CIE4801 Transportation and spatial modelling
Beyond the 4-step model

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Content

- The 4-step model itself
  - When to use what?
  - Which components are criticised?
- Future of the 4-step model
- The 4-step model and other models
- Extending the 4-step model to other topics

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1.

The 4-step model itself

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4-step framework and dominant model types

Trip generation	
Regression	Stop & Go

Simultaneous distribution and modal split	
Gravity model	Choice models

Assignment	
AON/stochastic	DUE
Cheap/simple	Best/complex

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4-step concept has more potential than just the model

- The modules are building blocks for more elaborate models as well

- You can use the distinction between the 4 steps for analysis purposes as well:
  - What's the demand that is produced/attracted?
  - Where do they come from/go to?
  - What is the role of the various modes?
  - Why do they use this road?

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Do you always need the full package?

- The order to use the modules is fixed
- However it depends on the research question which module you start with and/or which modules you skip

- If you're only interested in car?

Skip mode choice

- If you want to know the effect of a one-way street strategy?

Assignment only

- If you want to know the impact of changes in the PT-network

Mode choice and assignment

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Which components are criticised?

- Trip generation
  - Ignores actual behaviour with respect to activities => activity based
- Trip distribution
  - Not really criticised? Comment on quality OD-matrices raises a question
- Mode choice
  - Not really criticised
- Time of day
  - Still a bit simple?
- Assignment
  - Clear point of debate!

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What's wrong with the assignment?

- Modelling of long distance trips, e.g. The Hague – Arnhem in a peak hour
- The (non?) modelling of congestion
- The quality of the travel times
- Delays at junctions
- Debate on static assignment (as discussed so far) versus dynamic assignment

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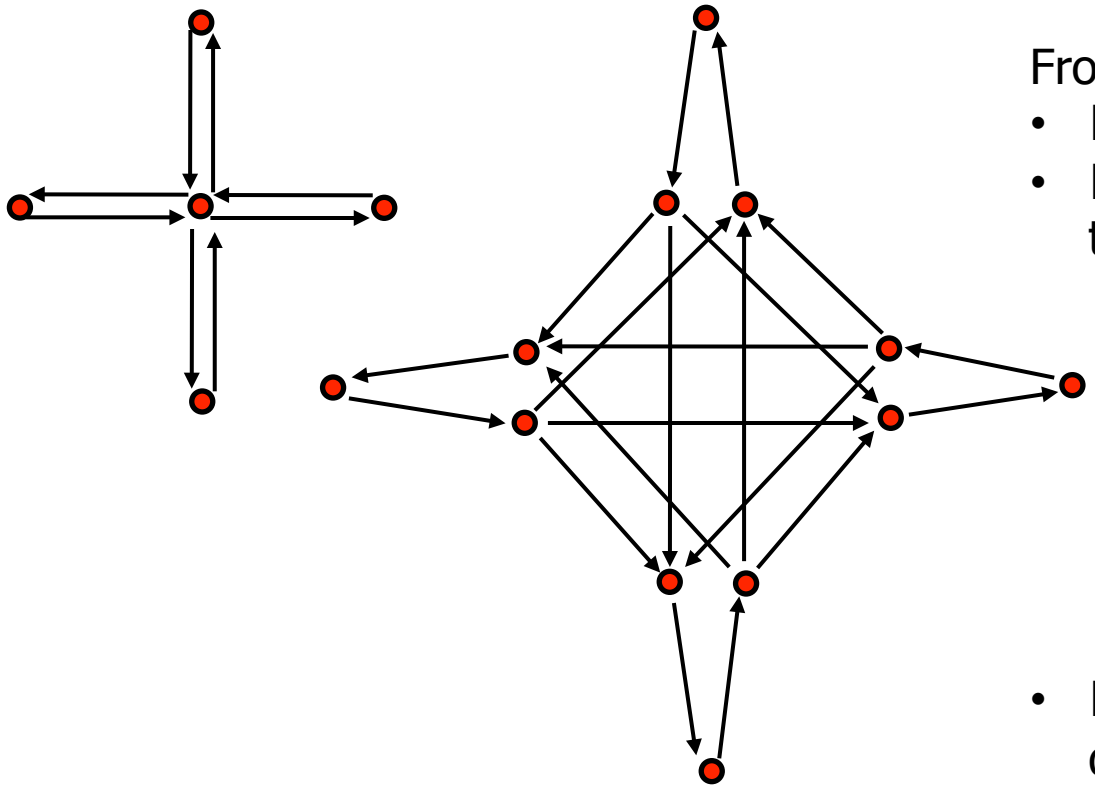
Junction modelling



From simple to complex

- Eliminate turns
- Define travel time functions per turn
  - Fixed capacity (number of lanes per direction)
  - Capacity depends on upstream node (merge, priority)
  - Capacity depends on green times
- Determine optimal green times during assignment

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Static model with dynamic characteristics: Qblok

