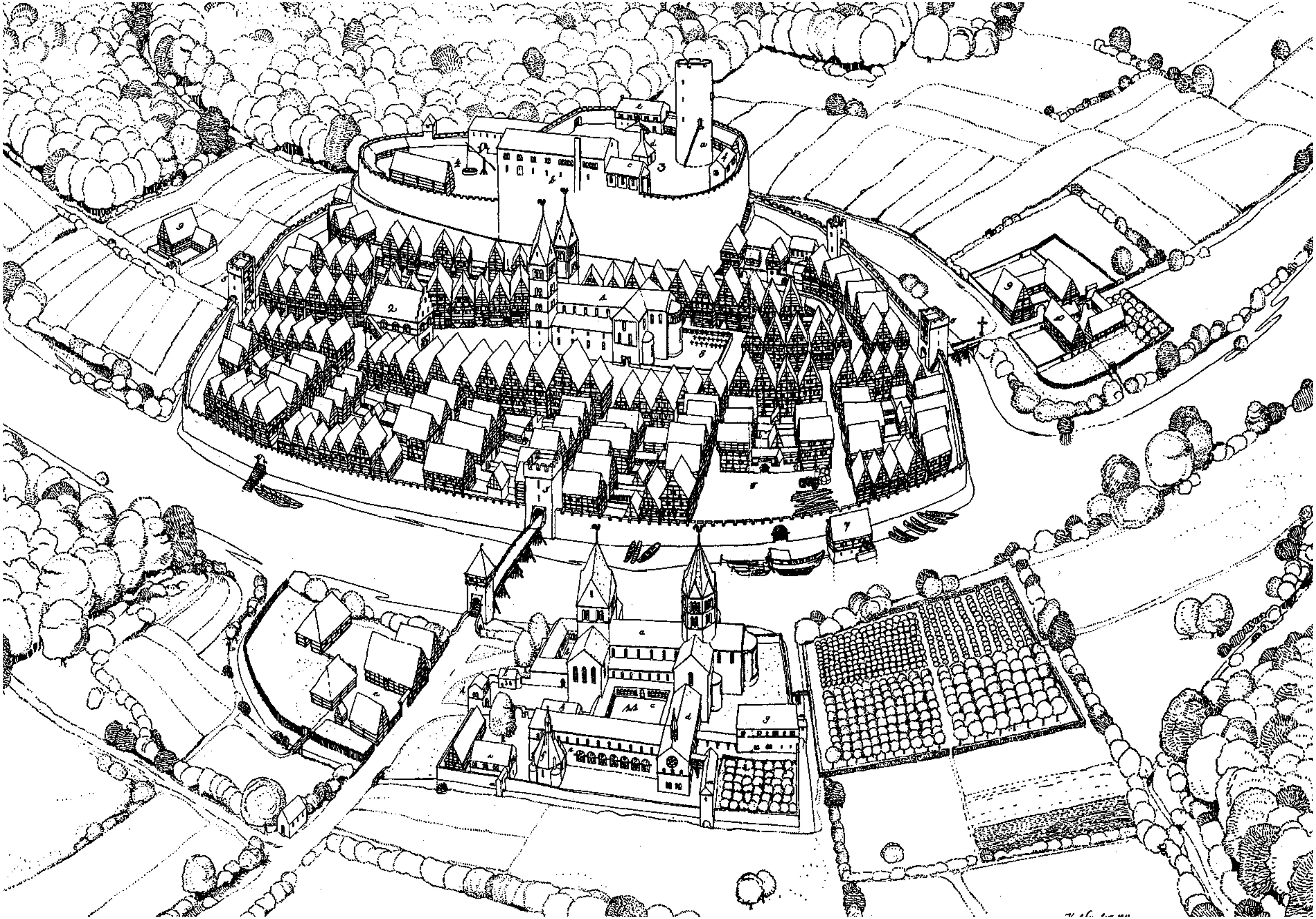
Integrated Land-Use Transport Modelling Progress around the Globe

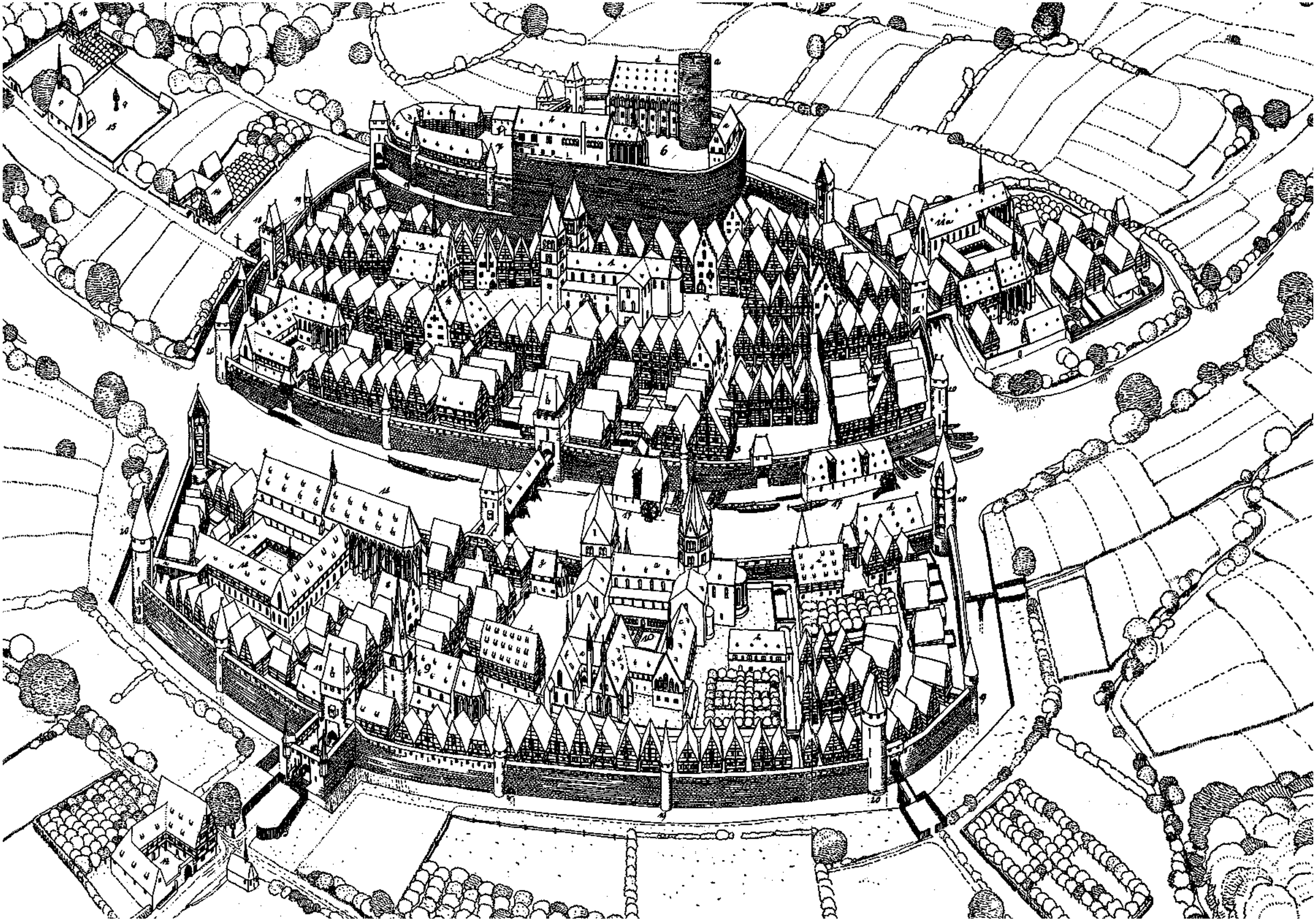
Michael Wegener, Spiekermann & Wegener, Dortmund

Fourth Oregon Symposium on Integrated Land-Use Transport Models
Portland, Oregon, 15-17 November 2005

Cities



1250



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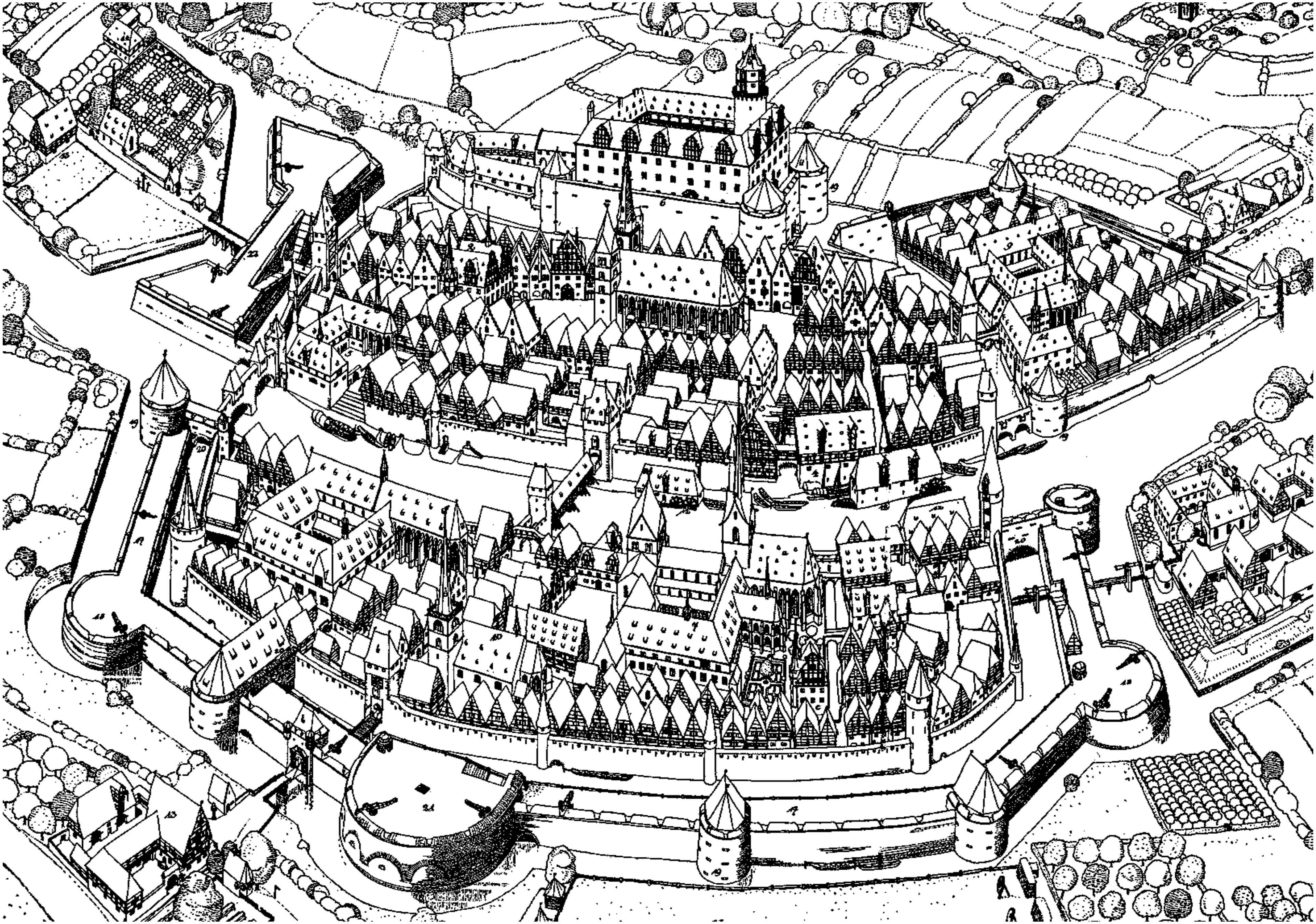

