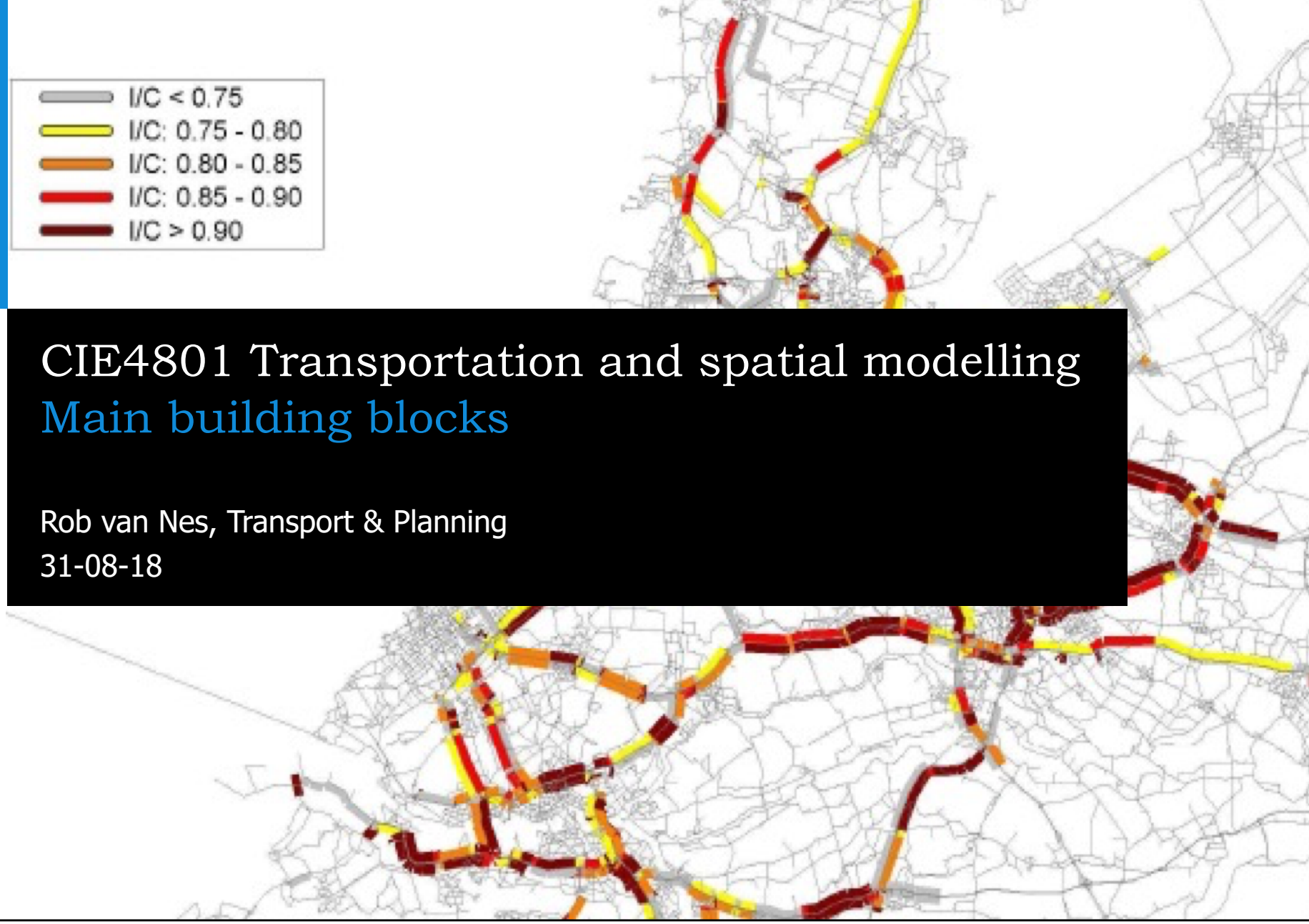


CIE4801 Transportation and spatial modelling

Main building blocks

Rob van Nes, Transport & Planning

31-08-18

Agenda

- Homework and leftovers
  - Three comments
  - 4-step model structure
- Main building blocks
  - Zones
  - Modelling unit
  - Networks
  - Data

1.1

Three comments to start with

Three comments to start with

- Modelling as a concept
- Civil engineering approach
- There's math in this course

1: Modelling as a concept

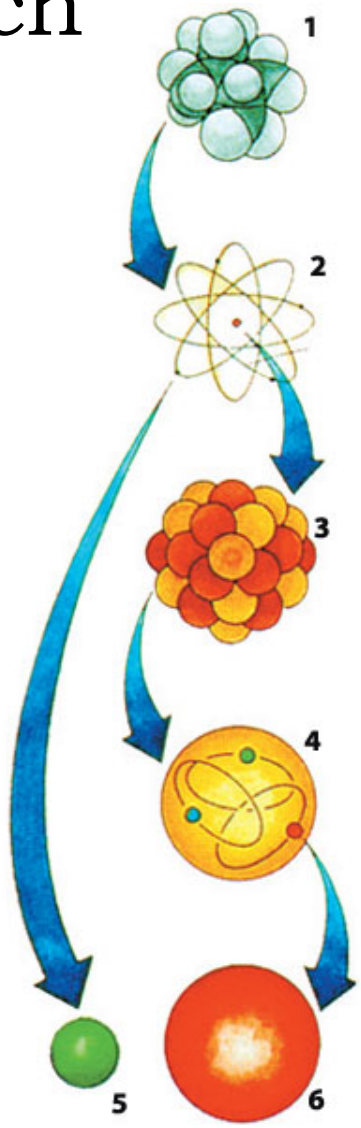
- Models are tools you use for different purposes
- It is not only about having an as accurate model as possible, it is also about usefulness
- And there are more comments to make on modelling. Please read this short essay:
  - Epstein, J. M. (2008). Why model? *Journal of Artificial Societies and Social Simulation, 11(4),* 12. http://jasss.soc.surrey.ac.uk/11/4/12.html.

Comments?

- Personal selection of quotes
  - Explicit models can be written down and can be calibrated using data
  - Feasibility of sensitivity analysis
  - Do not obviate the need for judgement but can discipline the dialogue
  - Models can be data driven, but often theory precedes data collection
  - Many simple beautiful models form the conceptual foundations of their respective fields.
  - All models are wrong, but some are useful
  - Seemingly unrelated processes have formally identical models
  - Models can surprise us, make us curious and lead to new questions
  - It enforces a scientific habit of mind
  - Intellectuals have a solemn duty to doubt and to teach doubt

2: “Civil engineering” approach

- Decomposition
  - Material
  - Molecule
  - Atom
  - Protons, neutrons, electrons
  - Etc.
- For each component there might be different options



Overview of approaches for demand modelling

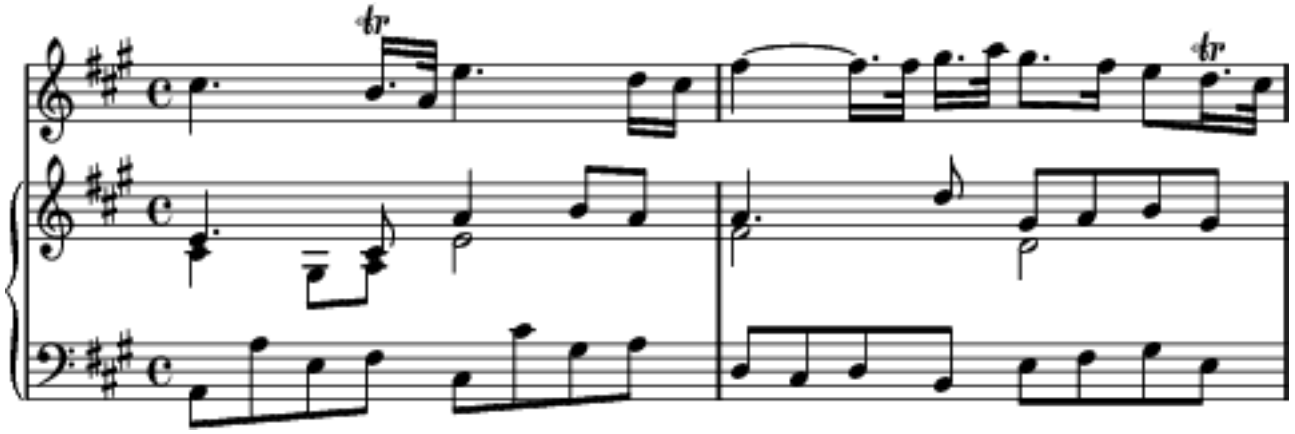
"Material"	"Molecule"	"Atoms"		
		Descriptive models/ Aggregate models		Choice modelling/ Disaggregate models
Transport demand models	Trip generation	A	B	I
	Distribution	C	D	II
	Modal split	E		III
	Time of day	F		IV
	Assignment	G	H	V

Consequences

- Make sure you grasp the relationships 'material-molecule-atom'
- Suggestion 1: make for each 'molecule' an A4 with
  - Input, output, key process, 'atoms' plus key characteristics, practical issues, links with other 'molecules'
- Suggestion 2: formulate possible exam questions for each 'molecule' itself as well as for the link with the 'material' or 'atoms'

3: There's math in this course....

$$\ln(T!) - \sum_{ij} \ln(T_{ij}!) + \sum_i \lambda_i \cdot \left(P_i - \sum_j T_{ij} \right) + \sum_j \lambda_j \cdot \left(A_j - \sum_i T_{ij} \right) + \beta \cdot \left(C - \sum_i \sum_j T_{ij} \cdot c_{ij} \right)$$



Why math?

- Math provides the most accurate description of models
- Mathematical derivations demonstrate essential assumptions
- For those of you who would like to go in more detail the basics of the model formulations should be familiar
- Of course there will also be students having different interests
- Therefore:
  - Derivations are not part of the exam
  - You're allowed to bring a formula sheet

So what kind of math do we use?