- Main idea is to check for blocking back in every iteration of the DUE, e.g.
  - Select the link having the highest V/C ratio
  - Estimate the size of the queue
  - Check whether this influences upstream links and adjust travel times of upstream links (and determine difference potential demand flow and actual flow)
  - Repeat until all links having a high V/C ratio are dealt with

- STAQ is a new algorithm for incorporating blocking back that is based on traffic flow theory

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Real remedy: dynamic assignment

- Modelling the propagation of traffic through the network
- Thus
  - Model capacity as a hard constraint
  - Model the upstream shockwave of congestion and thus blocking back
  - Model the way congestion dissolves
- Consequences
  - More detailed data on networks (esp. for potential bottlenecks)
  - Data needed on departure times per zone (OD-pair)
  - More computation time

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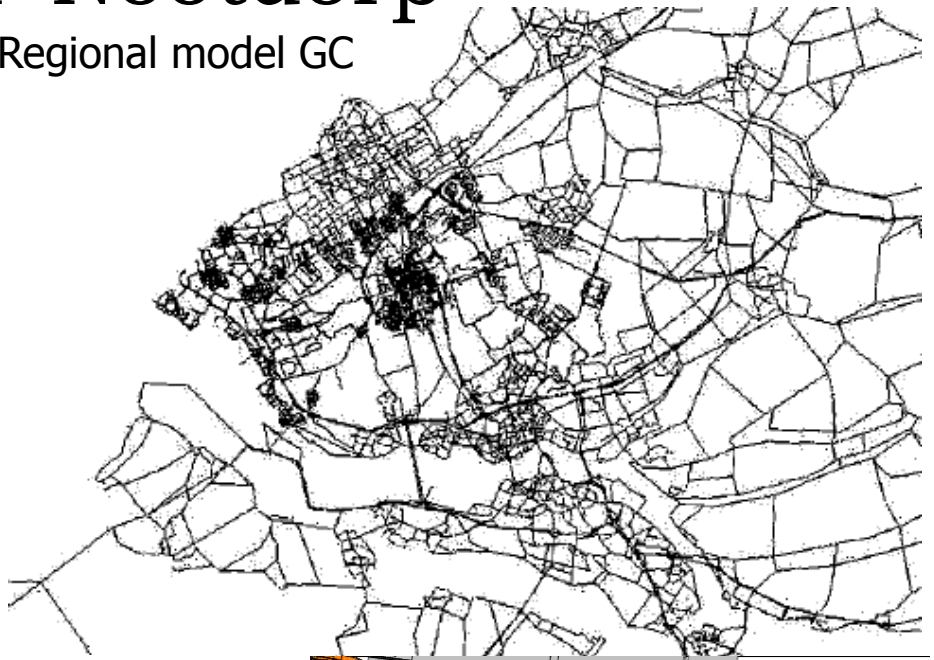
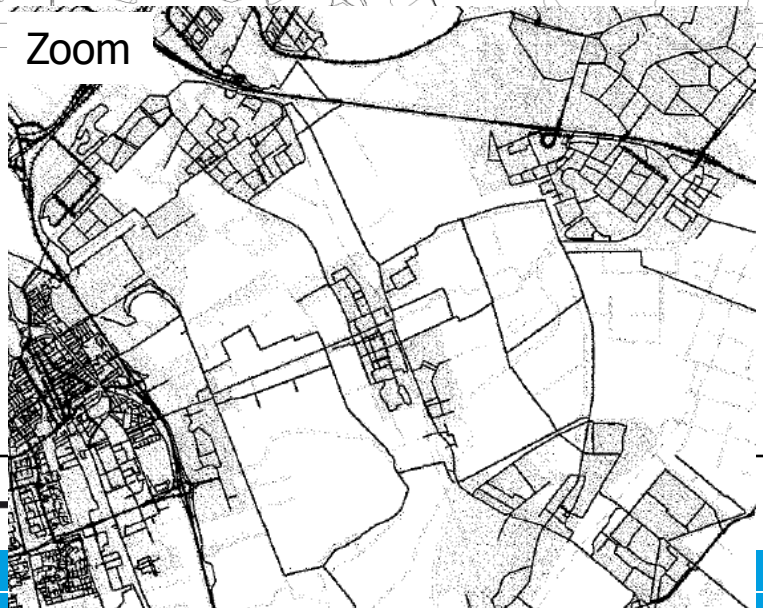
Example Pijnacker-Nootdorp