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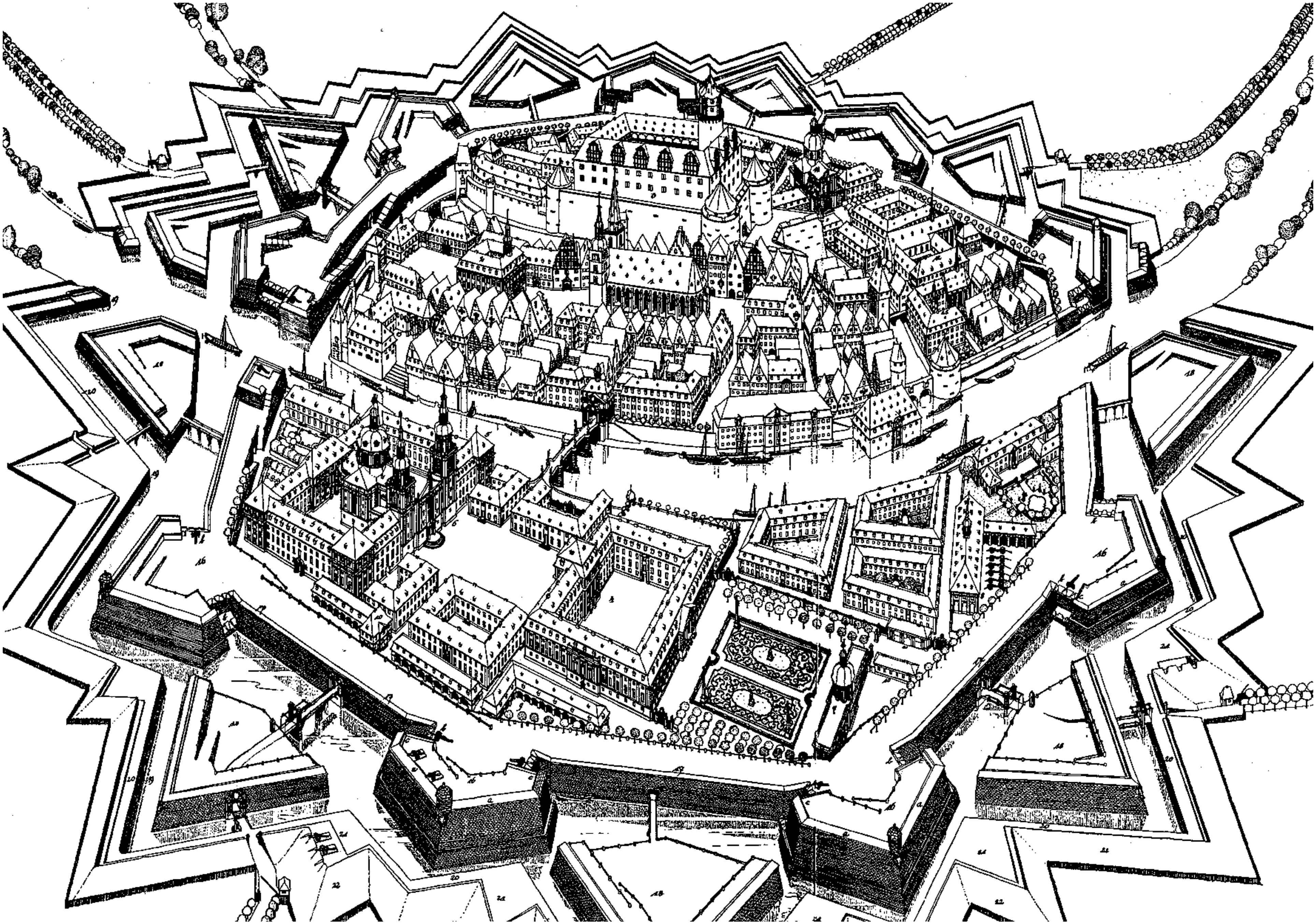
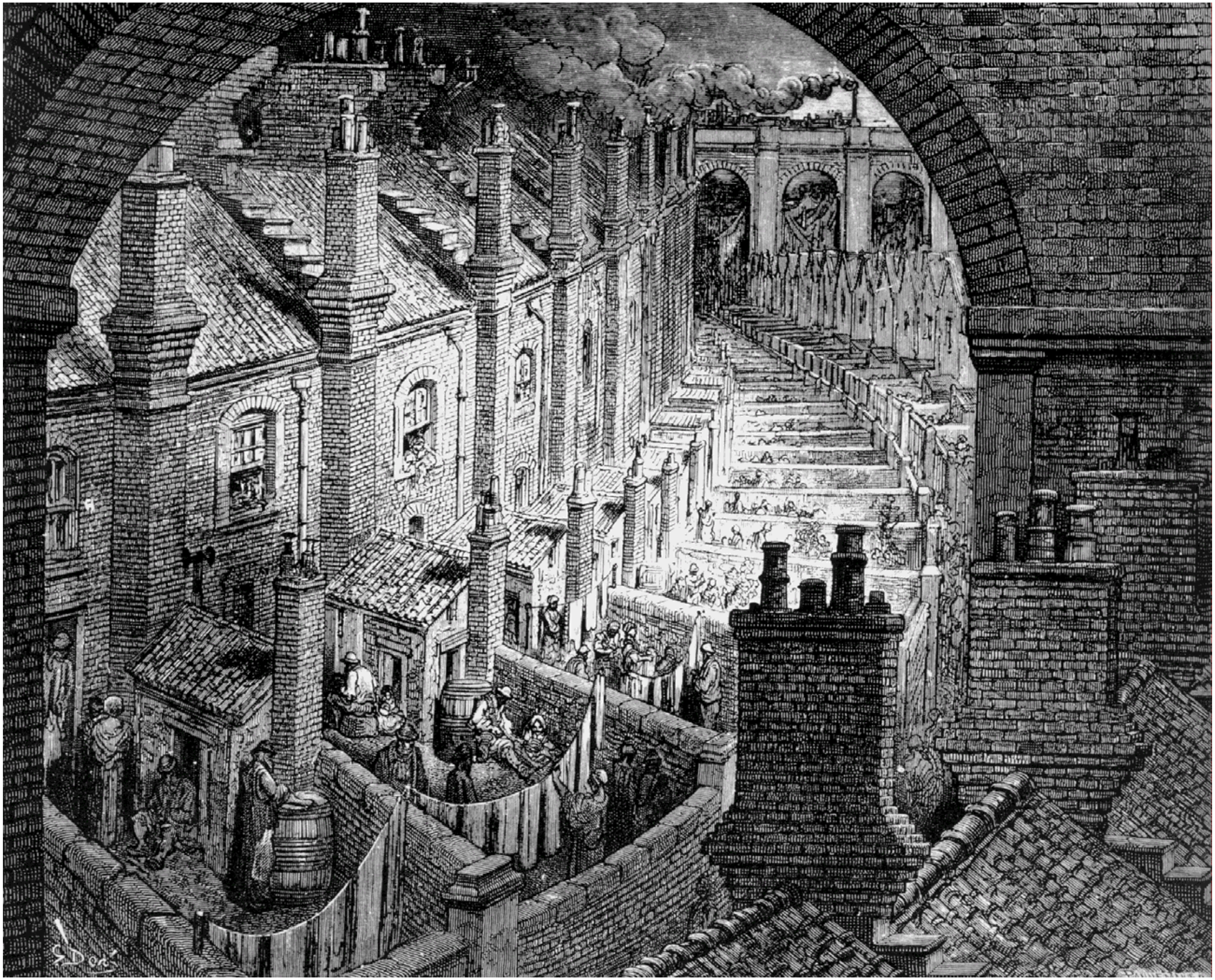
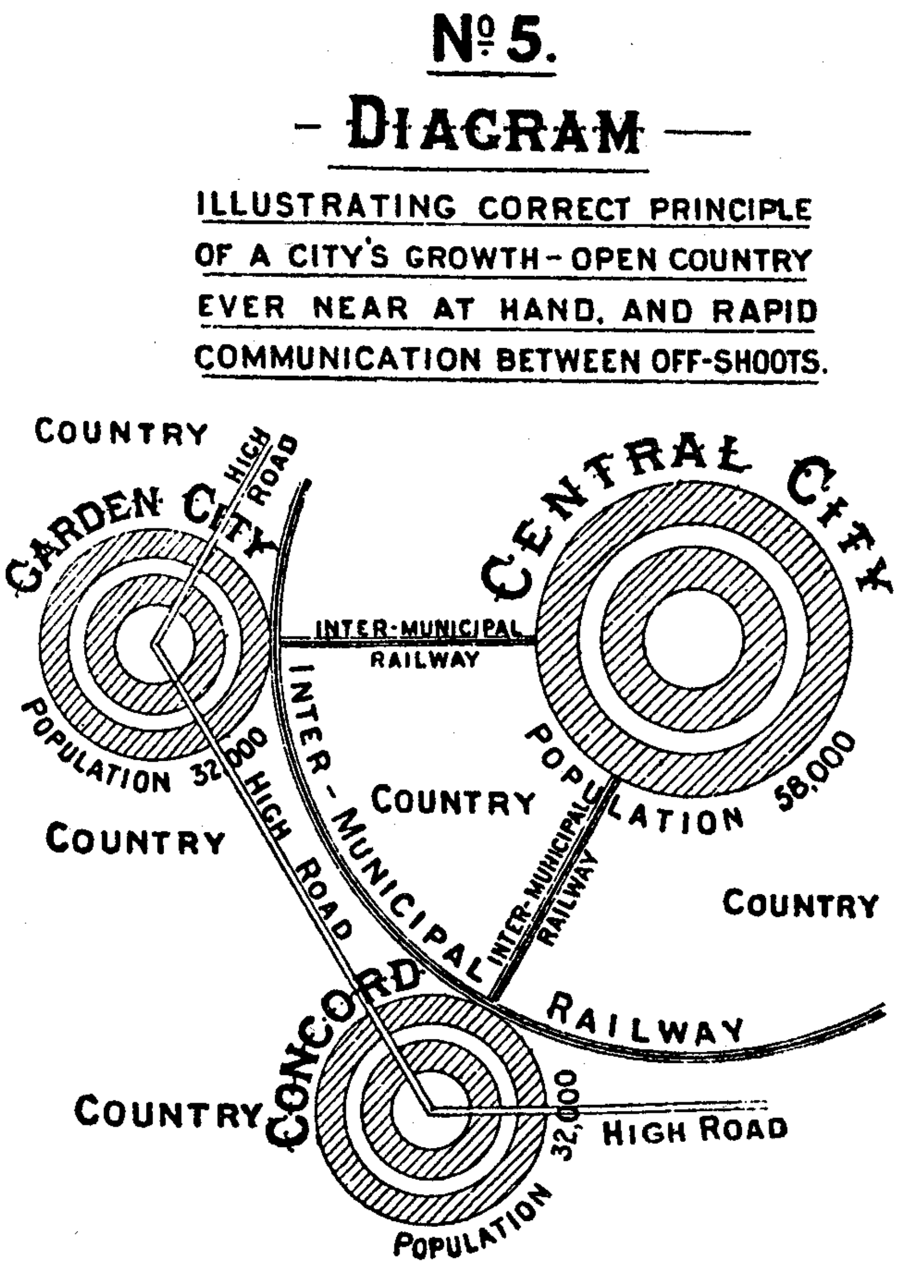


