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5 Ws of Land Use Transport Interaction Modeling

A Primer on Land Use Transport Interaction Modeling

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Presented at
The Oregon Symposium on Integrated Land Use and Transport Models

September 1998

Outline:

- **Introduction**
- intentions
- assumed background

- **WHAT is land use transport interaction modeling**
- transport system
- spatial activity system
- land use system
- land use transport 'line process' modeling
- land use transport interaction modeling
- implicit representation of transport effects on land use
- spatial activity system modeling

- **WHY develop and use land use transport interaction models**
  - why modeling in general
  - why land use transport interaction modeling in particular
  - areas of concern

- **WHERE, WHO, WHEN of land use transport interaction modeling**
  - general situations
  - a brief history
  - specific models

- **Concluding Remarks**
  - Oregon work in context
  - apparent future directions
  - important issues

Intentions:

- prepare for the rest of this symposium
  - provide background
  - explain basic concepts
  - define terms
  - provide a larger conceptual structure

- consider why work in Oregon is important and set it within the larger context of work elsewhere

- cover the ‘5 Ws’ of land use transport interaction modeling:
  who, what, where, when and why

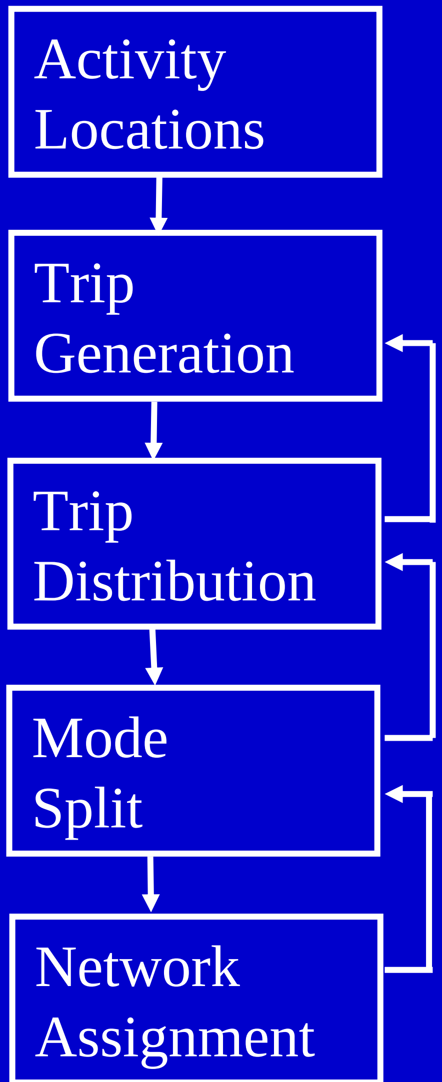
Assumed Background:

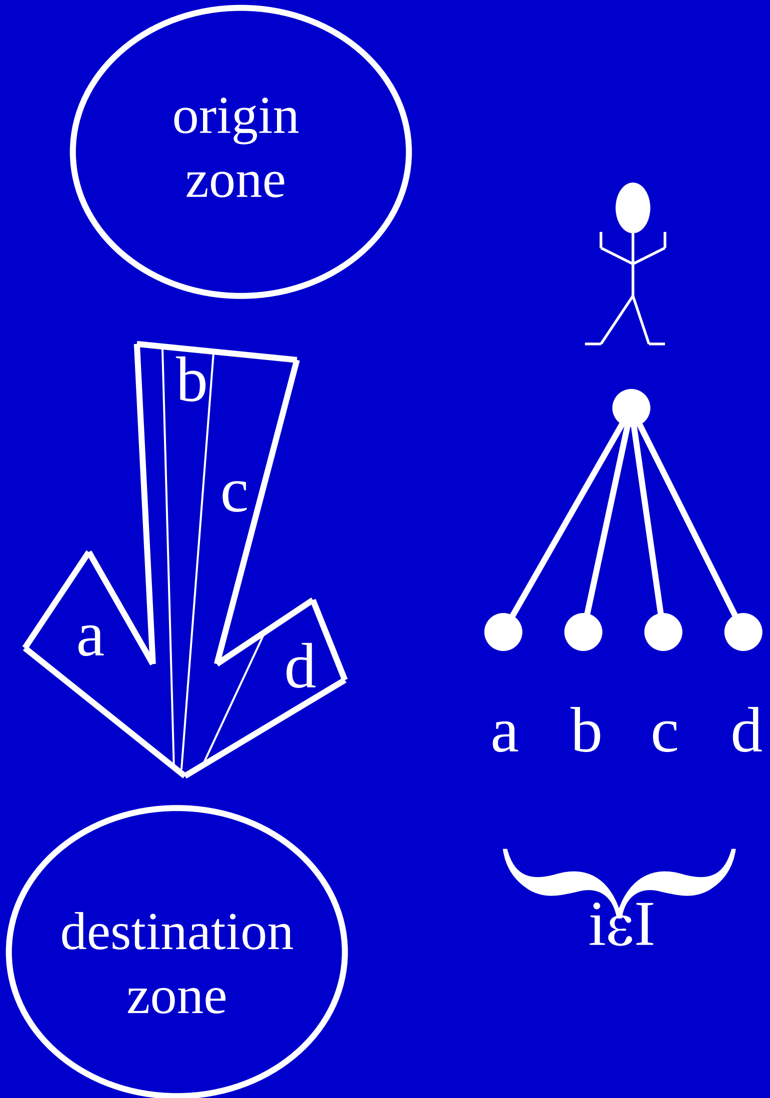
- expect mixed audience
- interest and exposure to issues
- transport models
- land use forecasts
- land use models
- land use transport interaction
- co-participants with many years of experience in both research and practice