NRM

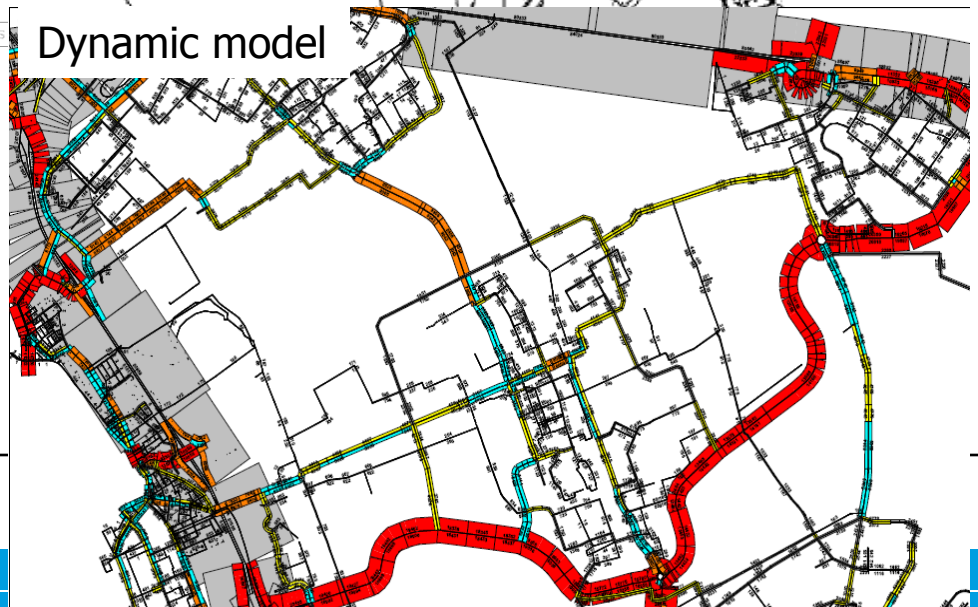
Regional model GC



Zoom



Dynamic model



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The future of the 4-step model?

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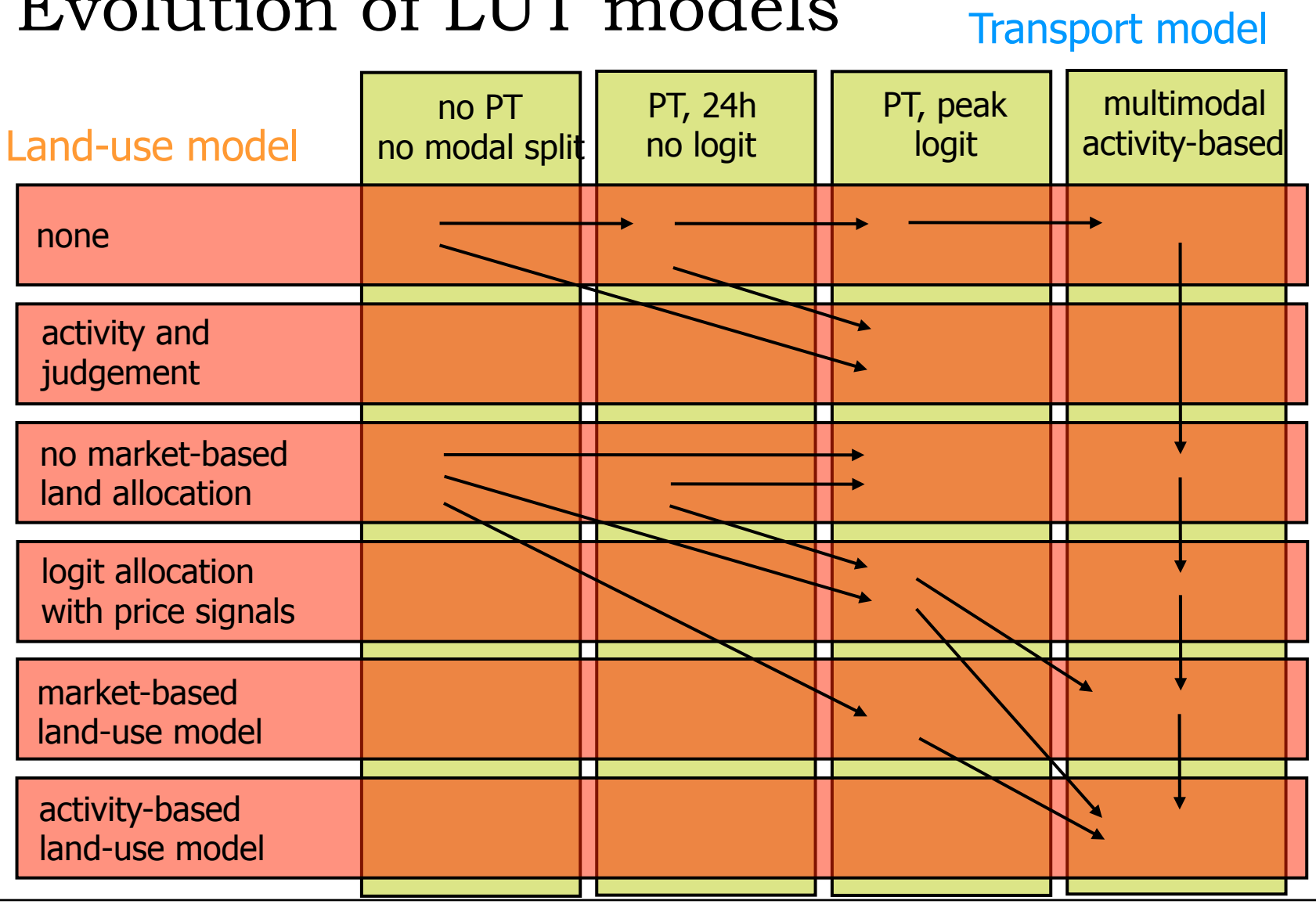
Evolution of LUT models



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Trends

- Dominant trend: more complexity, more detail
  - Requirement for practice
  - Models are being used for more than the purpose they were designed for (database)
  - Scientific research

- Yet, there's a need for small agile models
- Key question then is: what can be left out?
  Or is it about new modelling approaches?