1750

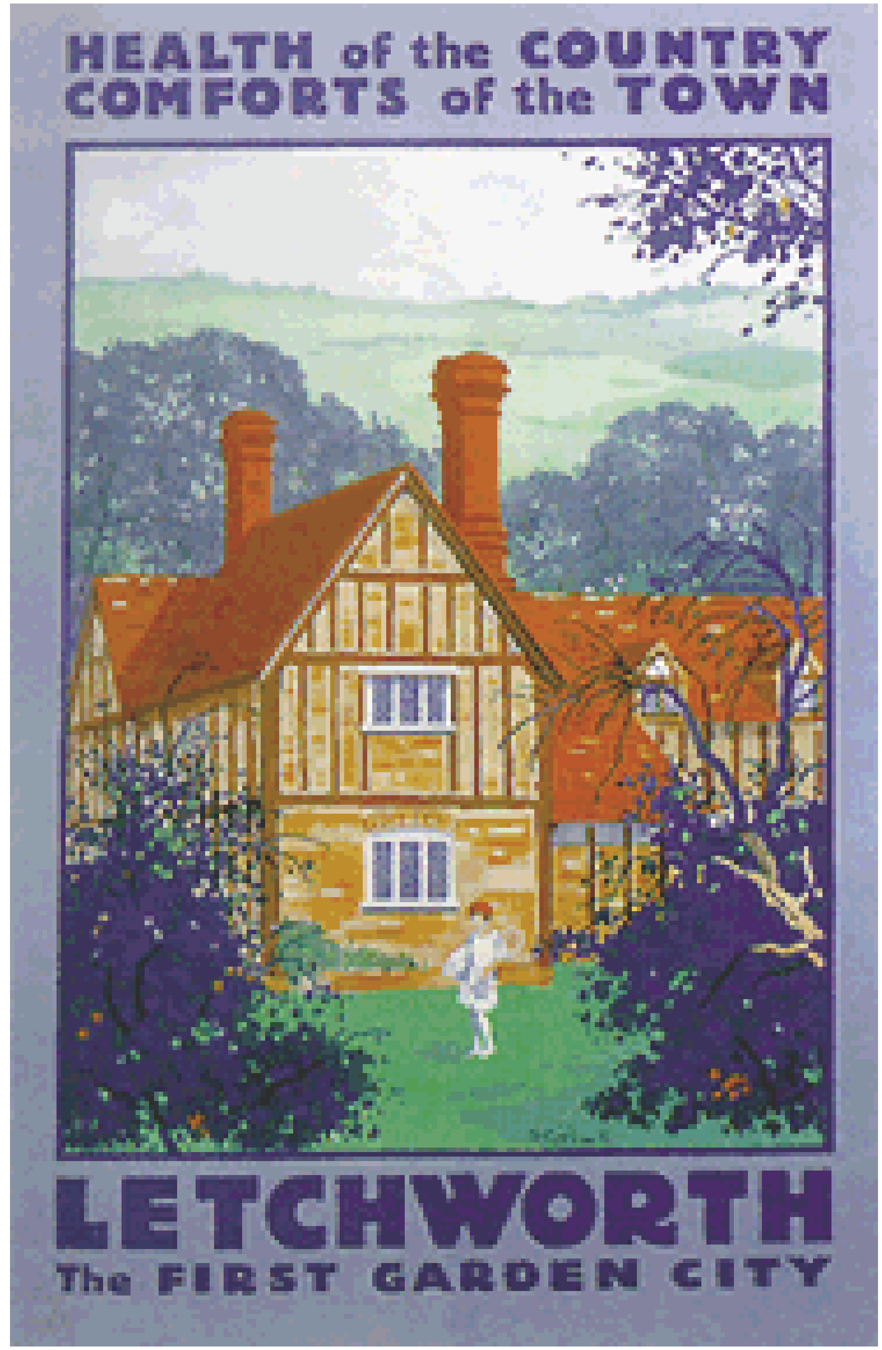
7



1872


No. 5.
- DIAGRAM -
ILLUSTRATING CORRECT PRINCIPLE
OF A CITY'S GROWTH - OPEN COUNTRY
EVER NEAR AT HAND, AND RAPID
COMMUNICATION BETWEEN OFF-SHOOTS.
COUNTRY
HIGH ROAD
GARDEN CITY
CENTRAL CITY
INTER-MUNICIPAL RAILWAY
POPULATION 32,000
POPULATION 58,000
COUNTRY
COUNTRY
INTER-MUNICIPAL
HIGH ROAD
INTER-MUNICIPAL RAILWAY
COUNTRY
RAILWAY
CONCORD
COUNTRY
HIGH ROAD
32,000
POPULATION