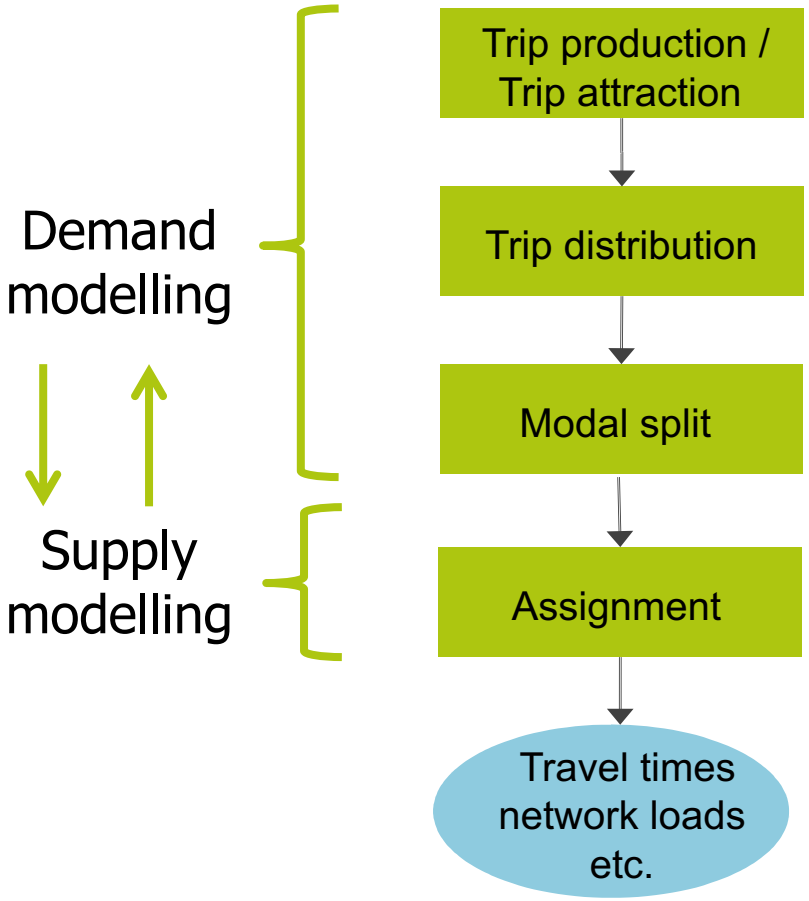
- Indices, summation and multiplication
- Exponential functions and logarithms
- Derivatives and integrals
- Maximisation and minimisation of objective functions
- Lagrange multipliers
- Maximum likelihood estimation, regression
- A bit of statistics: distribution function, mean, standard deviation

Check chapter 2 of the book for an update, if necessary

1.2

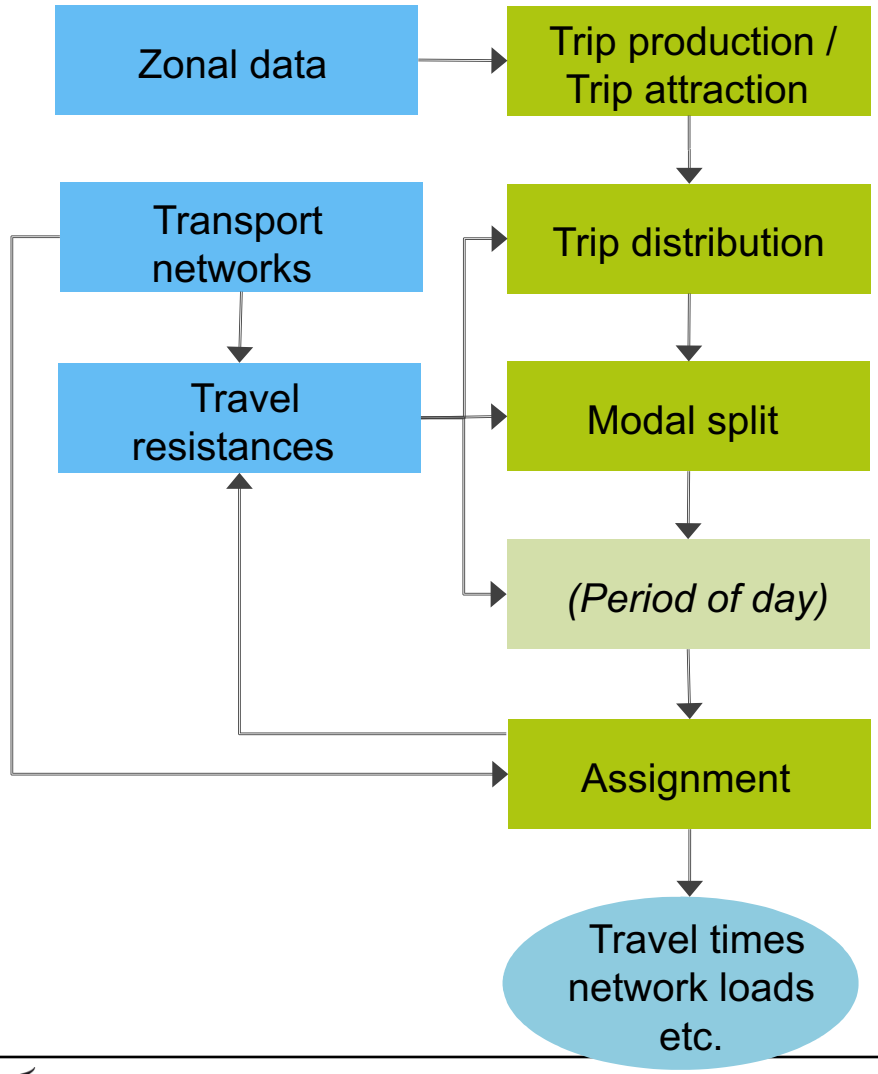
4-step model structure

Framework for transport modelling



- Logical?
- Additions?
- Alternatives?