- In both cases: remember Einstein:

  As simple as possible, but not simpler

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The 4-step model and other models

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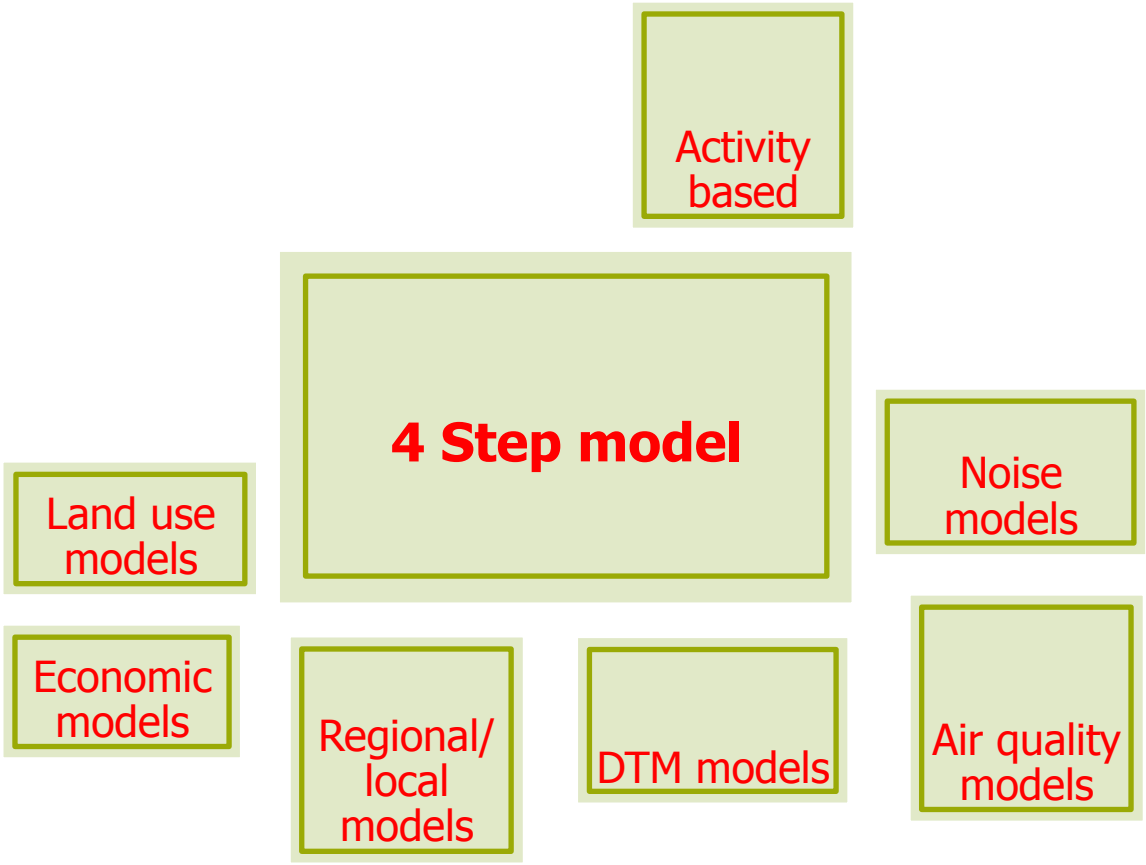
How does the four-step model relate to other models?



Activity based modelling

- Especially relevant when you expect changes in activity patterns
- Unit is person in a household
- Models the scheduling of activities in a chain considering both the utilities of activities and the disutilities of travelling
  - E.g. including coordination between household members
- Expertise at TU Eindhoven (Timmermans & Arentze)
- Note that choice modelling is, again, an important tool

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Land use and economic models

- Output of a transport model is used in land use models and in economic models (e.g. cost benefit analysis)
- Integrated models aim to link the different 'worlds'
  - See discussion on LUT models
  - In current projects integration with economic models is studied as well
- Ideal combination is all three

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Link with other transport models

- Two main options
- Linking of models to achieve consistency
  - E.g. using a regional model to determine ingoing, outgoing and through traffic for an urban model
- Use data of a model as an input for a more detailed model
  - Usually a 'cut out'
  - Usually requires new calibration of network and OD-matrix