- assume reasonable minimum of practical transport modeling exposure, including:
- ‘4-step framework’ and its component steps
- appreciate feedback from lower to higher steps for ‘consistency’
- appreciate logit, nested logit and composite utility (‘logsum’) for representing behavior

- if lacking, suggest texts:
  - Ortúzar and Willumsen, 1994
  - Ben Akiva and Lerman, 1985

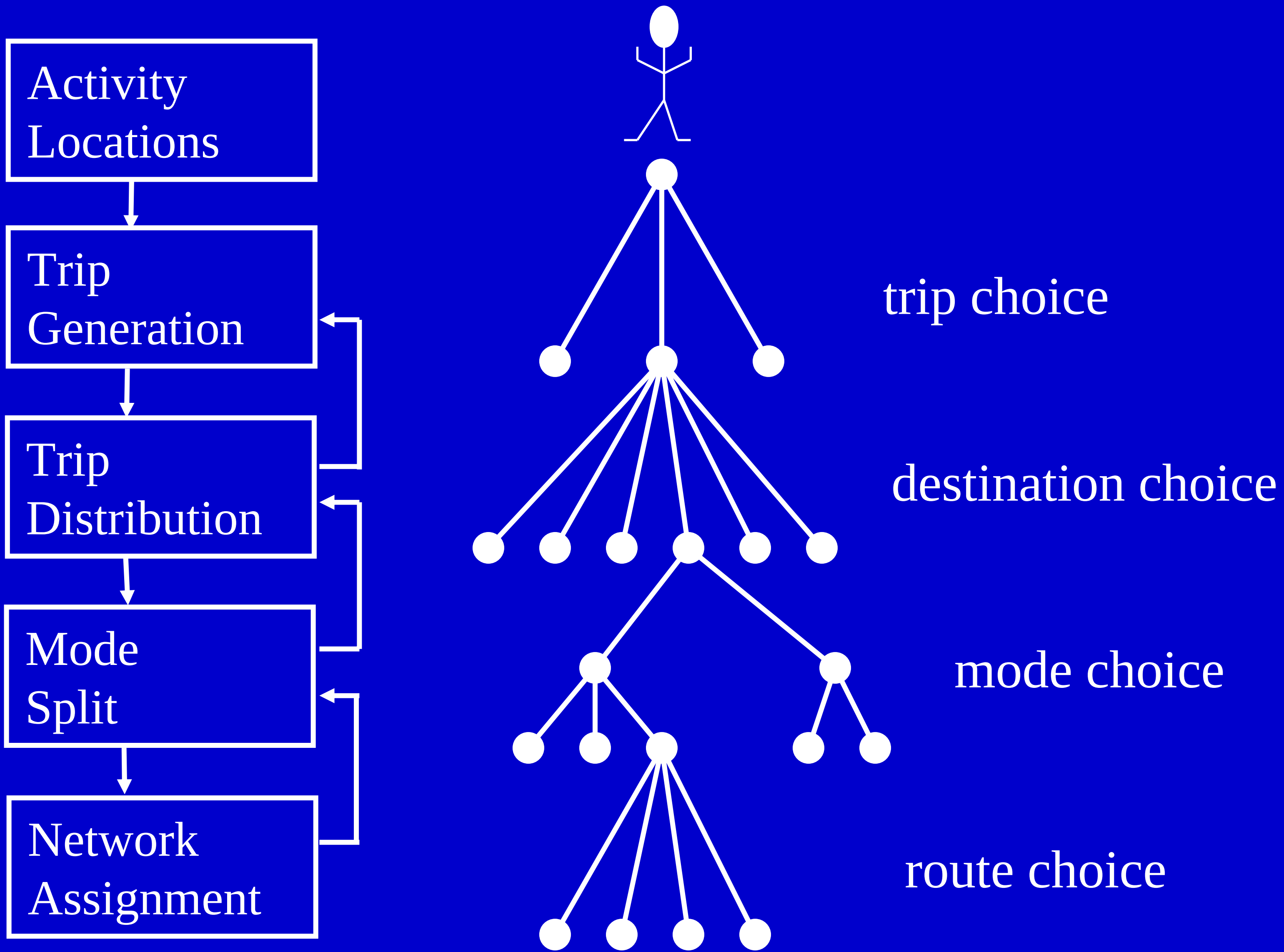
- offer some further observations to foster later discussion and considerations