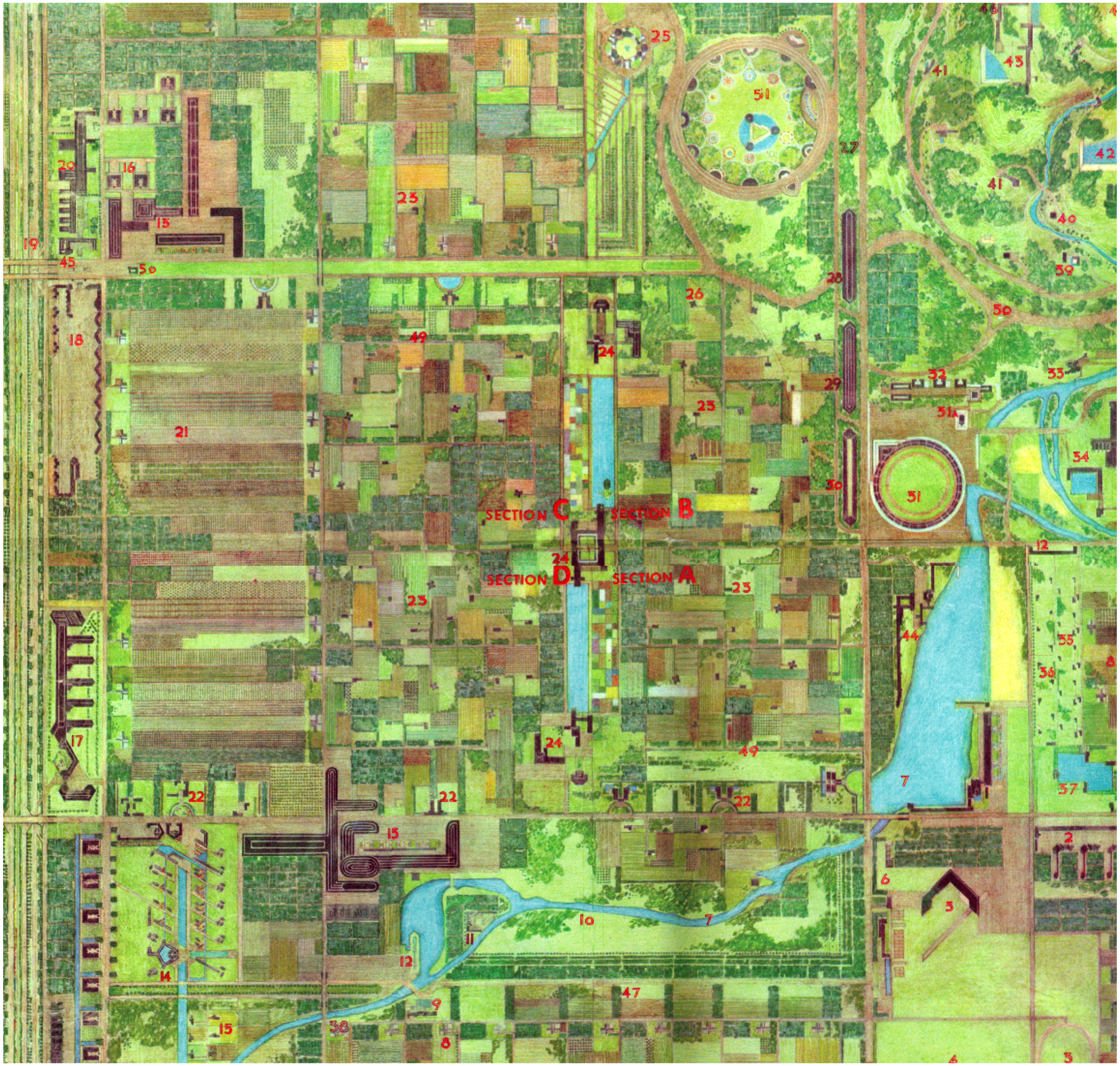
1900


HEALTH of the COUNTRY
COMFORTS of the TOWN
LETCHWORTH
The FIRST GARDEN CITY

1912

1925

Frank Lloyd Wright
Broadacre City



1934-58

1960

1990

1990

© Hoehfeld

Istanbul

Bangkok

Beijing

Problem

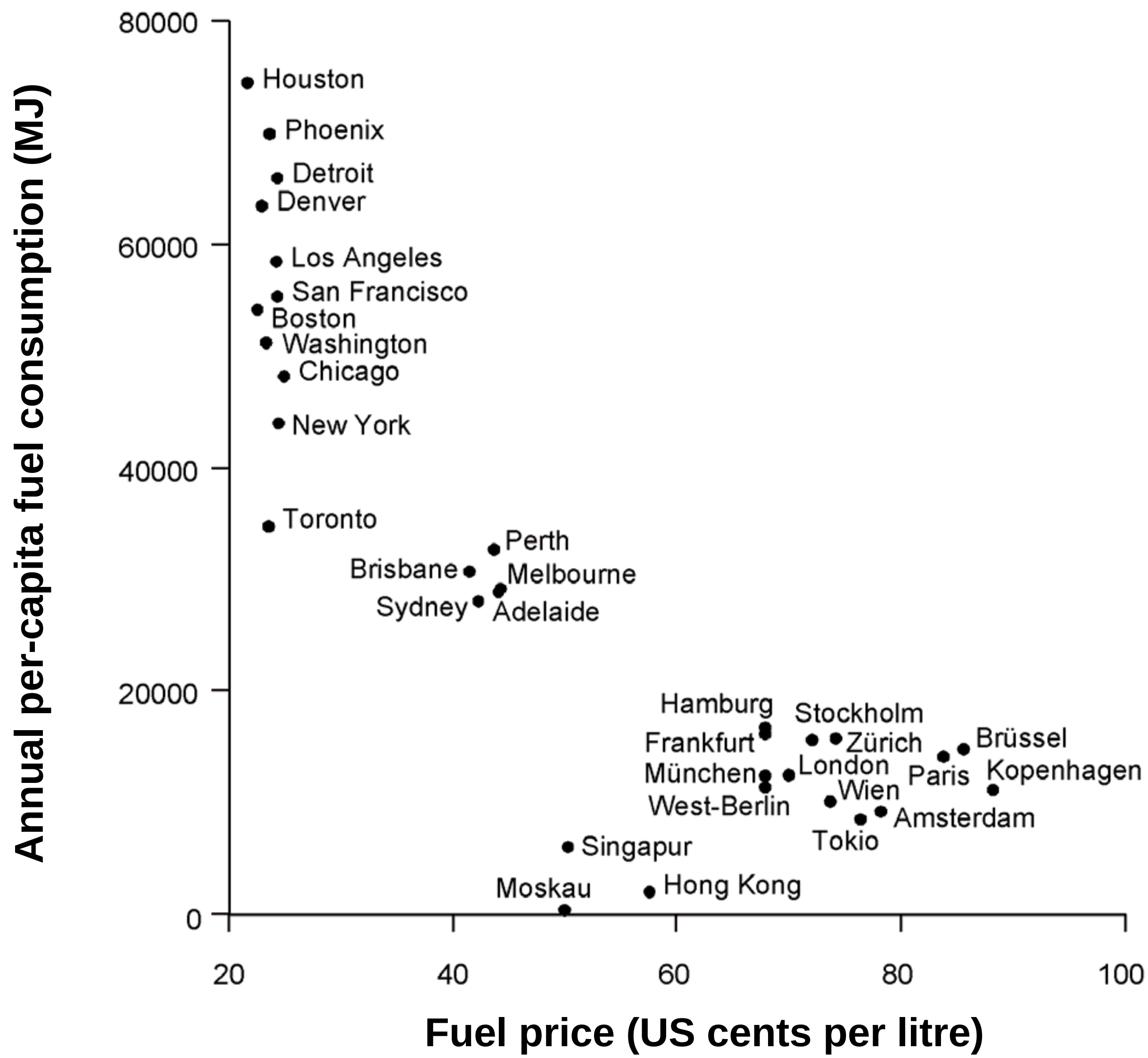
Way of life

It is increasingly becoming apparent that the way of life practised in the ***cities*** of the most affluent countries is ***not sustainable***.

Cities in the richest countries consume significantly more ***energy*** and ***resources*** per capita and produce more ***greenhouse gases***, noxious ***emissions*** and ***waste*** than cities in the poorest regions.

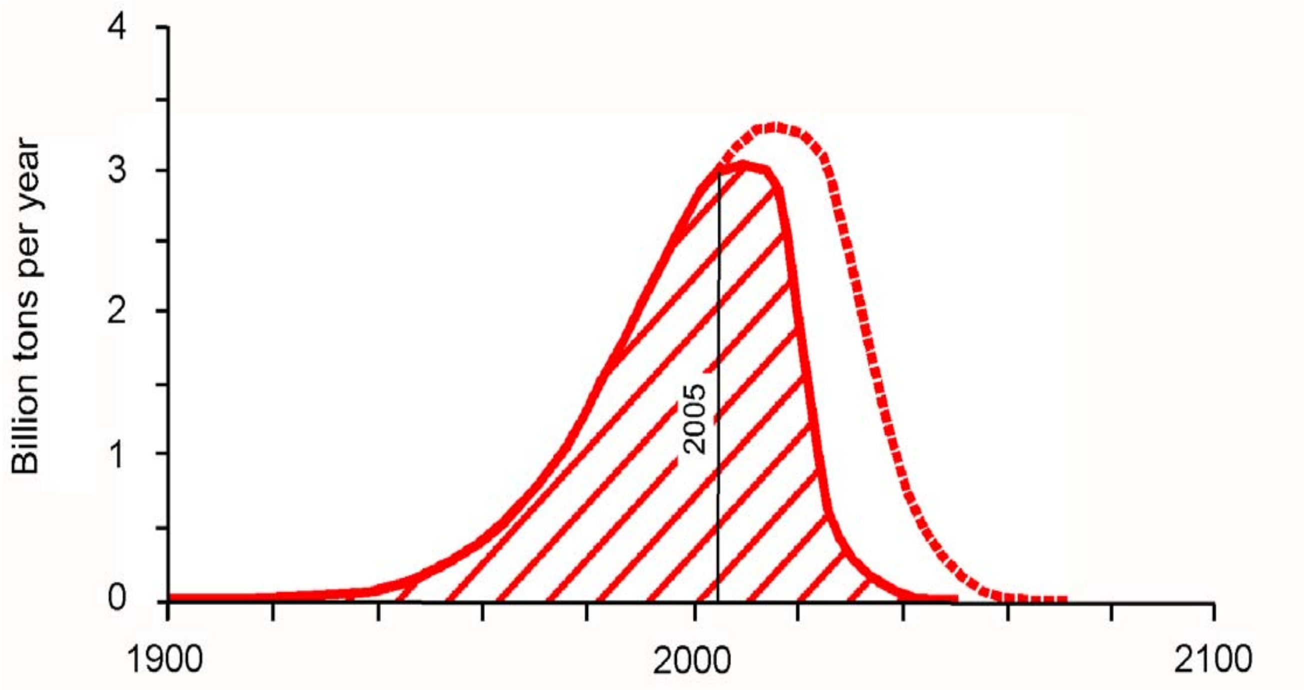
This imbalance is the consequence of market-driven interaction between urban ***land use*** and ***transport***.

Fuel consumption



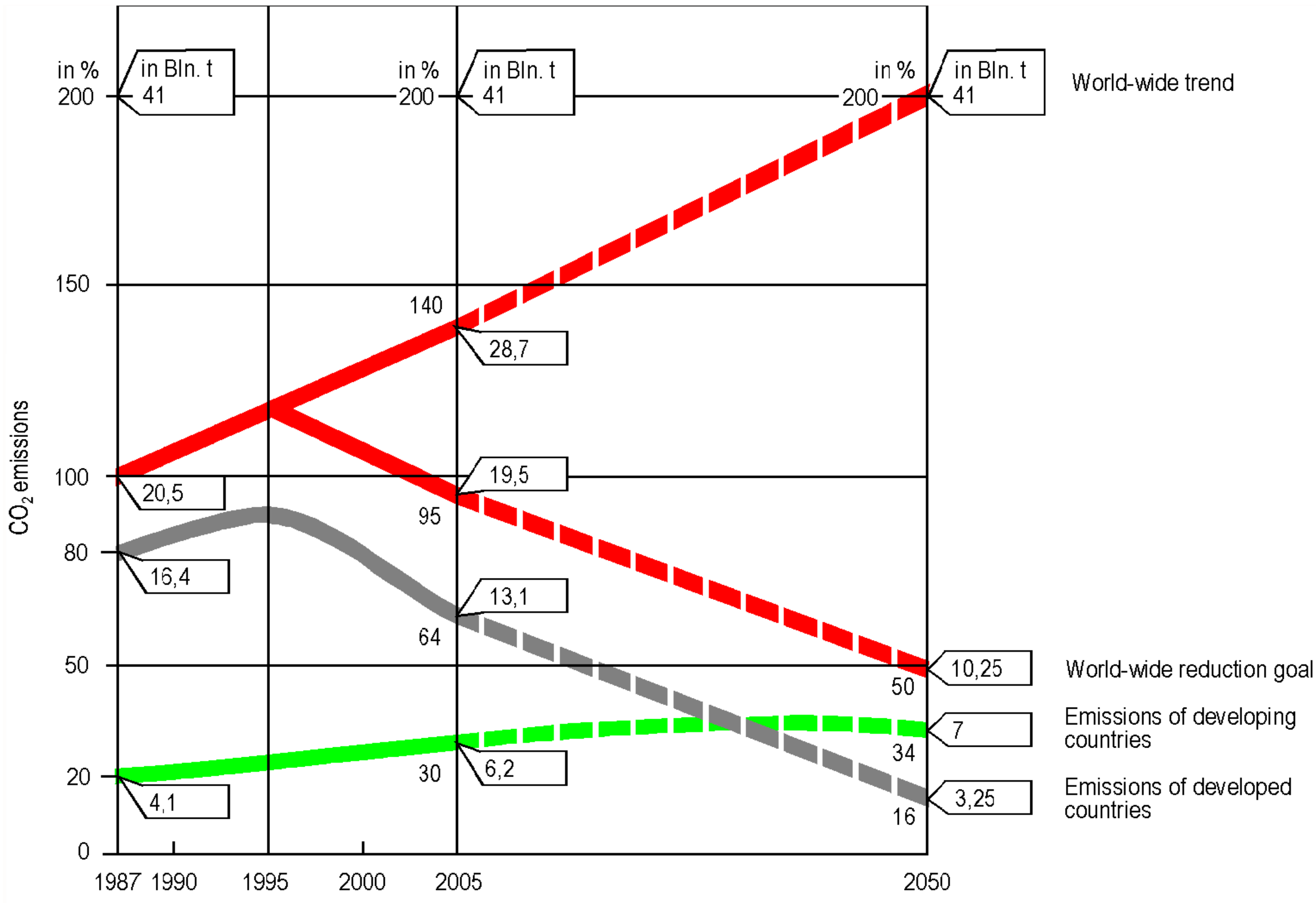
Source: Newman & Kenworthy, 1989

The end of the oil age



If the world-wide consumption of petroleum continues to rise as in the past, the petroleum resources known today will be exhausted by the year 2060.

Emission targets



From research to action

"Ecological self-destruction is well in the range of possibil-ities of evolution.

It is necessary to at least take account of the possibility that a system affects its environment in a way that it later cannot survive in that environment."

Niklas Luhmann:
Ecological Communication (1986)