Framework for transport modelling



Trip frequency choice

Destination choice

Mode choice

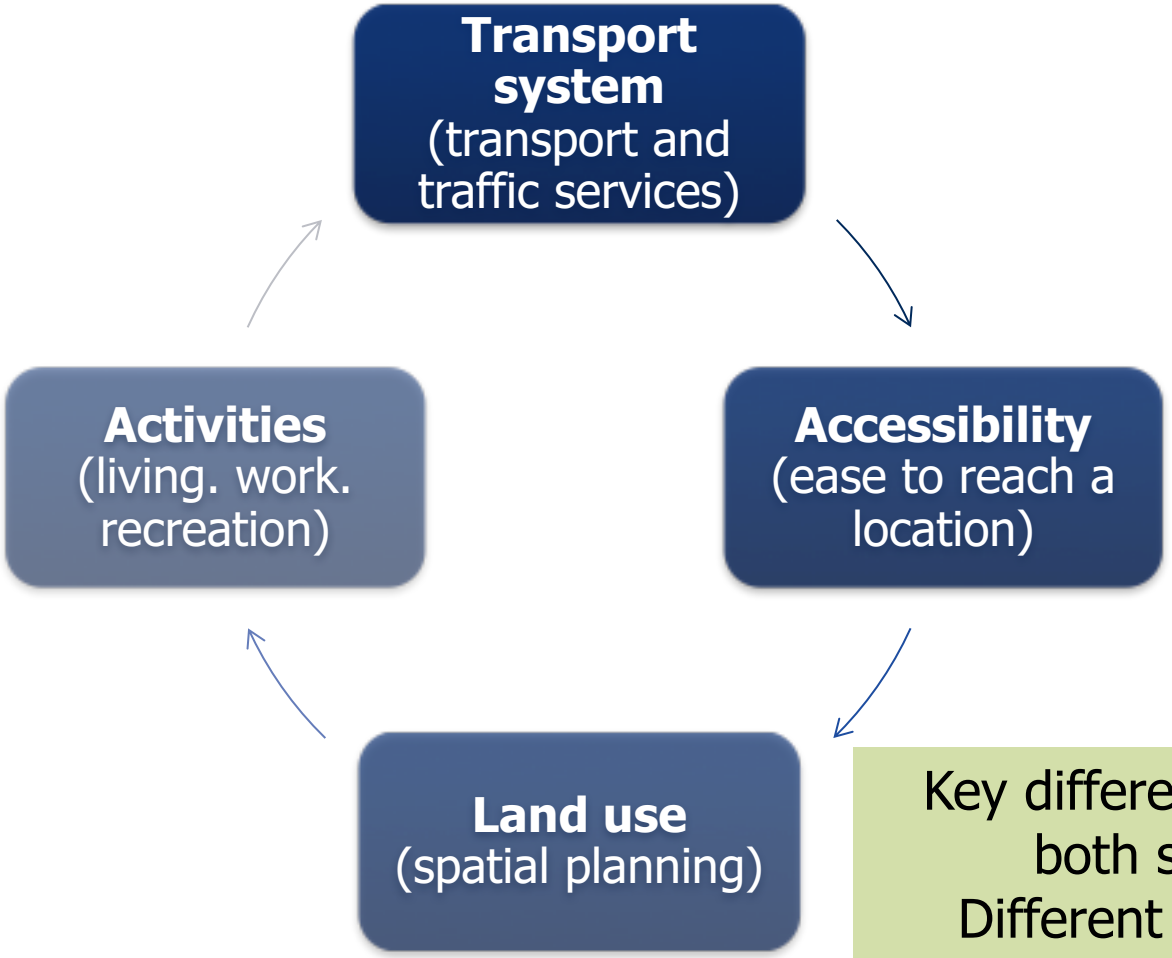
Time choice

Route choice

Questions

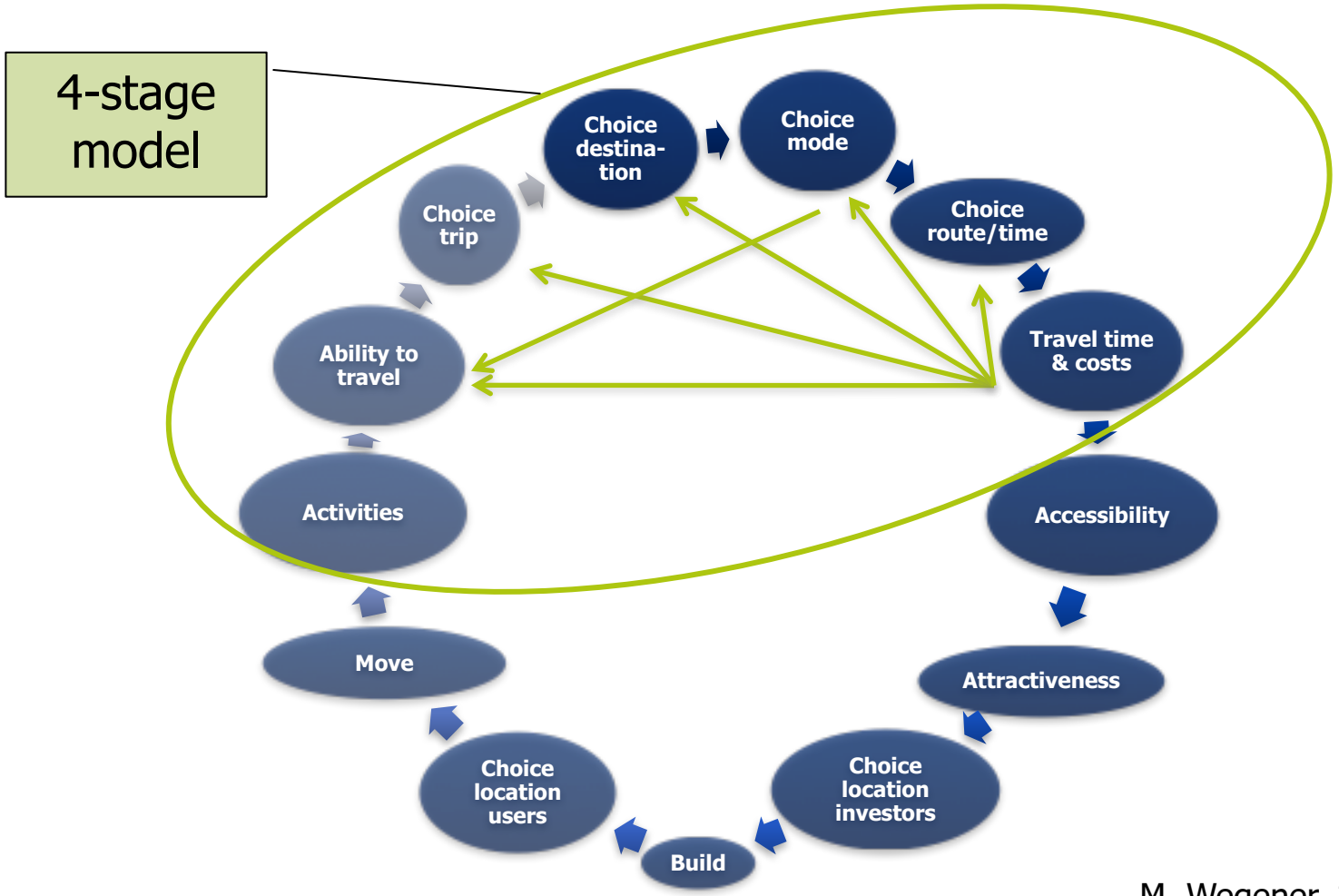
- Do you miss components?
- Are there too many components?
- Which component is unclear?
- Is there logic in the order of the components?
- What about the feedback in the scheme?
- How could you check the quality of the model?
- Where does OD-estimation fit in?

Relation transport system and spatial system



Key difference between both systems: Different time scales

In more detail: Wegener's circle

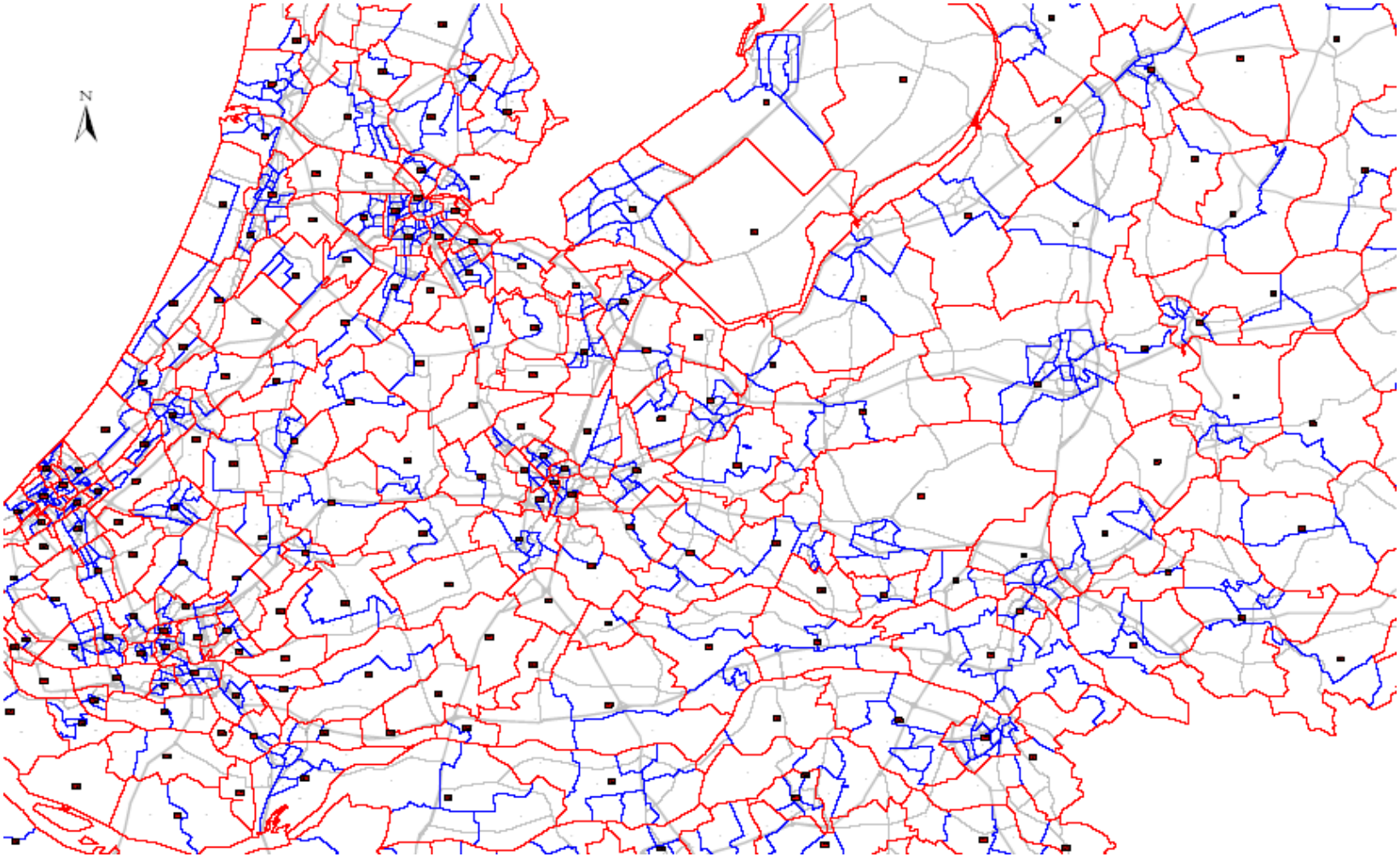


M. Wegener, 1995, 2004

2.1

Zones

Zones and transport models: example

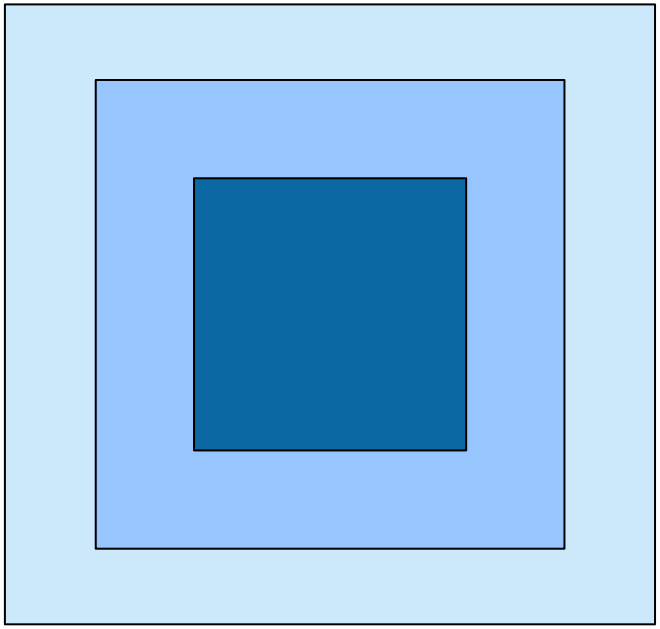


Zones and transport models: questions

- Why do we use zones?
- What are the requirements for a zone?
- What kind of data would you like to have for each zone?
- How large should a zone be?
- Are all zones similar in size?

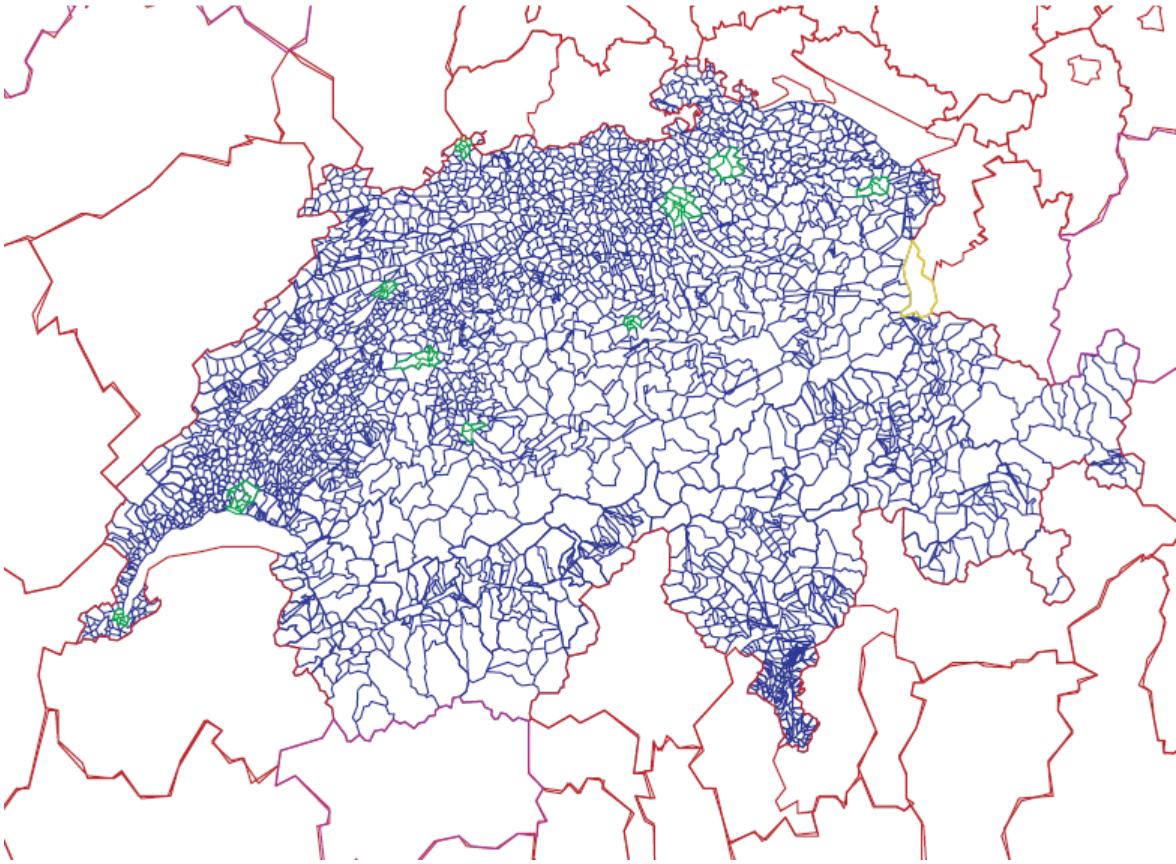
Which area do you model?