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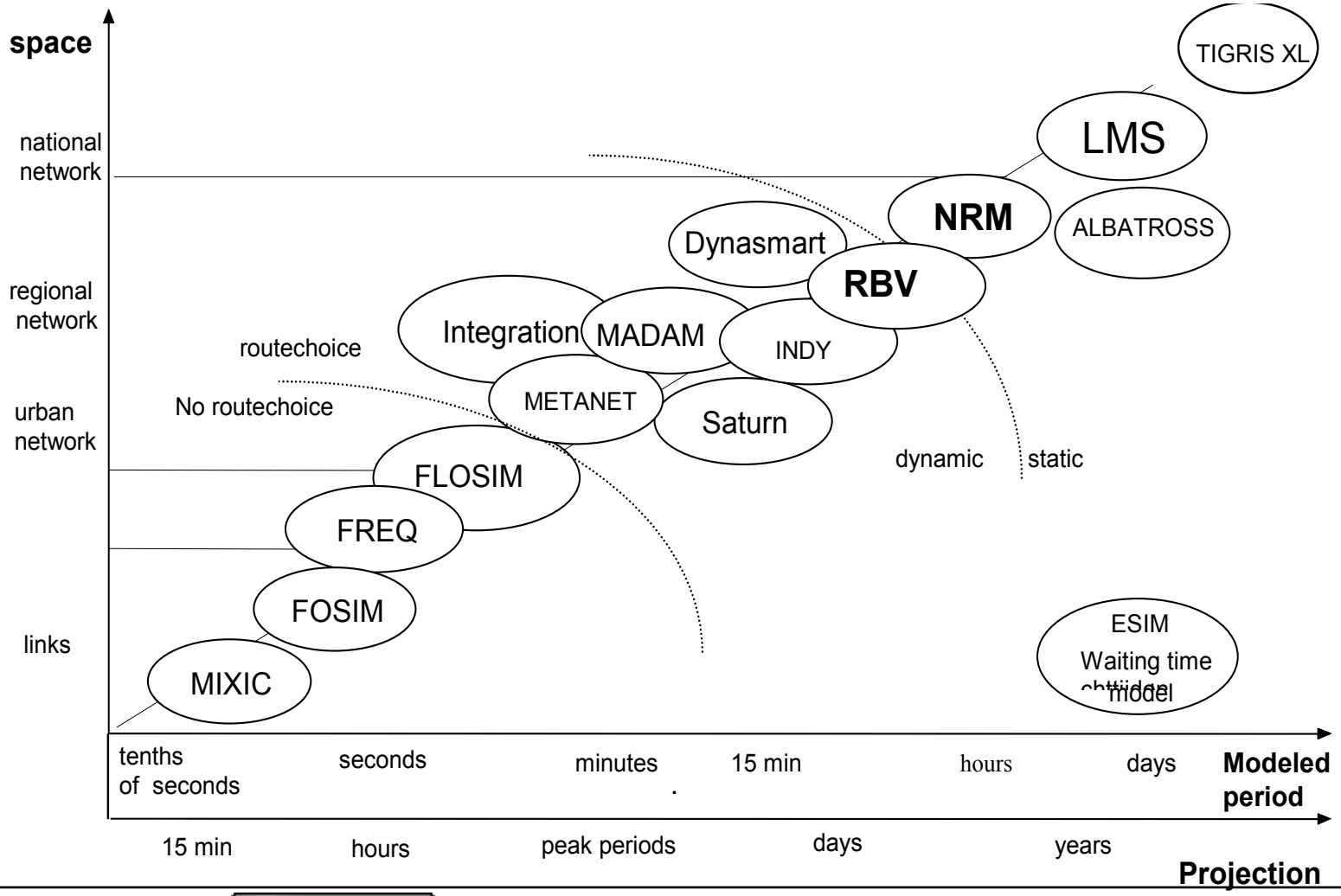
Model landscape



Environmental models

- In many studies the impact on noise hindrance and air quality needs to be quantified
- For both topics elaborate models exist which try to model physical phenomena using traffic flows as an input
- For both topics there's a dedicated data requirement
  - For noise hindrance the truck flows during the night are often critical
  - For air quality a yearly average is used with again a distinction in vehicle types

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Noise: the simple method

$$L_{Aeq} = E + C_{optrek} + C_{reflectie} - D_{afstand} - D_{lucht} - D_{bodem} - D_{meteo}$$

E:	Noise emission
C_{optrek}:	correction for junctions etc.
$C_{reflectie}$:	correction for reflection
$D_{afstand}$:	Correction for distance between source and receiver
D_{lucht}:	Correction for air damping
D_{bodem}:	Correction for impact of the ground surface
D_{meteo}:	Correction for meteorological conditions

$$E = 10\lg\left(10^{\frac{E_{lv}}{10}} + 10^{\frac{E_{mv}}{10}} + 10^{\frac{E_{zv}}{10}}\right)$$

E_{lv}, E_{mv} en E_{zv} Noise emission for light vehicles (index *lv*), medium weight trucks (index *mv*) and heavy weight trucks (index *zv*)

$$E_x = \alpha + \beta\lg\left(\frac{v_x}{v_0}\right) + 10\lg\left(\frac{Q_x}{v_x}\right) + C_{wegdek,x}$$

v_0:	Reference speed
v_x:	Actual speed for vehicle type *x*
Q_x	Normative flow for vehicle type *x*
$C_{wegdek,x}$	Correction for pavement type for vehicle type *x*