From research to action

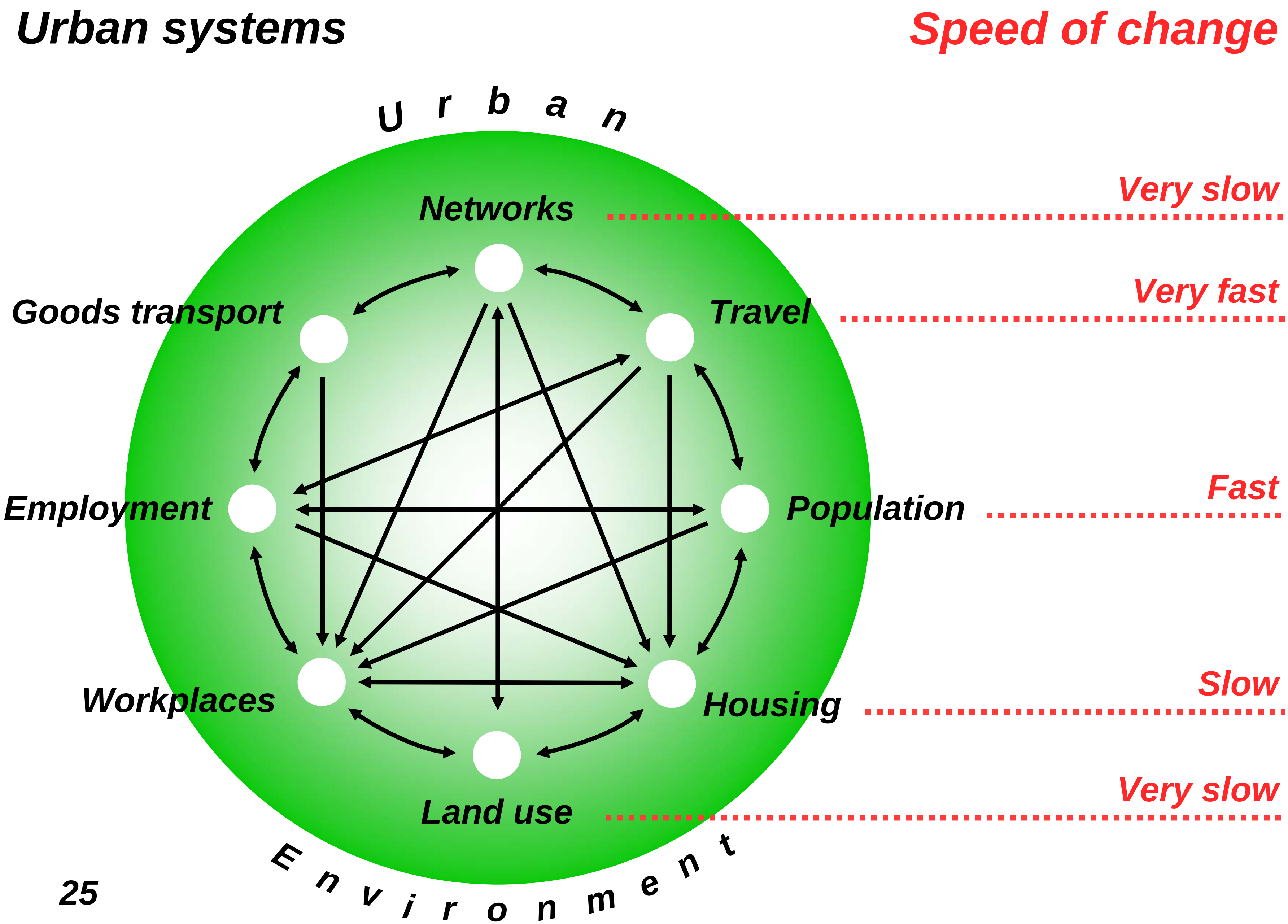
To live up to this responsibility, we need to ***know*** the causes of the growth in urban land use and mobility as a function of

- ***technical and socio-economic trends***
  - technological progress
  - population and economic growth
- ***policies*** in the fields of
  - land-use planning
  - transport infrastructure, pricing and regulation

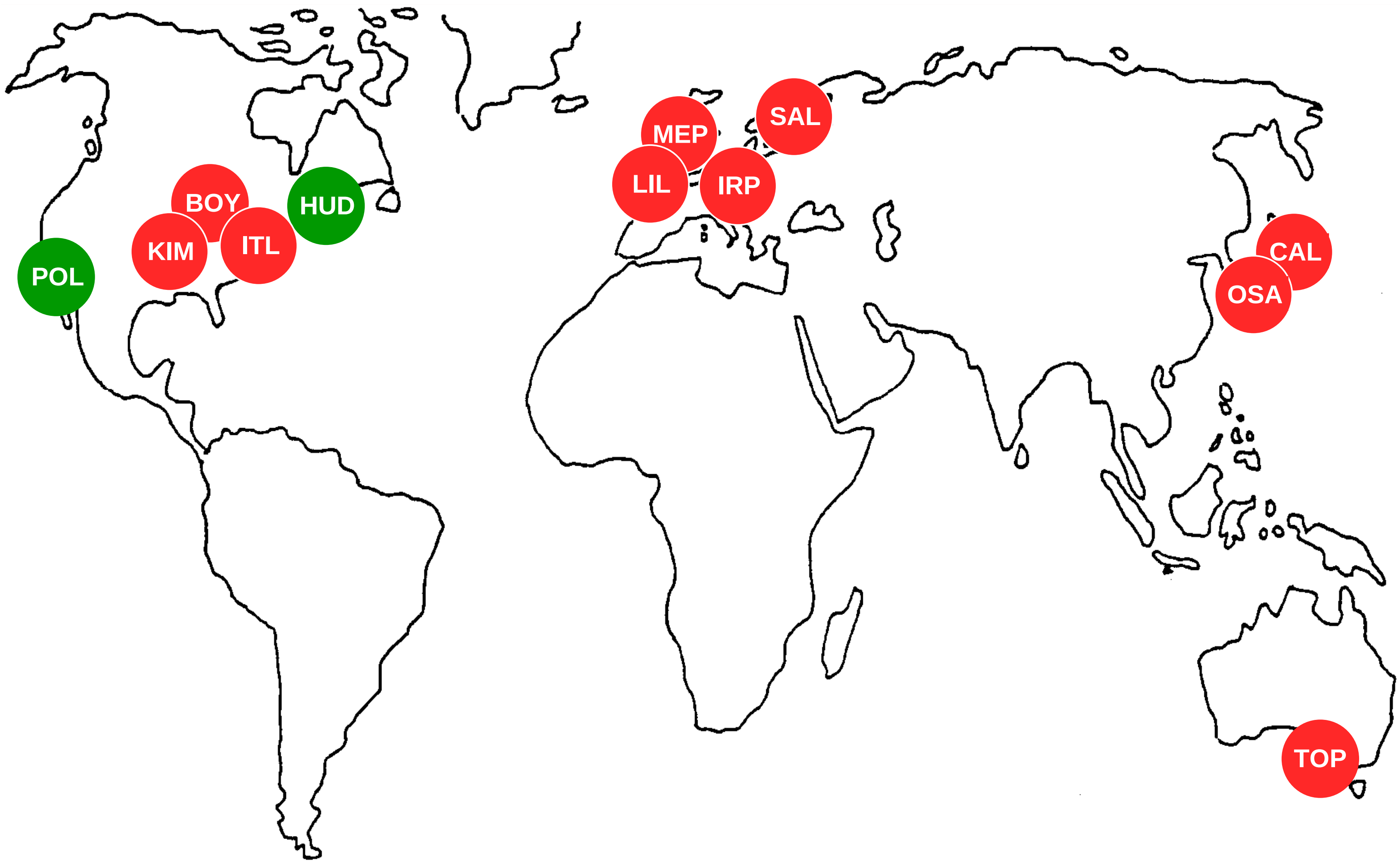
in order to ***forecast*** the future development and the impacts of possible policy interventions.

This is why we use ***integrated land-use transport models***.

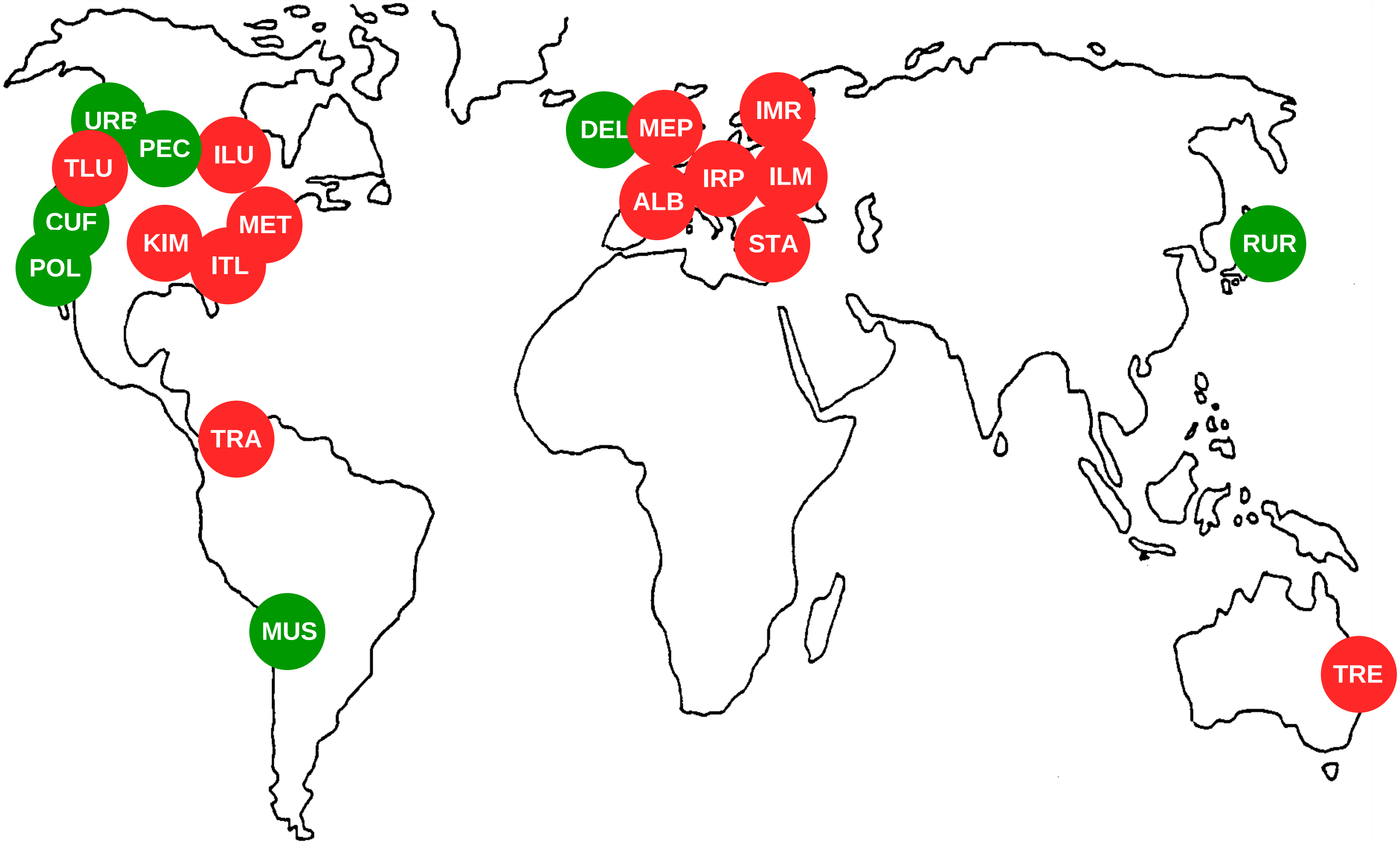
Integrated Land-Use Transport Models


Urban systems
Speed of change
Urban
Networks
Very slow
Goods transport
Travel
Very fast
Employment
Population
Fast
Workplaces
Housing
Slow
Land use
Very slow
Environment

