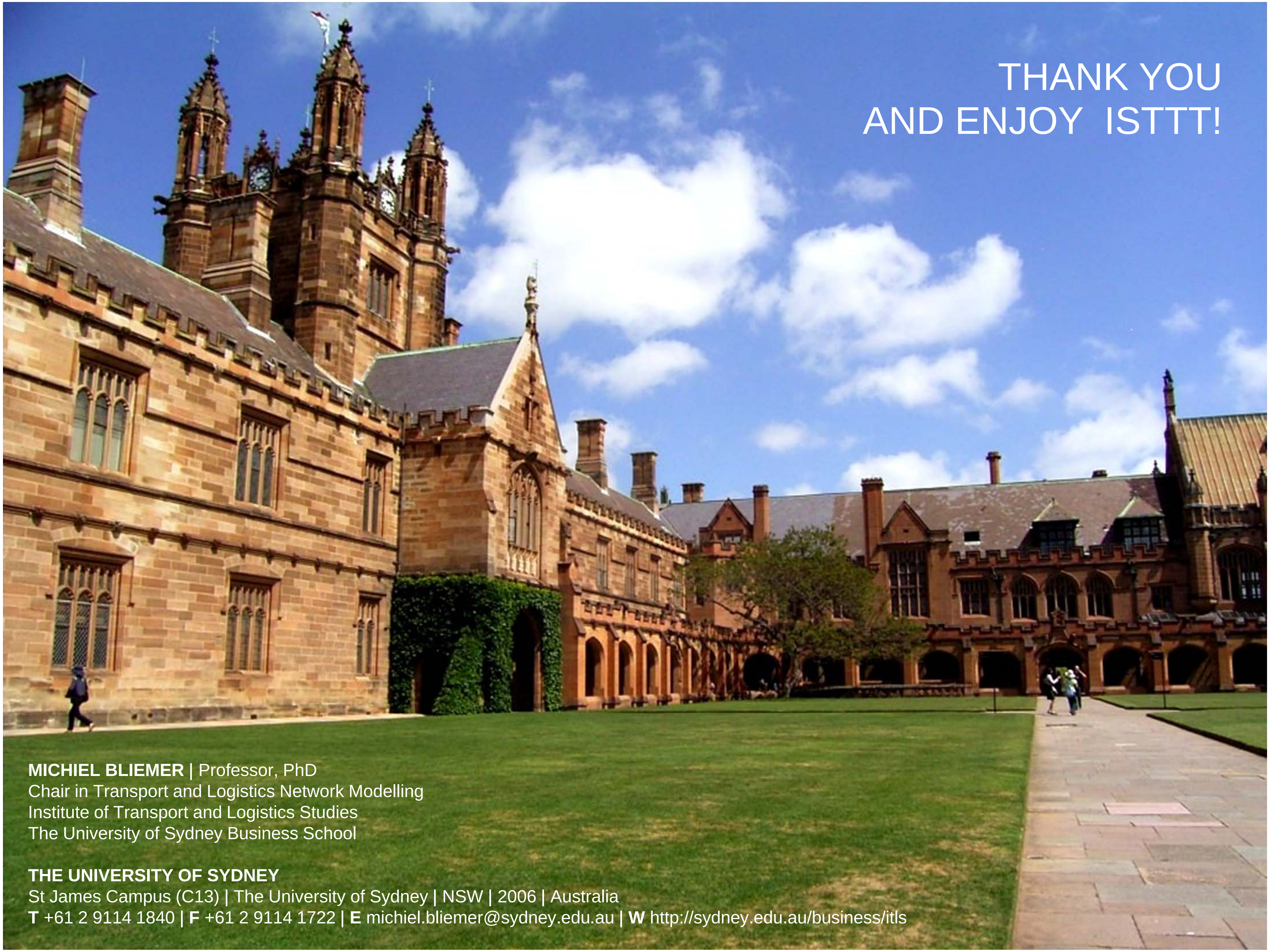
WHERE IS THE FIELD GOING?

Developments in transport planning models

› Demand models
  - Disaggregate discrete choice models including departure time choice (mainly Europe)
  - Activity based models (mainly USA)
  - More travel (behaviour) data available through new technologies (GPS, Mobile phone)
  - Inclusion of travel time reliability for cost-benefit analysis

› Supply models
  - Quasi-dynamic models replacing static models
  - Mesoscopic dynamic models increasingly popular
  - Consistency between macro, meso, and micro models increasingly important

› Challenges
  - Network design (road pricing, infrastructure extensions, new transit services)
  - (dynamic) OD estimation
  - Freight transport



THANK YOU
AND ENJOY ISTTT!

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