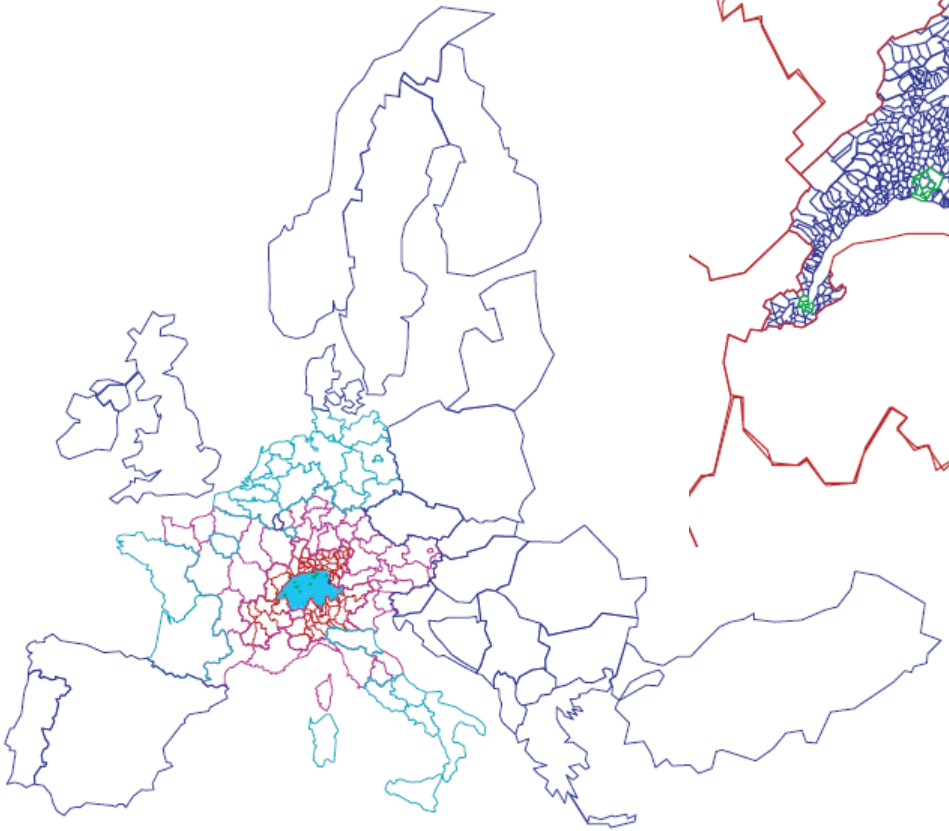
	Study area	Cordon
Study area	Internal	Out
Cordon	In	Through



	Study area	Influence area	External area
Study area	Internal	Out	Out
Influence area	In	Through and…..	Through and…..
External area	In	Through and…..	Through and…..

Swiss model





2.2

Modelling unit

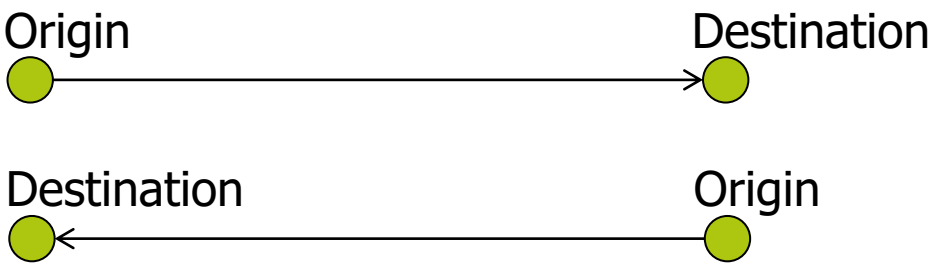
Modelling unit

Zone	Individual
Groups within zones	Individual types/Households

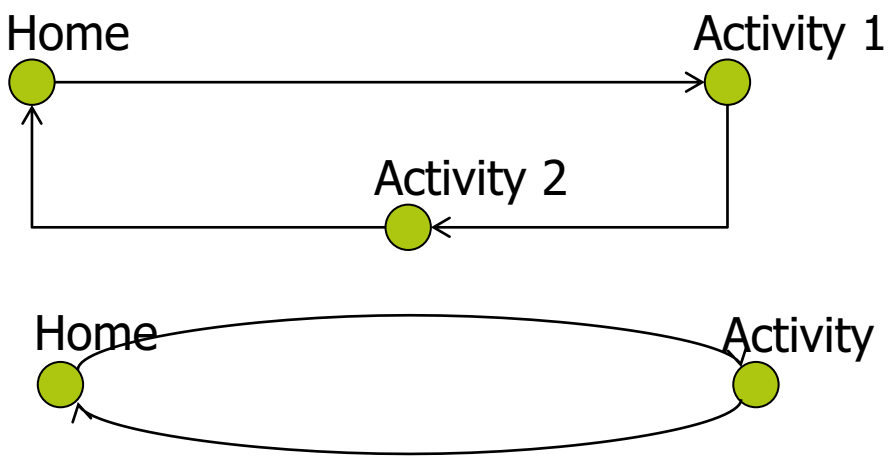
Aggregate or descriptive models	Disaggregate or choice models

What is modelled: trips or tours?

- Trip



- Tour

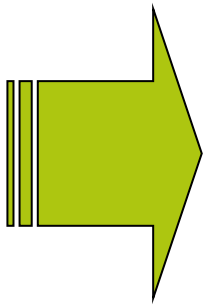


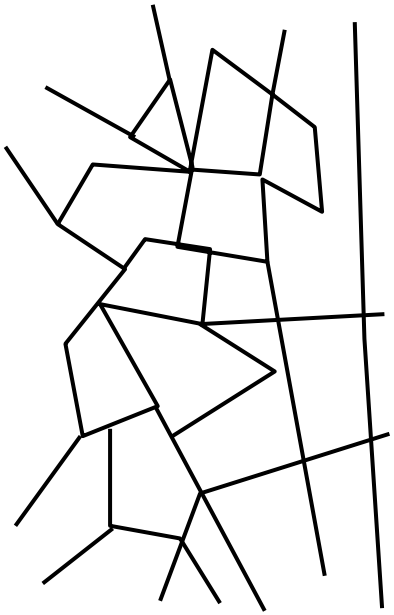
2.3

Networks

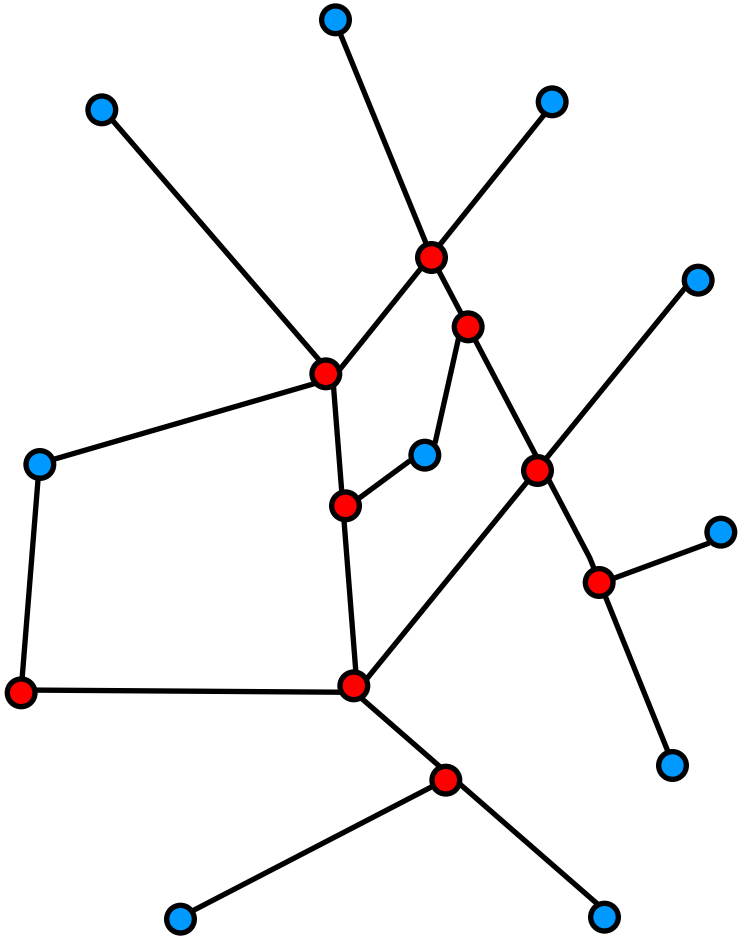
Constructing a transport network

Given a map of the study area,
how to represent the infrastructure and the travel demand in a model?