Urban models in the 1980s



Urban models today

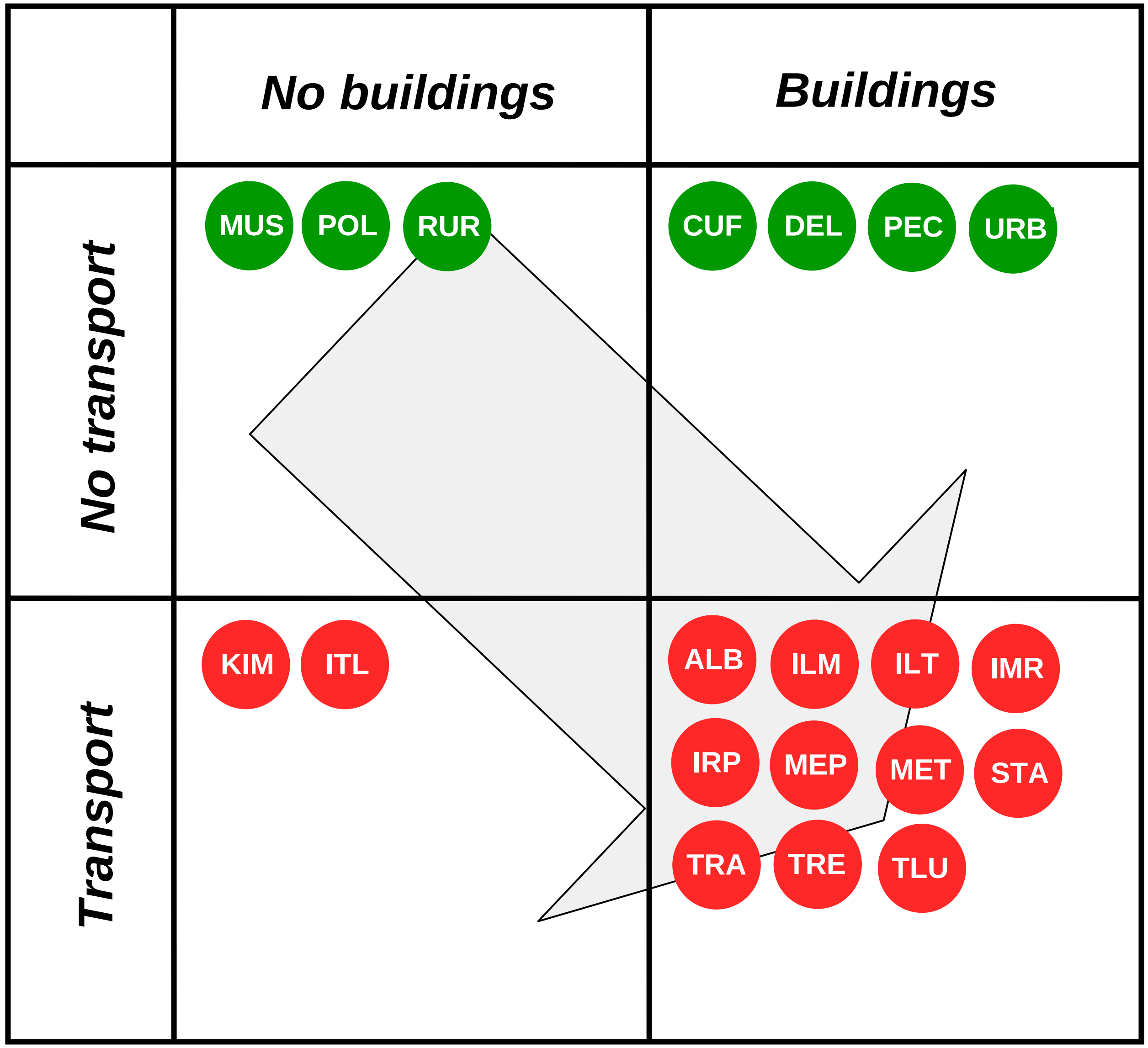


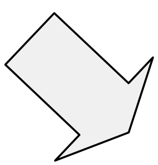
Urban models today

- ALB ALBATROSS
- CUF CUFM
- DEL DELTA
- ILM ILUMASS
- ILT ILUTE
- IMR IMREL
- IRP IRPUD
- ITL ITLUP
- KIM Kim
- MEP MEPLAN
- MET METROSIM
- MUS MUSSA
- PEC PECAS
- POL POLIS
- RUR RURBAN
- STA STASA
- TLU TLUMIP
- TRA TRANUS
- TRE TRESIS
- URB URBANSIM

Trends

Comprehensiveness

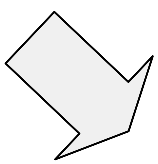




Trend

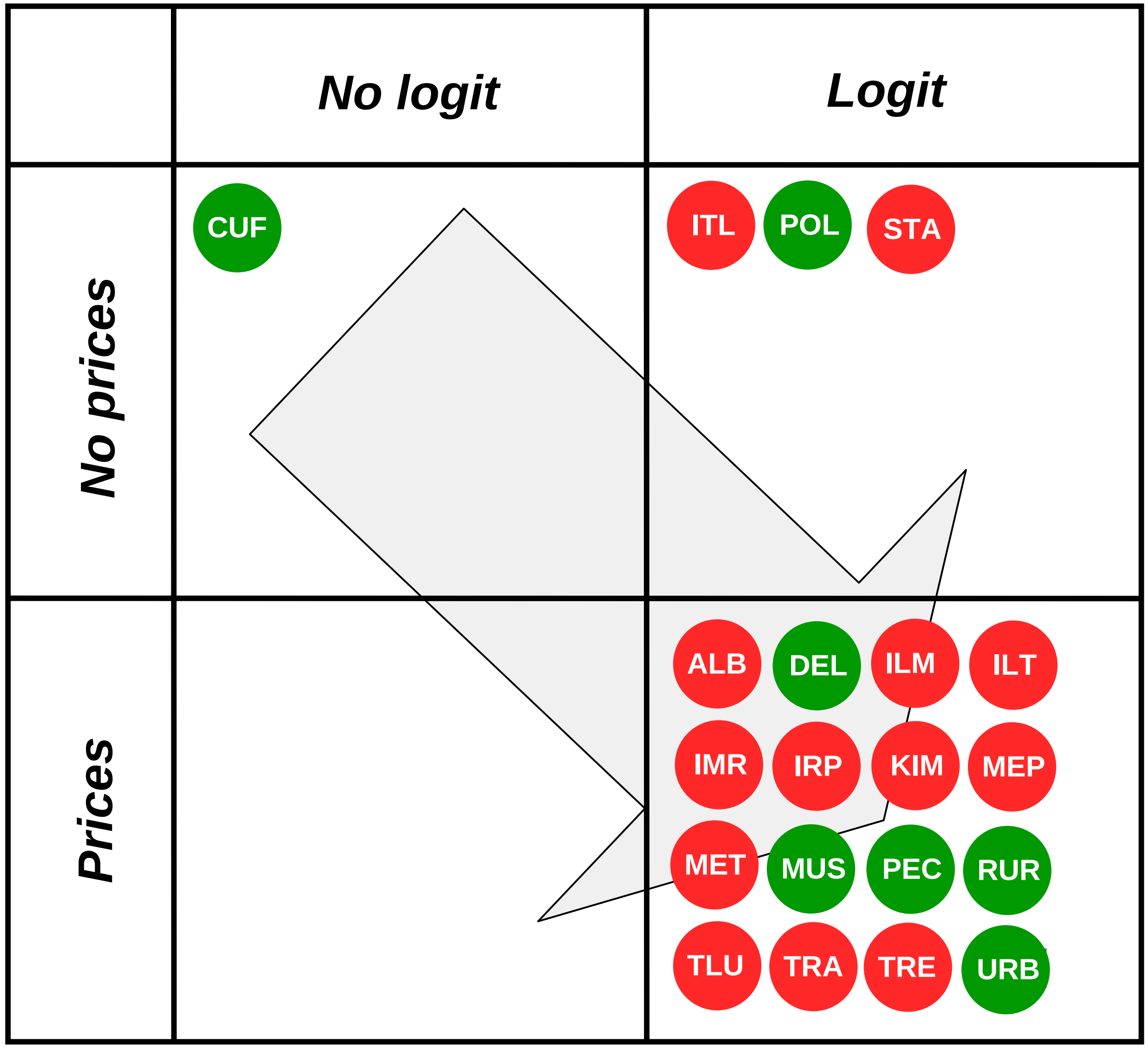
Model structure

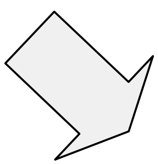
	Unified	***Composite***
Static	KIM	IMR
Quasi-dynamic	MEP, MET, MUS, PEC, RUR, STA, TRA	ALB, CUF, DEL, ILM, ILT, IRP, ITL, POL, TLU, TRE, URB



Trend

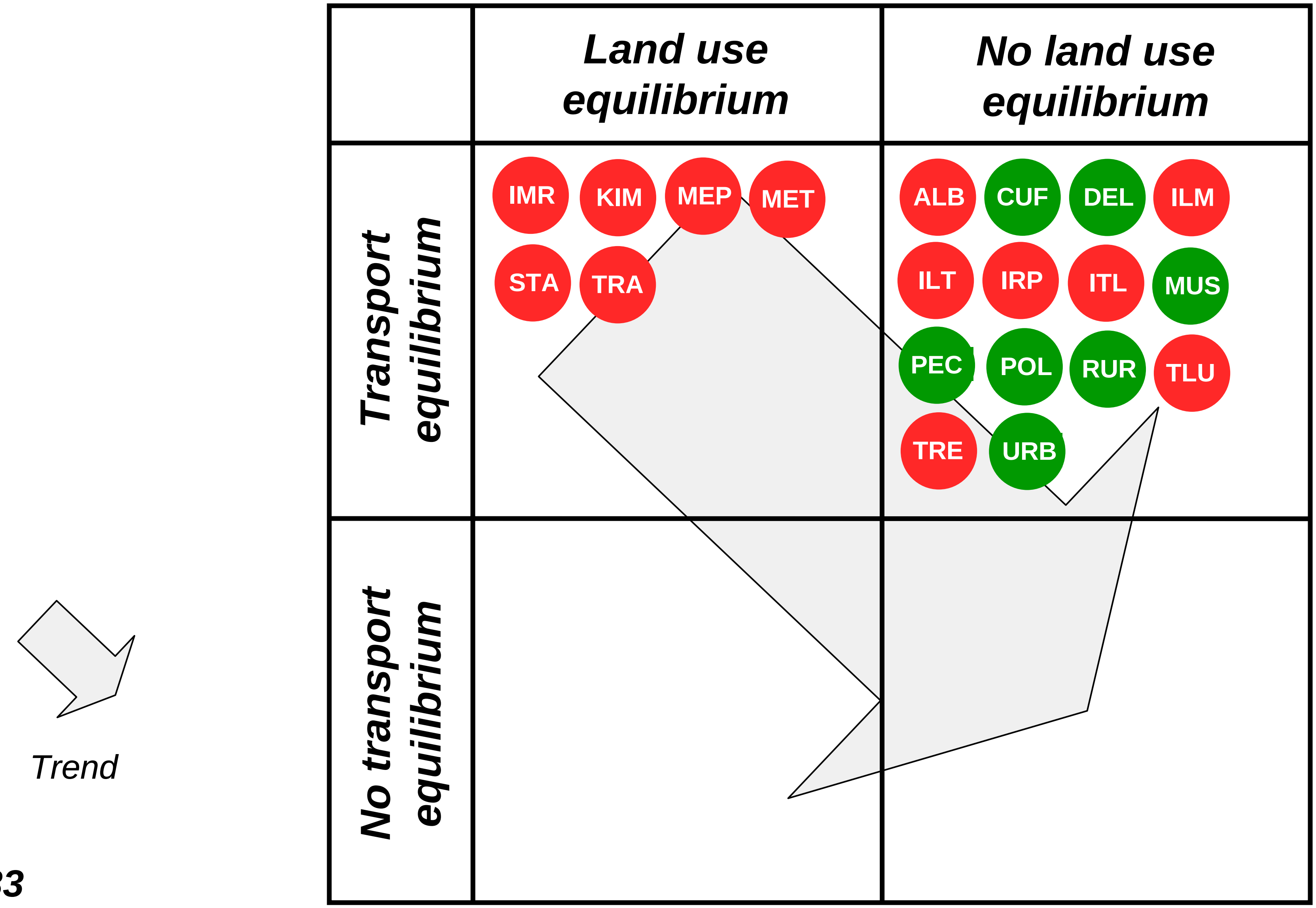
Theory





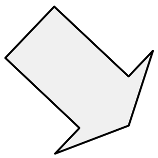
Trend

Equilibrium



Model technique

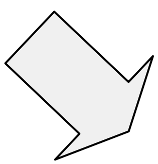
	Mesoscale	***Microscale***
Spatial interaction	IMR, KIM, MEP, PEC, TRA	
Accessibility	DEL, IRP, ITL, MET, MUS, POL, RUR, STA, TRE	ALB, CUF, ILM, ILT, TLU, URB