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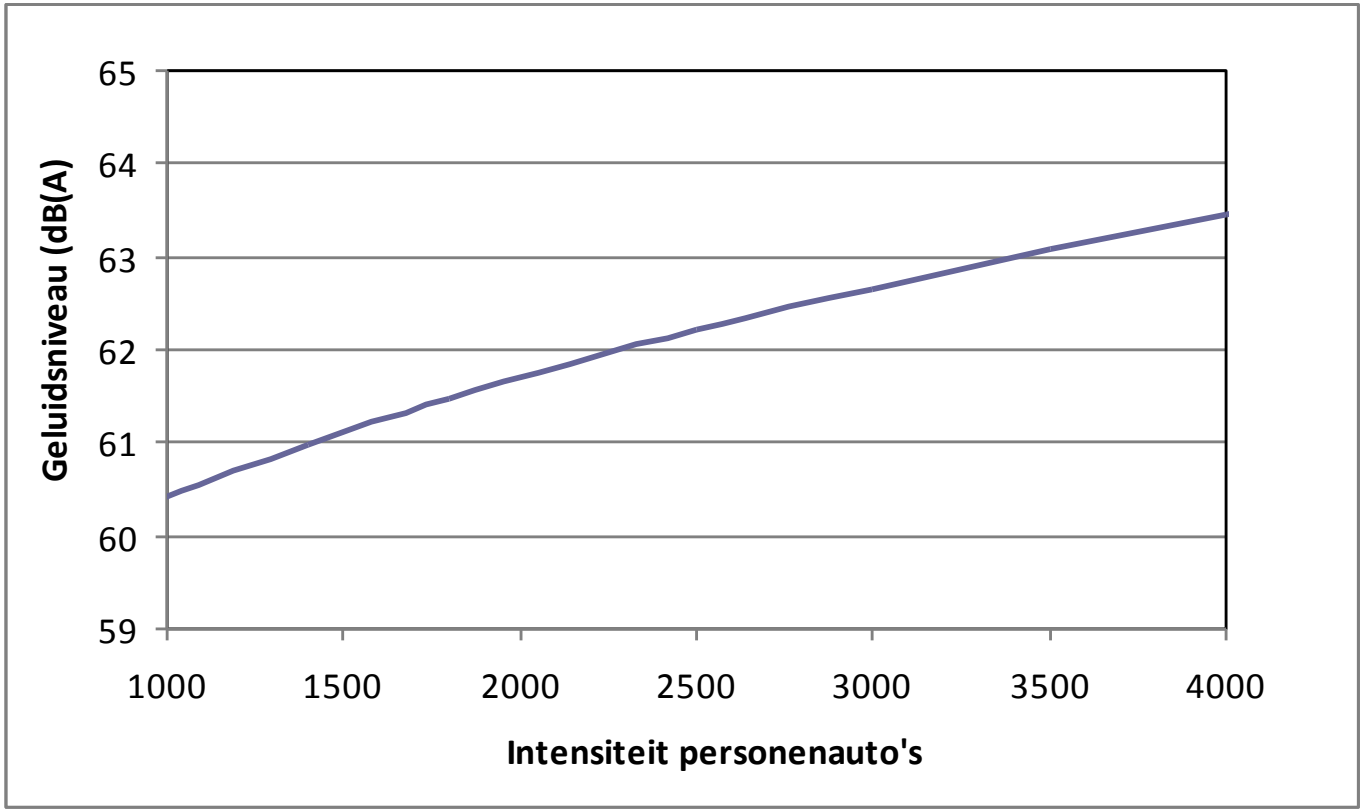
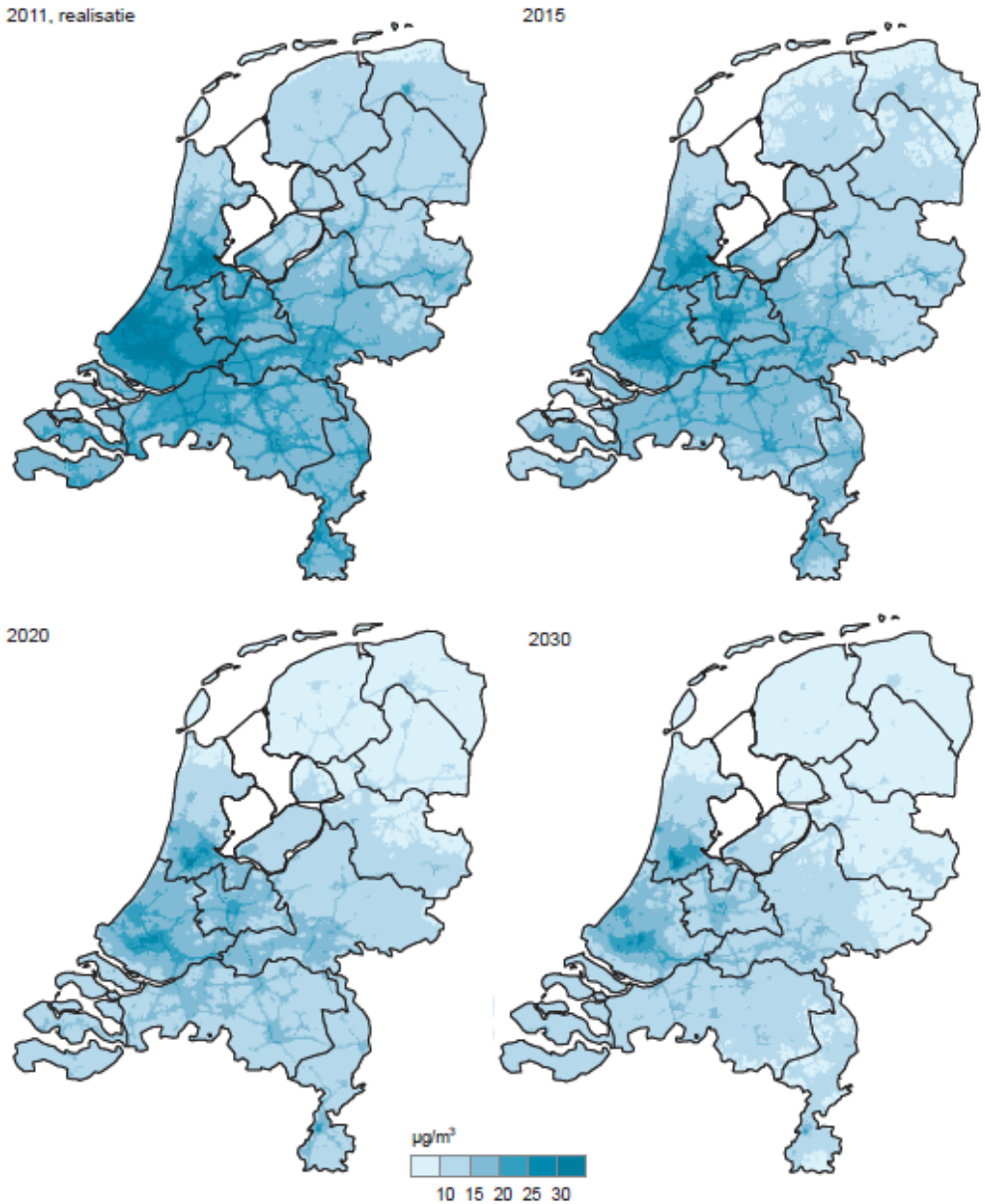
Impact of flow on noise hindrance