Network attributes

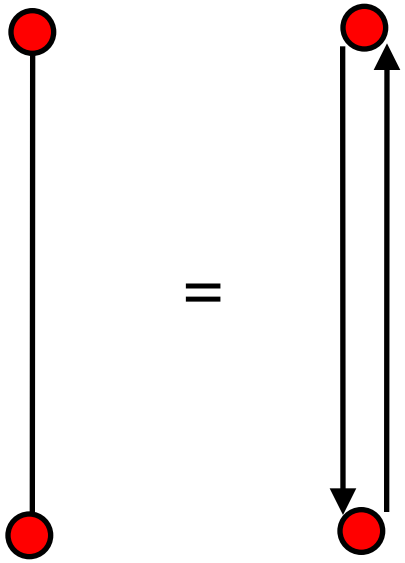


node
- x-coordinate
- y-coordinate

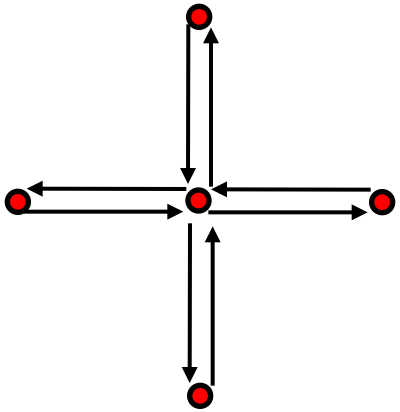
centroid node
- zonal data
- origin/destination

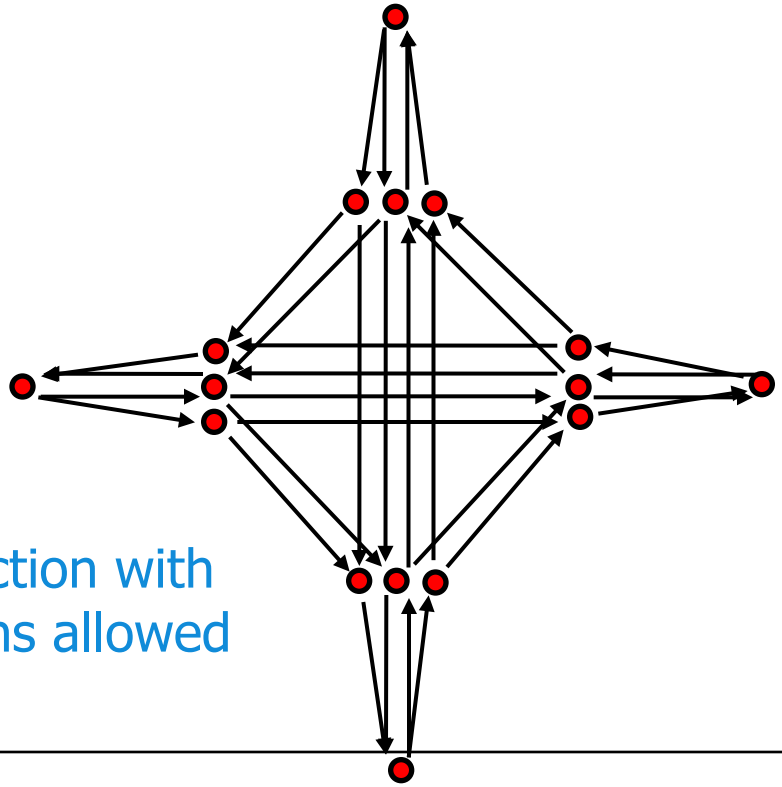
link
- node-from
- node-to
- length
- maximum speed
- number of lanes
- capacity