Trend

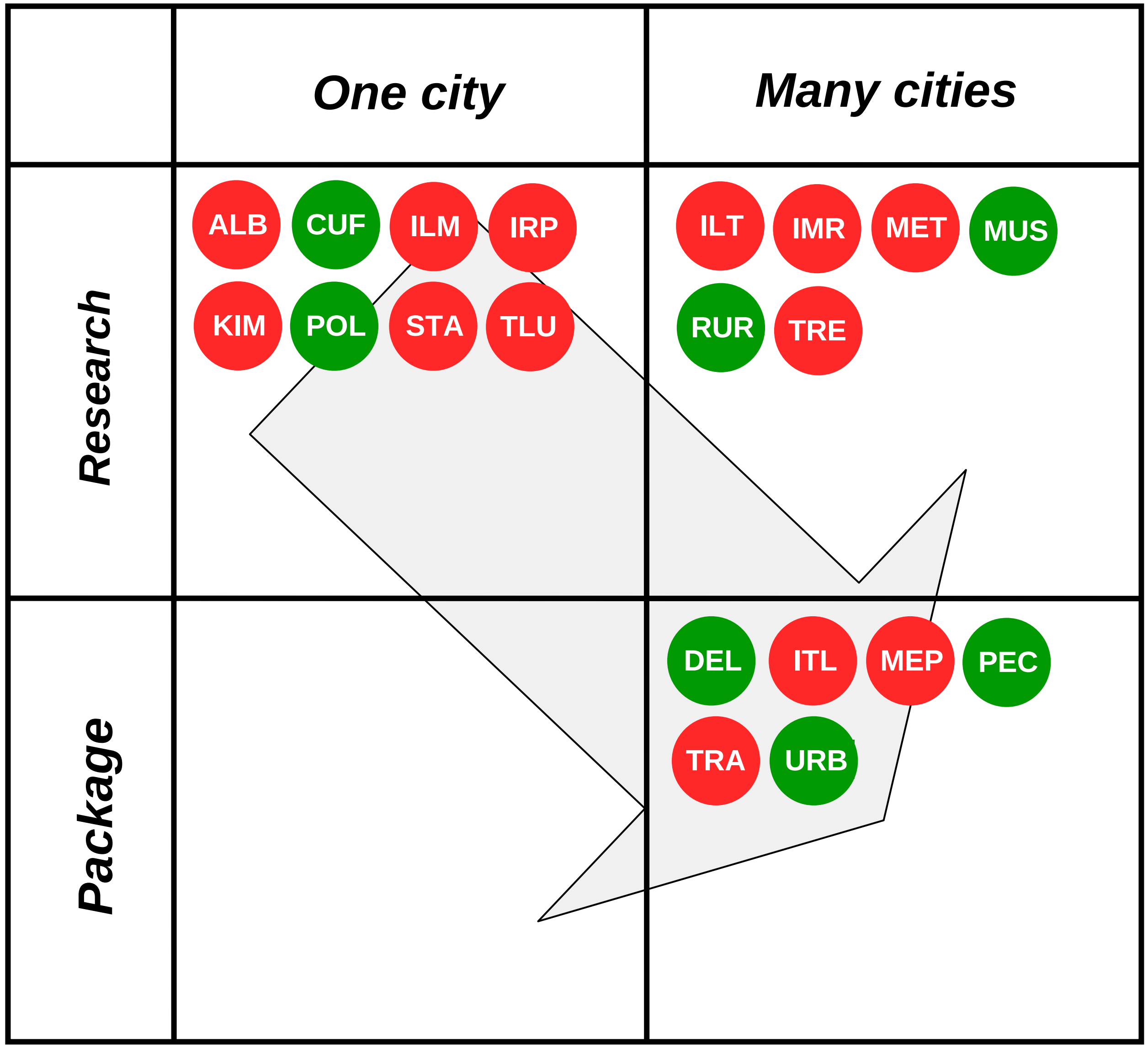
GIS integration

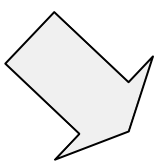
		GIS provides GIS functions for ...			
		none	input	output	both
Model uses GIS functions for ...	none	ALB, IMR, ITL, KIM, PEC, POL, STA, TRE			
	input		CUF, IRP, MUS		
	output				
	both				DEL, ILM, ILT, MEP, MET, RUR, TLU, TRA, URB



Trend

Operationality and application





Trend

Achievements

Achievements

Today there is a ***new interest*** in integrated urban land-use transport models:

- ***Environmental legislation*** in the USA has triggered a new wave of applications of urban land-use transport models

- In Europe, the ***European Commission*** has funded a number of studies employing urban land-use transport models.

- Several integrated urban land-use transport models are being ***applied*** to an increasing number of metropolitan areas.

Applications (1):

- ***DELTA*** has been applied to Edinburgh, Glasgow, Greater Manchester, Derby, Harlow and Auckland (NZ) and to the regions Trans-Pennine, South-West Yorkshire and Central Scotland and Scotland,

- ***IMREL*** has been applied to Stockholm county, the Mälar valley and the Öresund region in Sweden.

- ***PECAS*** (besides its application in TLUMIP) has been applied to the cities of Sacramento, Edmonton and Baltimore and the province of Alberta.

- ***RURBAN*** has been applied to the metropolitan areas of Sapporo and Sendai in Japan.

Applications (2):

- ***TRANUS*** (besides its application in TLUMIP) has been applied to the cities of Baltimore, Bogota, Brussels, Inverness, Buenos Aires, Mexico City, Maracaibo, Maracay, Valencia, Barcelona, Barquisimeto, Recife, Campinas, Sao Paolo, Caracas and regions in South America.

- ***URBANSIM*** (besides its application in TLUMIP) has been applied to the cities of Honolulu, Salt Lake City,Houston, Phoenix, Seattle, Amsterdam, Paris, Zurich and to Washtenaw County, Michigan.

- ***TRANUS*** and ***URBANSIM*** (and in the future ***TLUMIP***) are available for download as Open Source software. ***MUSSA*** is being distributed worldwide commercially.

Challenges

Challenges

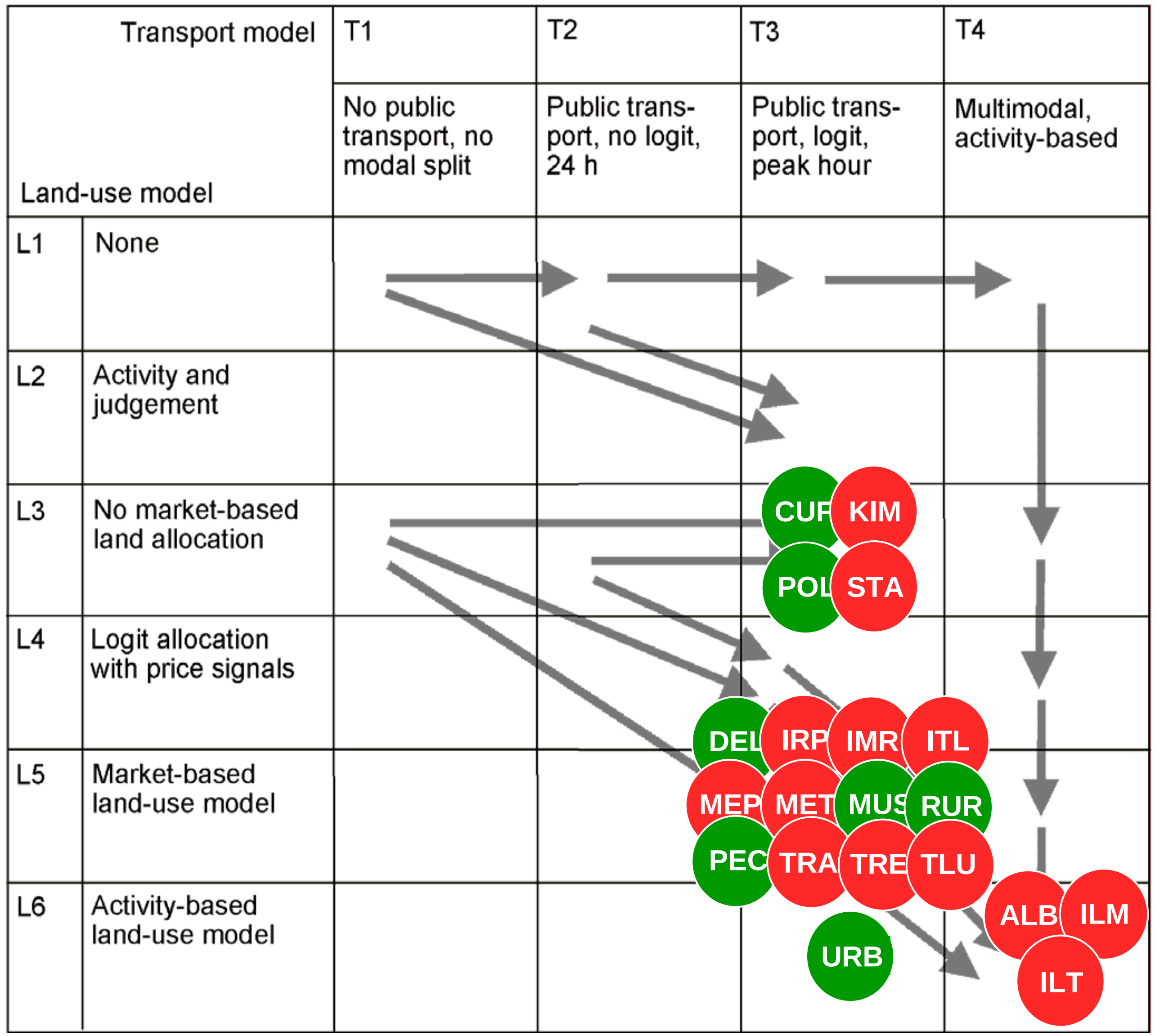
However, there are important challenges to be met by integrated urban land-use transport models

(1) The transport submodels used by most existing land-use transport models do not yet use state-of-the-art ***activity-based travel modelling*** techniques.

(2) The spatial resolution of most existing land-use transport models is too coarse to model ***environmental impacts*** and ***environmental feedback***.

(3) Most existing models do not take account of the impacts of ***telecommunications*** on urban mobility and location.