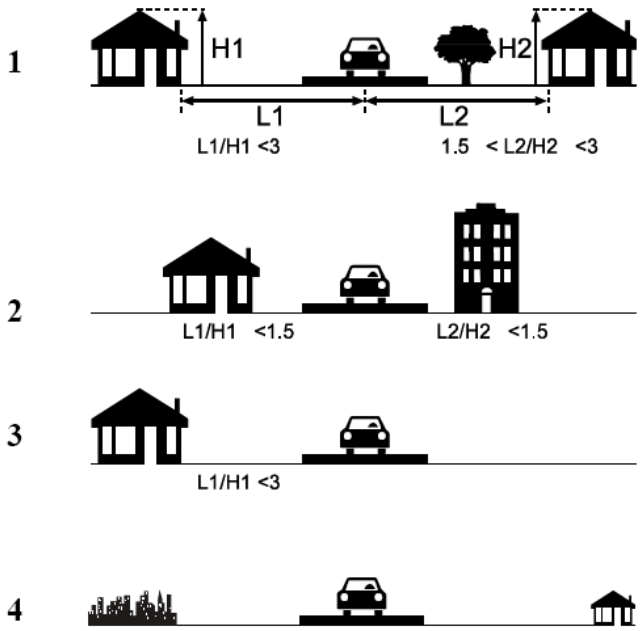
Air quality

- Combination of back ground concentration and emission due to traffic



Air quality: simple method

$$E = \left[\begin{array}{l} (1-F_s)\cdot\left(\left(1-(F_m+F_v+F_b)\right)\cdot E_p + F_m\cdot E_m + F_v\cdot E_v + F_b\cdot E_b\right) + \\ F_s\cdot\left(\left(1-(F_m+F_v+F_b)\right)\cdot E_{p,d} + F_m\cdot E_{m,d} + F_v\cdot E_{v,d} + F_b\cdot E_{b,d}\right) \end{array} \right] \cdot \frac{1000\cdot N}{24\cdot 3600}$$



H= Hoogte gebouw (m)
L= Afstand weg-as tot bebouwing (m)