Links and junctions



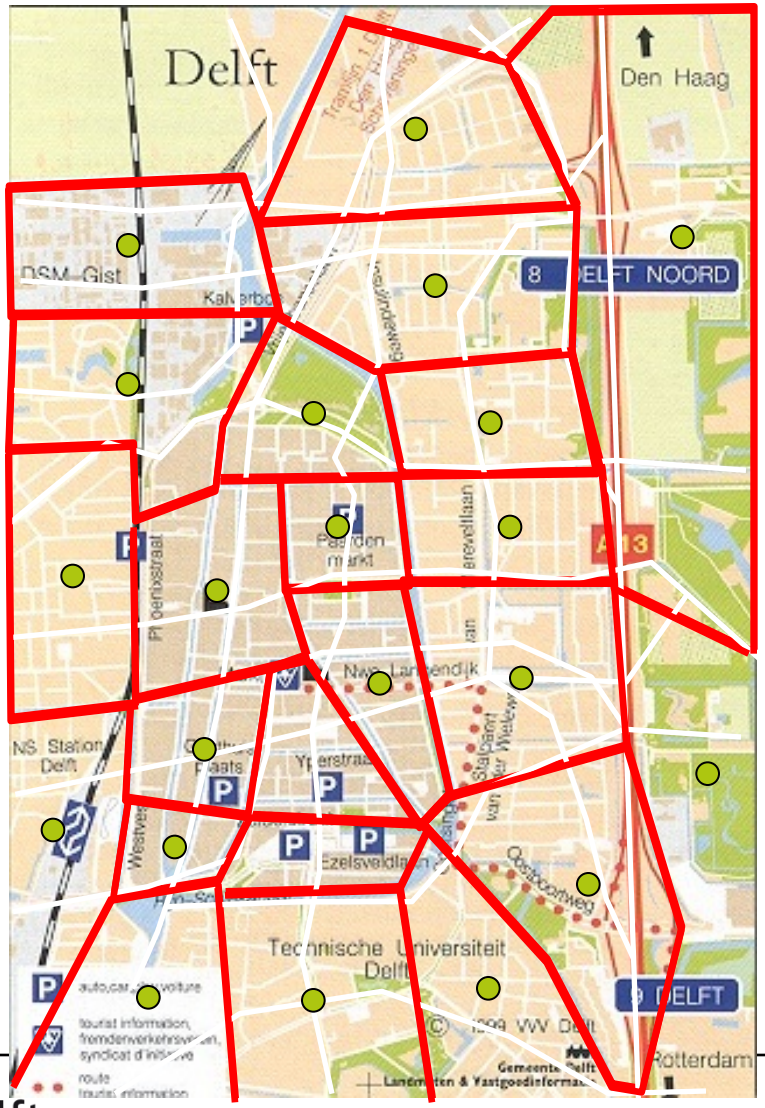
Junction with all turns allowed

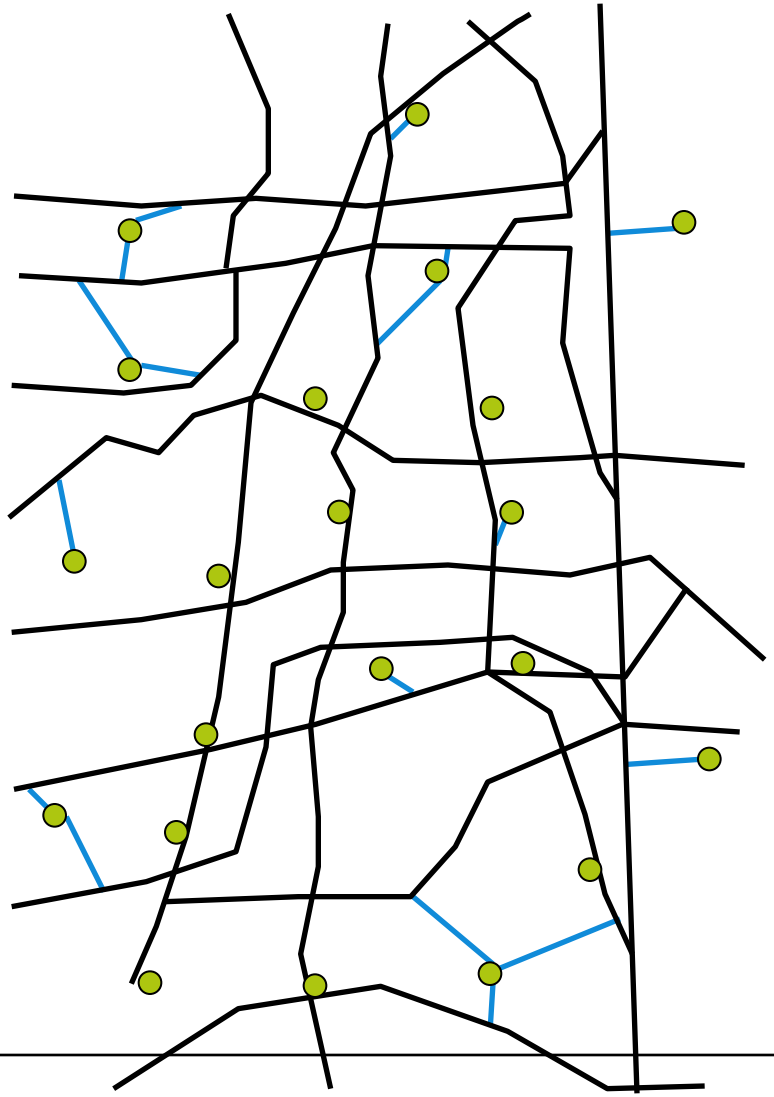




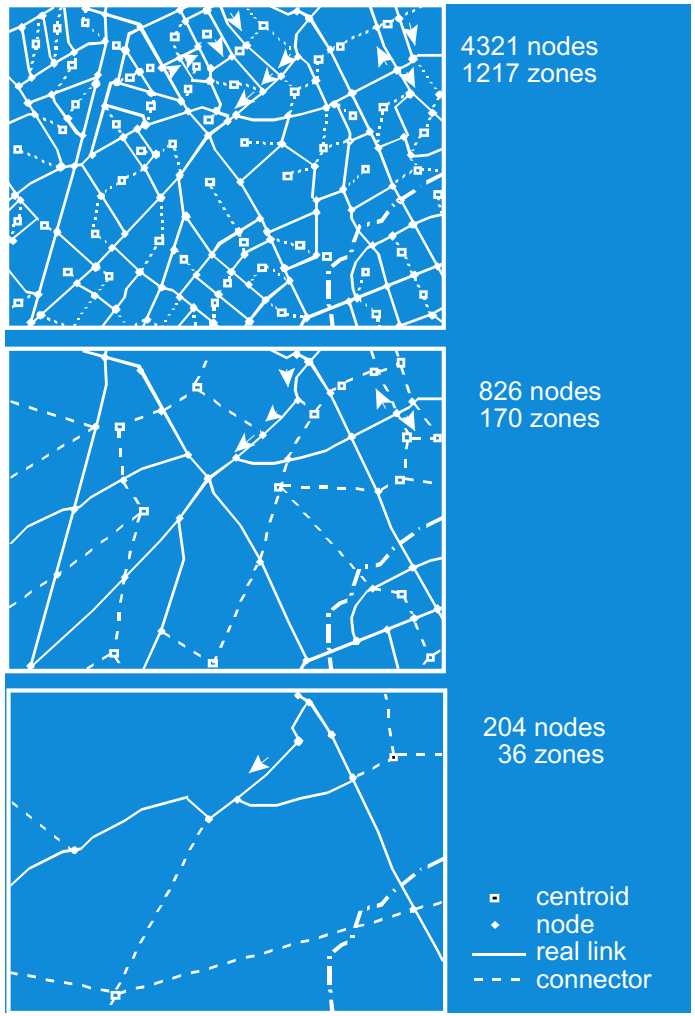
Junction with no left turns allowed

Define zones and select roads





Selection of links

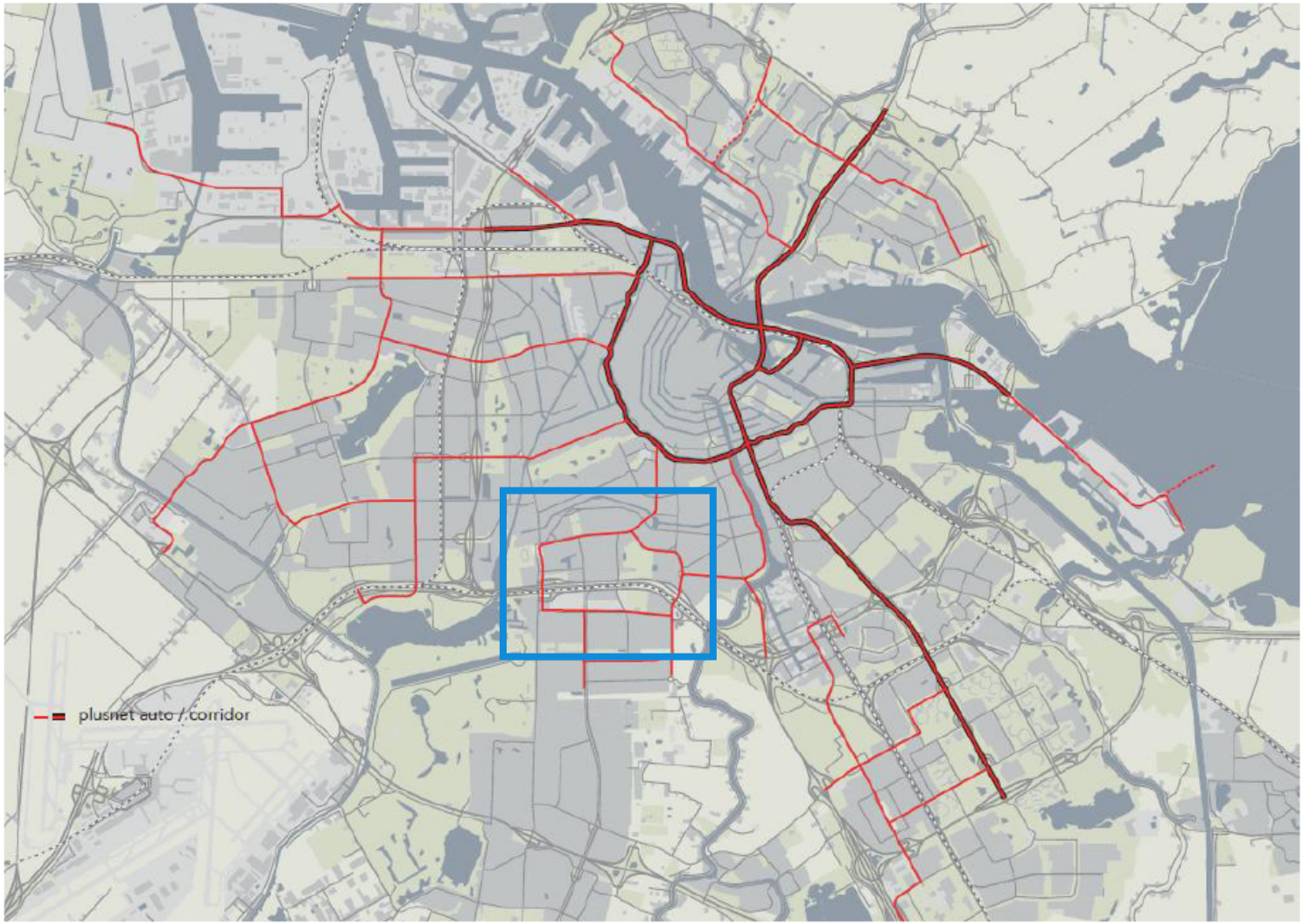


How many zones / nodes / links?

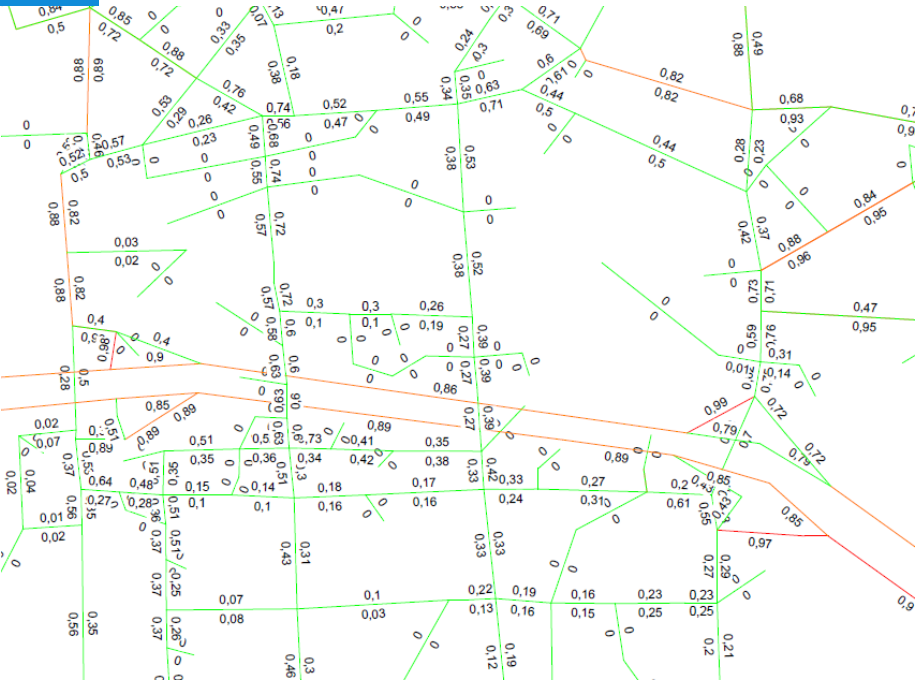
- depends on the application
- rule of thumb:
  include 75% of the network capacity
  (note: 20% of the network accounts for 80% of the travelled kilometers)
- alternative approach:
  include one network level lower than the network you're interested in.

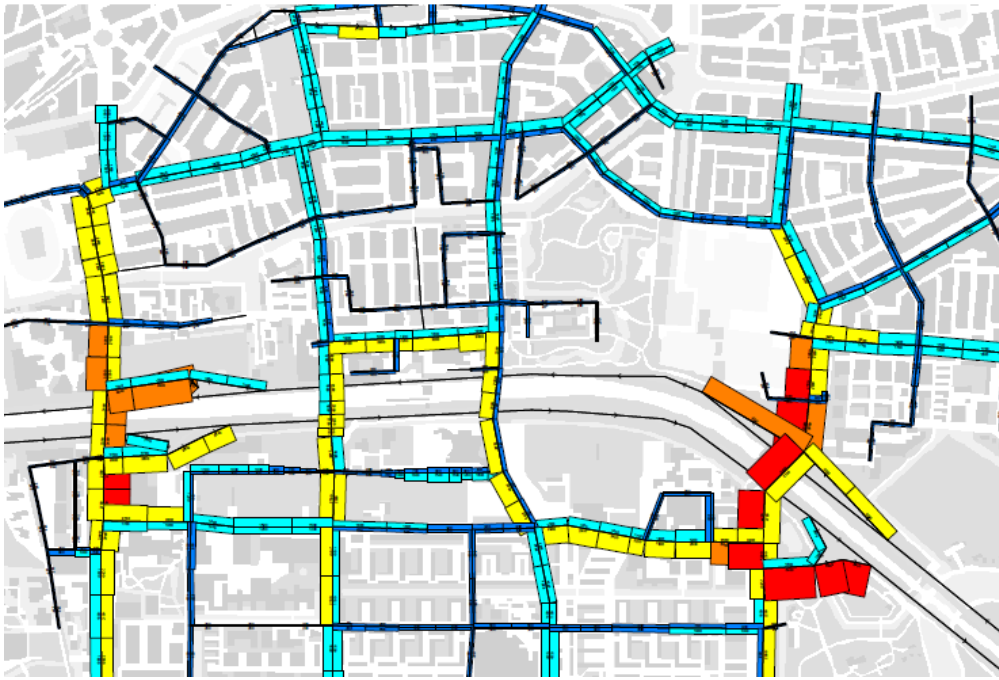
modelling
=
the art of leaving things out

Which roads should be included?



Urban or regional model?