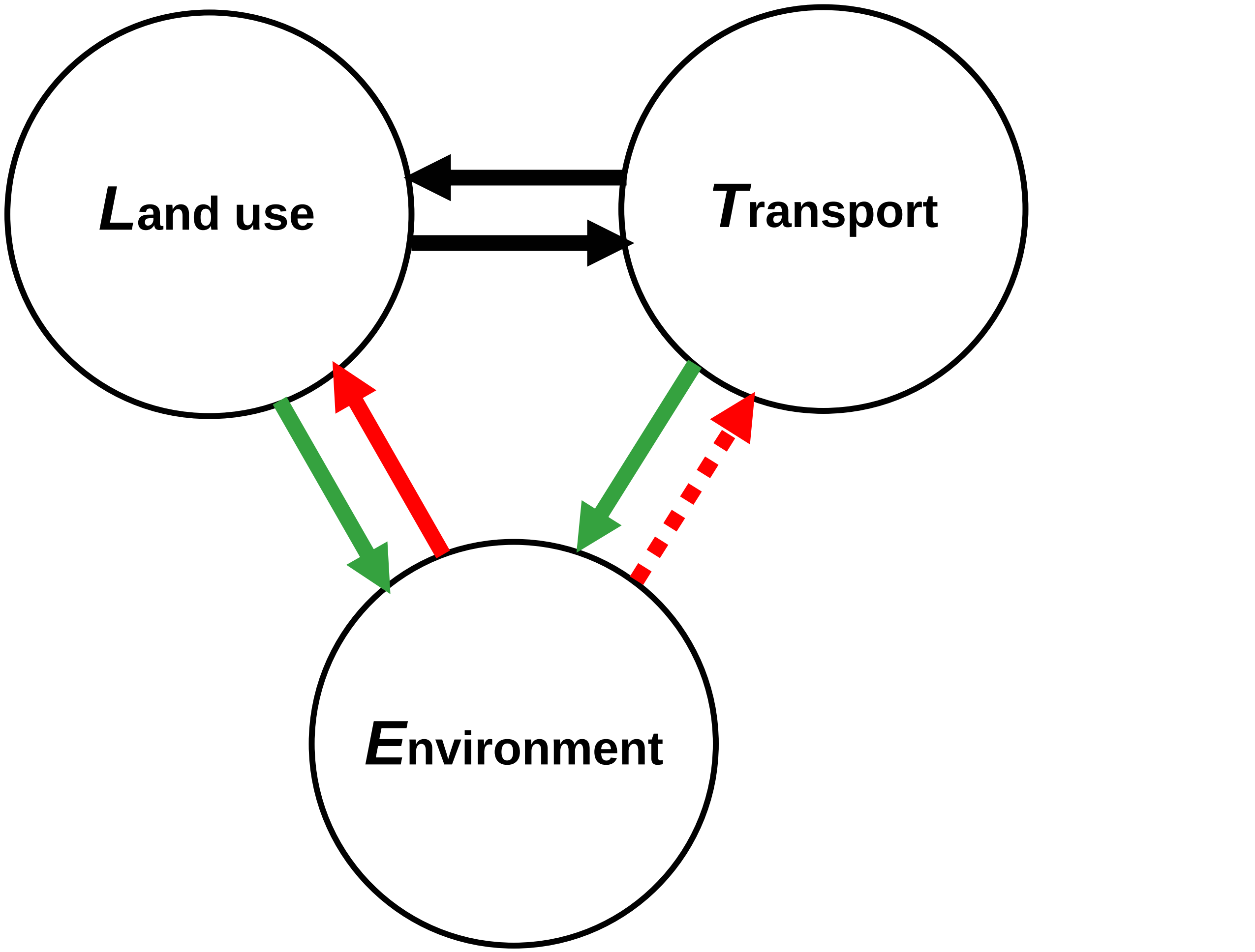
Activity-based modelling



(adapted from Miller et al. 1998)

Development path

Environmental Impacts/Feedback



Modelling environmental impacts

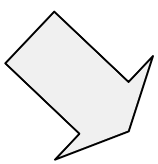
Examples:

Air distribution models modelling two- or three-dimensional distribution of pollutants from emission sources require ***raster data*** of emission sources, elevation and surface characteristics such as green space, built-up area and high-rise buildings.

Noise propagation models modelling propagation of noise from emission sources require ***raster data*** on emission sources, topography, land cover and sound barriers such as dams, walls or buildings.

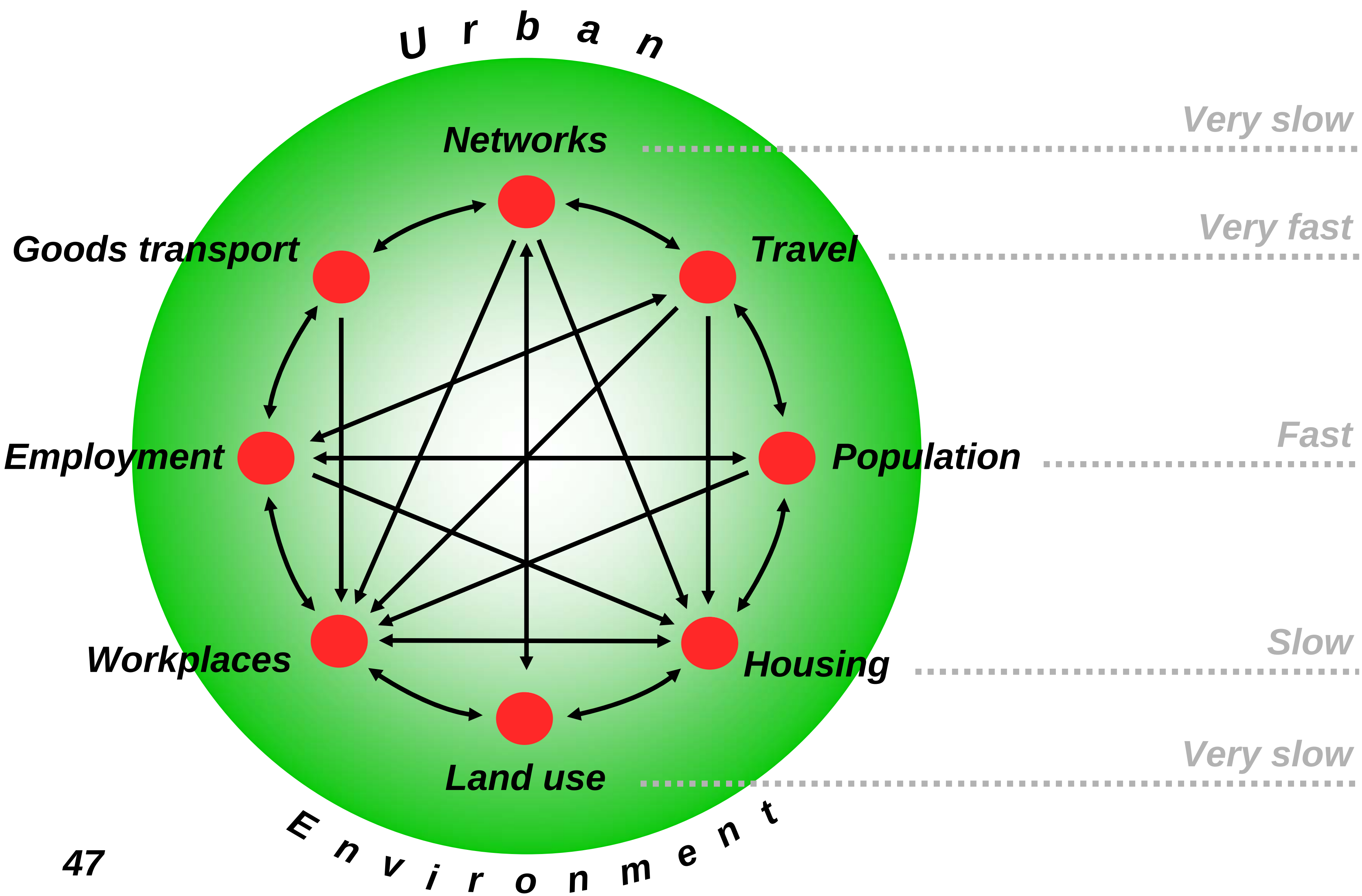
Environmental impacts/feedback

	No environmental impacts	***Environmental impacts***
No environmental feedback	ALB, CUF, DEL, IMR, ITL, KIM, MET, MUS, PEC, POL, TRA, STA	ILT, MEP, RUR, TRE
Environmental feedback		IRP, ILM, TLU, URB



Trend

Urban systems **Telecommunications** **Speed of change**



Open Question(s)

How much disaggregation?

There is a trend in urban modelling to move towards highly disaggregate. microscopic modelling approaches.

Only integrated ***microsimulation*** land-use transport models models permit the modelling of

- ***"soft"*** and ***local*** planning policies
- individual ***lifestyles***
- environmental ***impacts*** and ***feedback***
- ***micro locations*** and spatial ***equity***

However, there is a price for the microscopic view in terms of ***data requirements*** and long ***computing times***.

There are also ***privacy*** and ***ethical*** issues involved.

The benefits of disaggregation

Disaggregate integrated urban land-use transport models allow to model ***activities*** of human actors, such as

- new ***lifestyles*** and ***work patterns***, such as ***part-time work***, ***telework*** and ***teleshopping***,
- the interaction between ***travel demand***, ***car ownership*** and ***residential*** and ***firm location***,
- the interaction between ***land use, built form*** and ***mobility behaviour***,
- ***environmental impacts*** of transport such as ***traffic noise*** and ***exposure to air pollution***,
- the role of ***environmental quality*** for location decisions of households and firms.

The limits to disaggregation

Theory. Theoretical limits may appear when the strong behavioural patterns dictated by necessity and constraints are overshadowed by random context ("Where do your friends live?").

Data. Data restrictions may appear when subjects start to resist the trend towards surveillance and breach of privacy ("With whom did you spend the evening?").

Computing. Computing time limits may appear when the computing times of models exceed the duration of real processes.

Practical experience with disaggregation

All ambitious urban microsimulation modelling projects in the world have had the same experience:

- Development, calibration and testing of microsimulation models has taken longer than planned.
- Long computing times have prevented the necessary number of experimental runs of the models.
- Significant adjustments and simplifications of the model concepts have been necessary to make the models operational.

Conclusions

Conclusions (1)

In the last decade, ***significant progress*** in the state of the art of integrated urban land-use transport modelling has been made.

There exists a ***wide range*** of theoretically sound and empirically validated integrated urban land-use transport models.

Several integrated urban land-use transport models are being ***practically applied*** to an increasing number of metropolitan areas.

Future improvements of integrated urban land-use transport models include ***activity-based transport*** modelling, ***higher spatial resolution*** and ***telecommunications***.

Conclusions (2)

Under constraints of ***data collection*** and ***computing time***, there is for each planning problem an optimum level of ***con-ceptual***, ***spatial*** and ***temporal*** resolution.

This suggests to work towards a ***theory*** of ***balanced multi-level models*** which are as ***complex*** as needed for the task at hand yet as ***simple*** as possible but no simpler.

Future urban models will be ***modular*** and ***multi-level*** in ***scope***, ***space*** and ***time***.

Two recent reviews of urban models

Hunt, J.D., Kriger, D.S., Miller, E.J. (2005): Current operational land-use transport modelling frameworks: a review. *Transport Research* **25**, 3, 329-376.

Wegener, M. (2004): Overview of land-use transport models. In: Hensher, D.A., Button, K. (Eds.): *Transport Geography and Spatial Systems*. Volume 5 of *Handbook in Transport*. Kidlington, UK: Pergamon/Elsevier Science.