E	Emission (µgr/m/s)
N	Number of vehicles per average weekday
F_m	Fraction middle weight vehicles
F_v	Fraction heavy weight vehicles
F_b	Fraction busses
E_p	Emission factor for passenger cars (gr/km)
E_m	Emission factor for middle weight trucks (gr/km)
E_z	Emission factor for heavy weight truciks (gr/km)
E_b	Emission factor for busses (gr/km)
F_S	Fraction congested traffic
$E_{*,d}$	Emission factor for vehicle type * in congested conditions (gr/km)

$$C_{jm-bijdrage} = 0,62\cdot E\cdot \Theta\cdot F_b\cdot F_{regio}$$

$C_{jm\text{-}bijdrage}$	Yearly average contribution due to traffic
F_b	Correction factor for trees
F_{regio}	Regional correction factor for meteorological conditions
Θ	Dispersion factor

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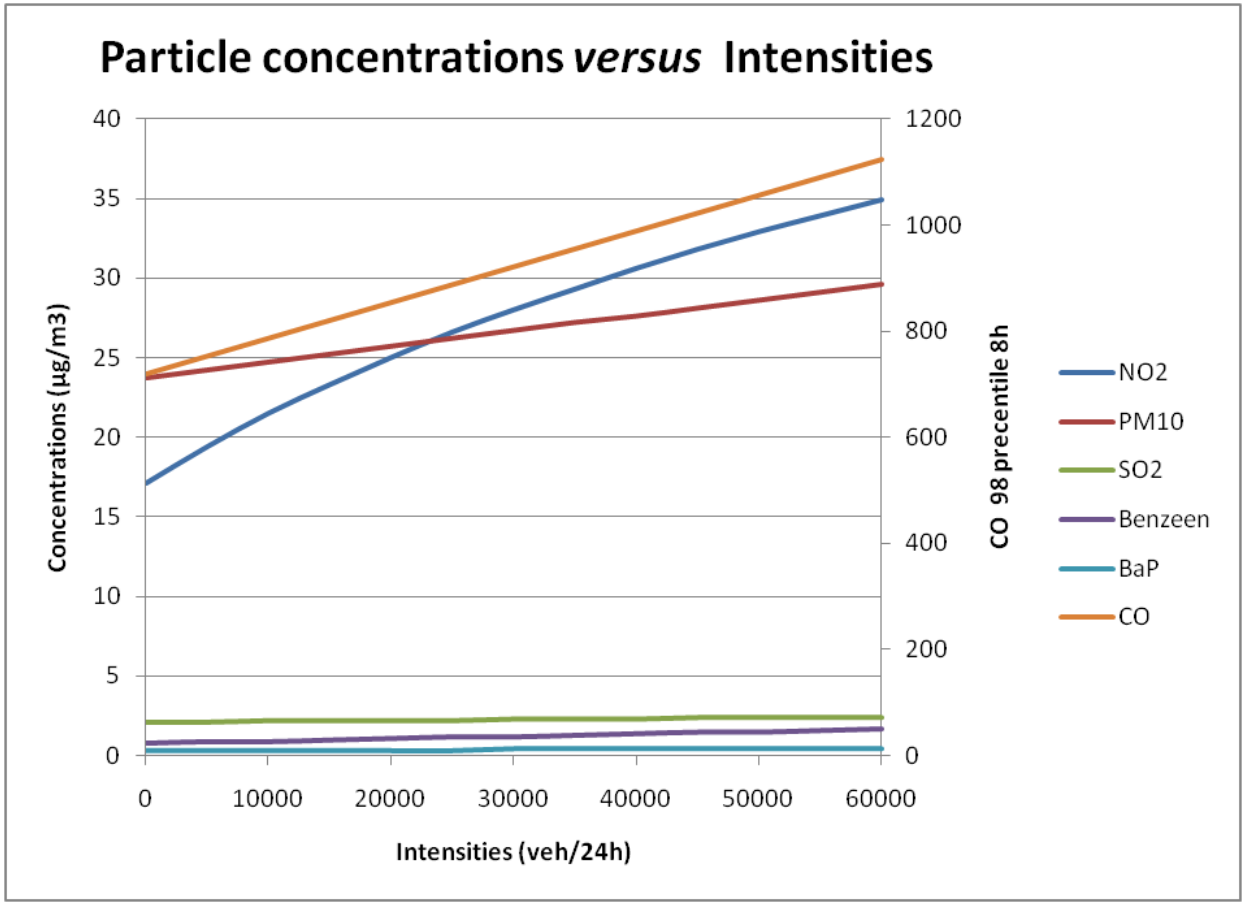
Impact of traffic flow on air polution



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Extending the 4-step for other topics

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Policy and research topics

- True multimodality
- Robustness of networks
- Reliability in transport
- Special conditions, e.g. evacuation
- Network design problems, e.g. network structure or network attributes (pricing)

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Challenges

- Every topic sets requirements for the building blocks of the model

- How to combine dynamic assignment with discrete time schedules?
- How to model behaviour in case of exceptional conditions? Does the equilibrium principle still hold?
- How do all kinds of information services affect network usage? Adaptive route choice instead of pre-trip route choice
- In network design and in robustness/reliability analyses you need many network evaluations. So how can you speed up a model run?

- See CIE5802-09

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