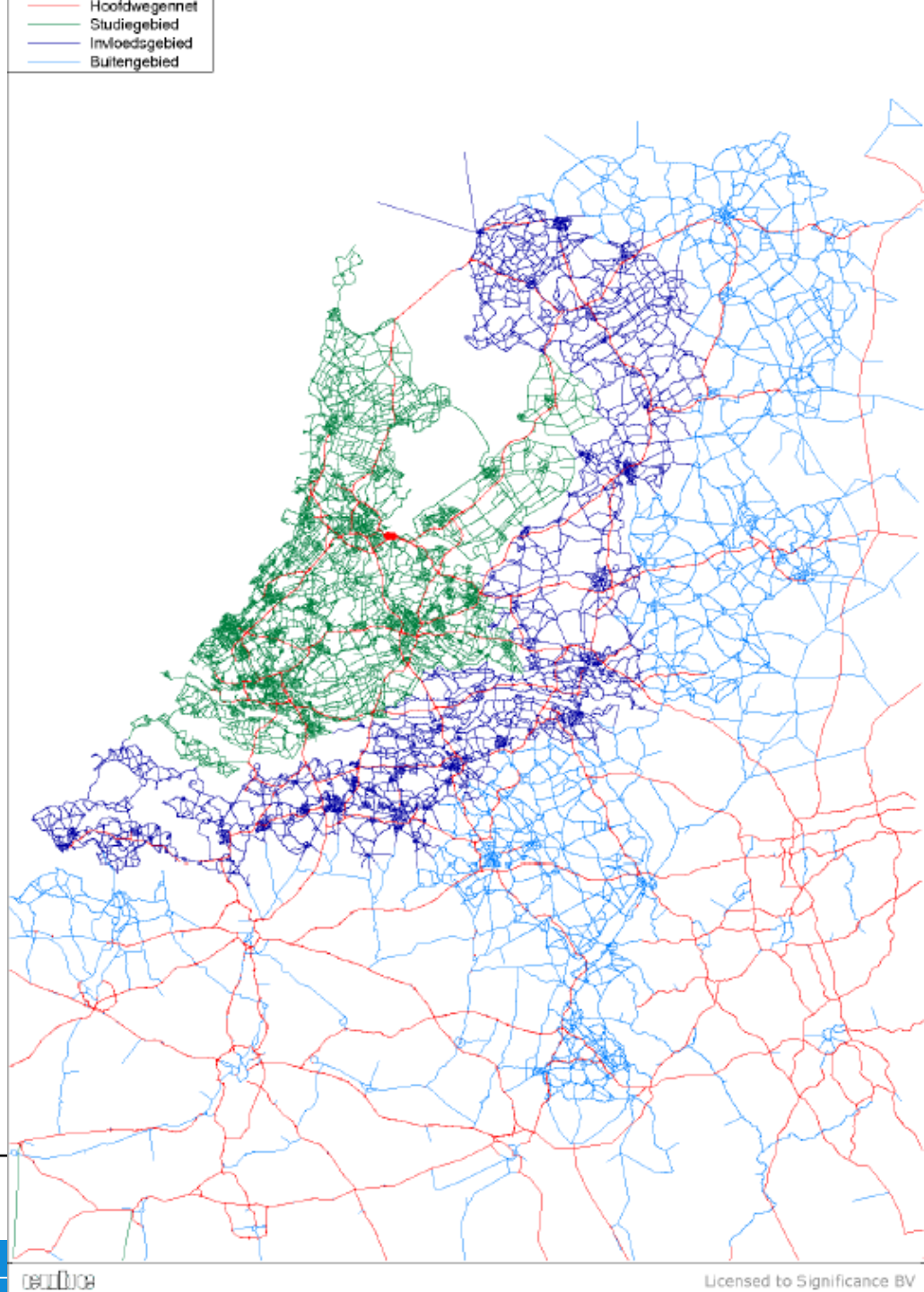




Regional

Urban

Example car network regional model



Public transport networks

- Link network plus public transport lines
- Link network: two functions
  - Access and egress, transfer
  - Infrastructure (road, rail) for public transport lines
- Public transport lines
  - Sequence of (infrastructure) links
  - Correction factors for link travel times
  - Stops
  - Line characteristics: frequency, one-way/two-way lines, fare system

Important issues

- Connecting the zones to the network:
  - Single connector or multiple connectors?
  - Connecting to which type of node/link?
- Choices have major consequences for the assignment to the network!

2.4

Data

Data needed for modelling

- Zonal data
- Network data

- Data from other models
  - E.g. regional model as input/constraint for an urban model
  - OD-matrix trucks from a freight transport model

- Date for modelling travel behaviour

- Data for modelling travel choice behaviour
  - To be discussed in Lecture 4

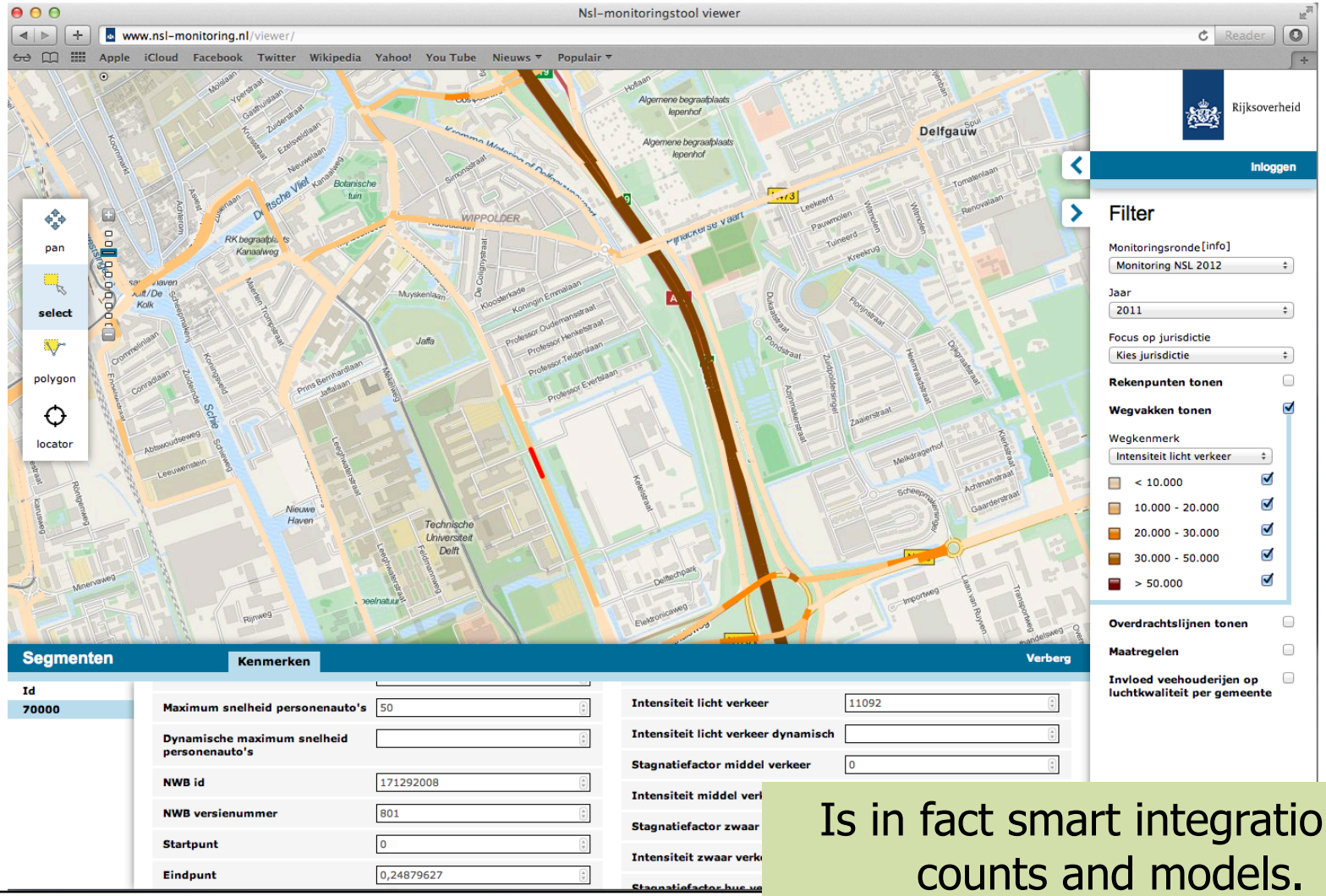
Data sources

- Traffic/Passenger counts
  - Road
  - Public transport
- Surveys
  - Roadside
  - Public transport
  - License plate
  - Household
- New data sources
  - Cell phones
  - Route planners
  - Chip cards

Counts versus surveys

- Counting seems simple
  - In practice quite a difference in quality
  - Limited number of locations
- Just numbers, no information on traveller
- Surveys focus on travellers
  - Road side surveys or PT surveys are still limited
  - Limited number of locations
- Household (or person) survey are most informative

Example traffic counts: NSL Monitor



Is in fact smart integration of counts and models.
Includes model forecasts as well.

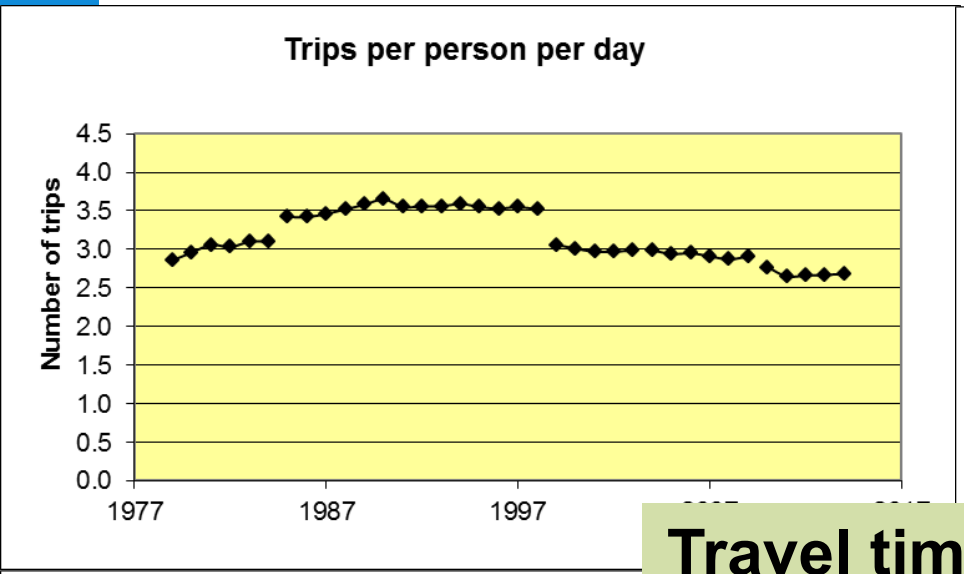
Example travel pattern from a survey

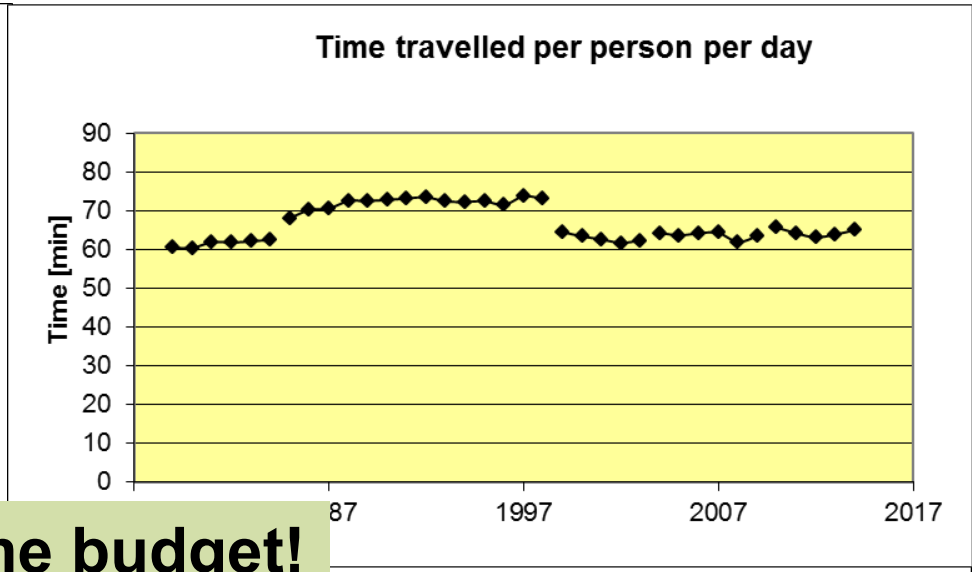
Departure time	Destination	Modes	Distance	Arrival time
06:32	To work	Bike, train, walk	28 km	7:20
	1. Train station	*Bike*	*2 km*	*6:40*
	2. Train station	*Train*	*25 km*	*7:10*
	3. Work	*Walk*	*1 km*	*7:20*
14:30	To home	Walk, train, bike	28 km	15:18
	1. Train station	*Walk*	*1 km*	*14:40*
	2. Train station	*Train*	*25 km*	*15:10*
	3. Home	*Bike*	*2 km*	*15:18*
15:23	Pick up kid from school	Walk	0,6 km	15:30
15:35	To home	Walk	0,6 km	15:44
19:27	Tour with a friend	Bike	19 km	20:43
23:55	Walk the dog	Walk	2 km	0:20

Survey issues

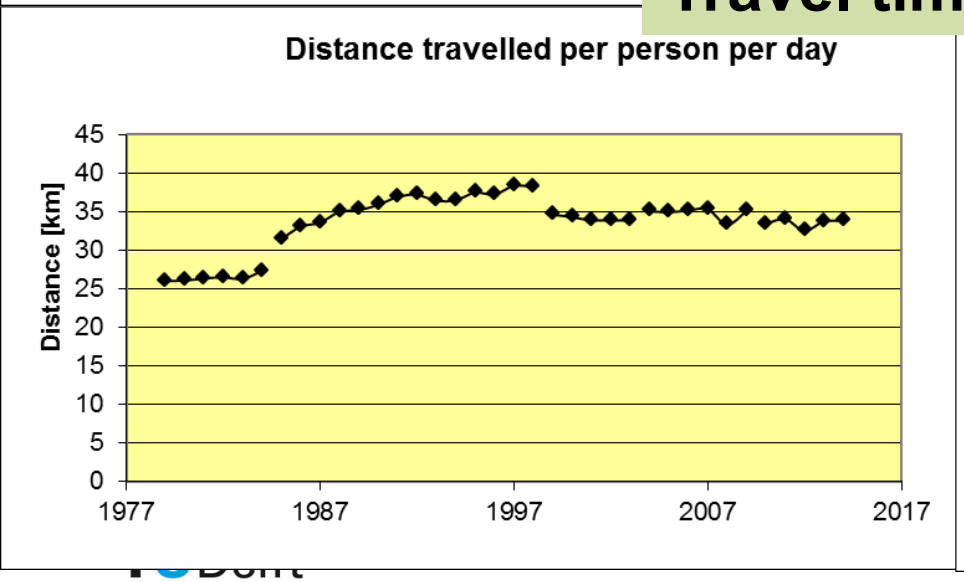
- Non-response / Non-reporting
  - Persons / specific trips
- In-/excluding kids <12 year
- Inconsistency in definitions and phrasing of the questions over time
- Splitting roundtrips or not
- Registration of frequent (professional) trips
- Pedestrians/cyclists

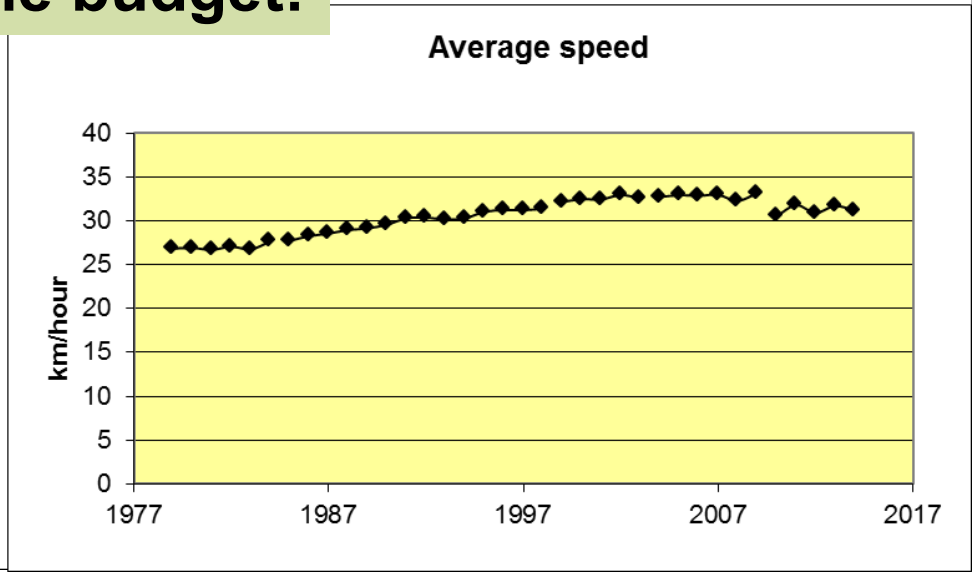
Travel characteristics Netherlands (MON)



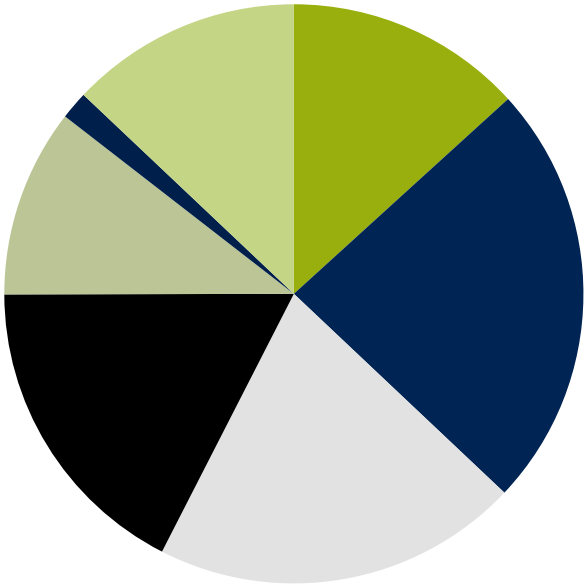


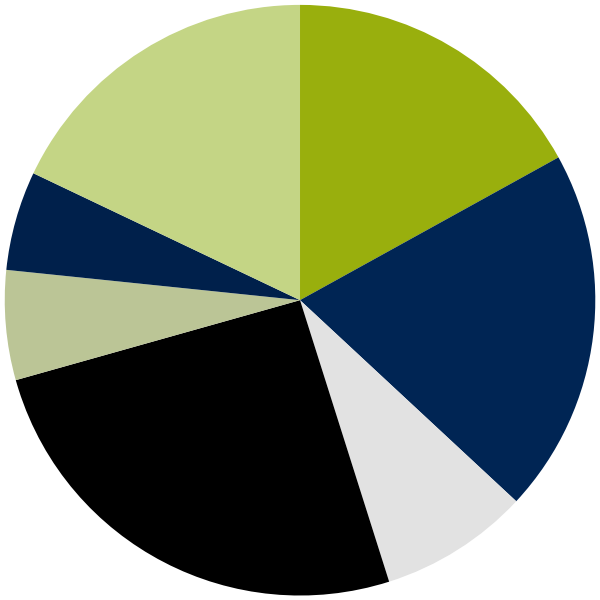
Travel time budget!





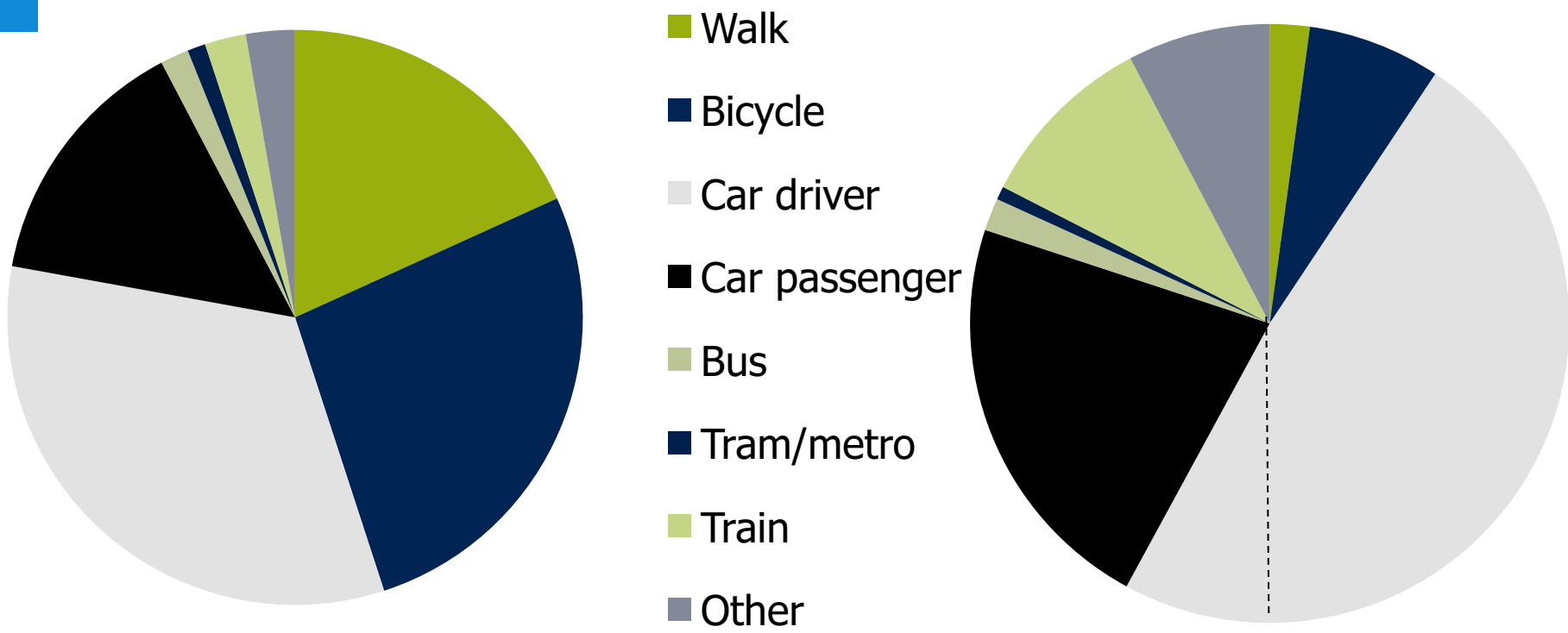
Trip purpose (Netherlands)
Trips and trip kilometres for an average day





Trip purpose is defined by the activity at the destination, except when the destination is home, then the activity at the origin is decisive

Modal split (Netherlands)
Trips and trip kilometres for an average day



Trip length distributions (Netherlands)