Activity Locations
Trip Generation
Trip Distribution
Mode Split
Network Assignment



$$P_a = \frac{e^{\lambda U_i}}{\Sigma_i \, e^{\lambda U_i}}$$

$$U_I = \frac{1}{\lambda} \Sigma_i \, e^{\lambda U_i}$$


Activity Locations
Trip Generation
Trip Distribution
Mode Split
Network Assignment
trip choice
destination choice
mode choice
route choice

2: WHAT is land use transport interaction modeling

- places transport system in context within larger spatial activity system

- essential element: circular interaction

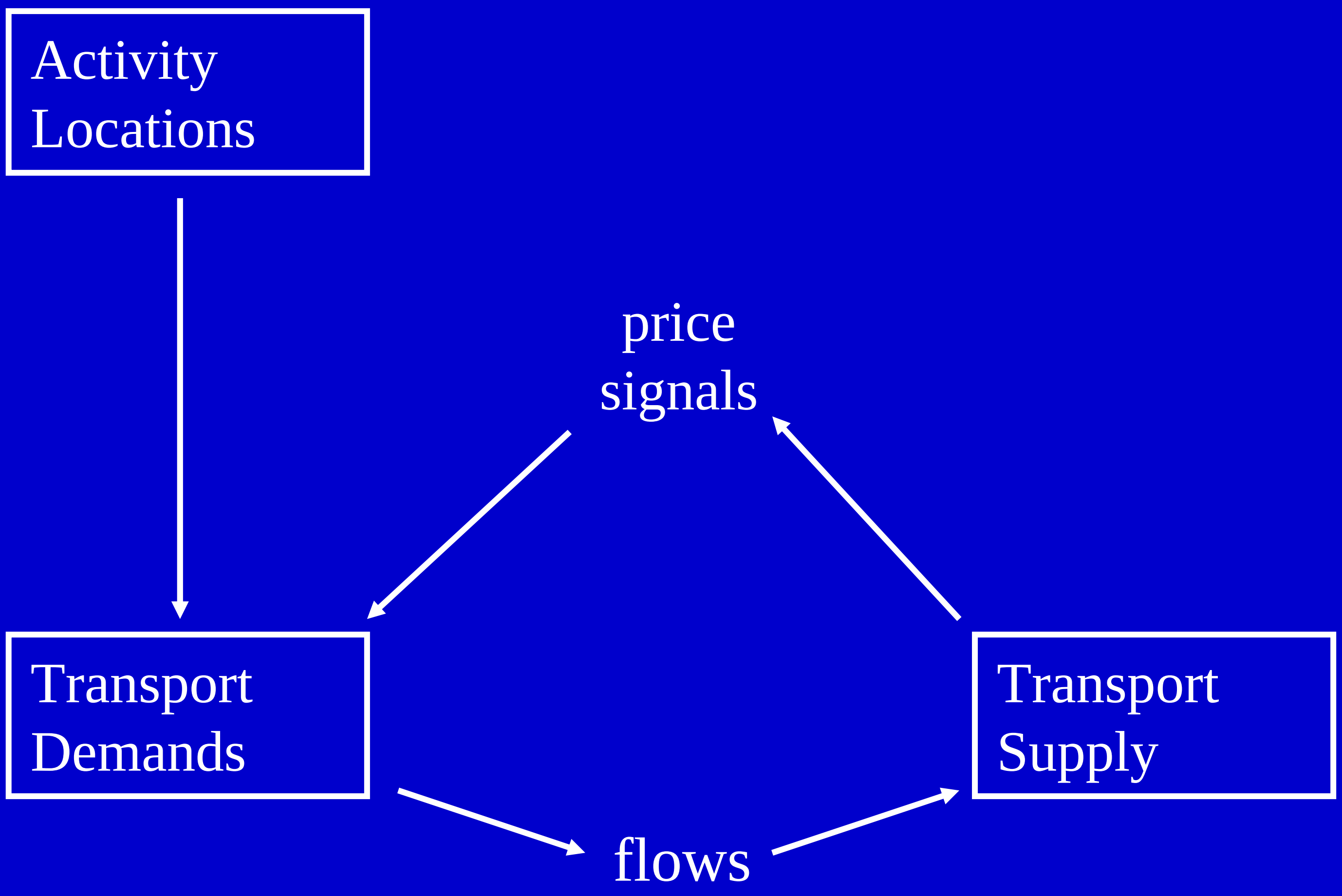
- transport to land use interaction accomplished with alternative signals

- need some definitions

Transport System Definition:

- includes:
  - demand for movements of people and goods & services through space,
  - supply of transport services facilitating such movements, and
  - interaction between this supply and demand causing:
    - ◊ actual movements: flows of people and goods & services in space
    - ◊ price signals (times & costs)
    - ◊ use of resources, including time and land (for transport supply)
    - ◊ degradation of environment in production of supply
    - ◊ transfer of resources (such as money) among groups

- transport models intended to represent aspects of this system; the domain of typical traffic forecasting models and other 4-step models


Activity
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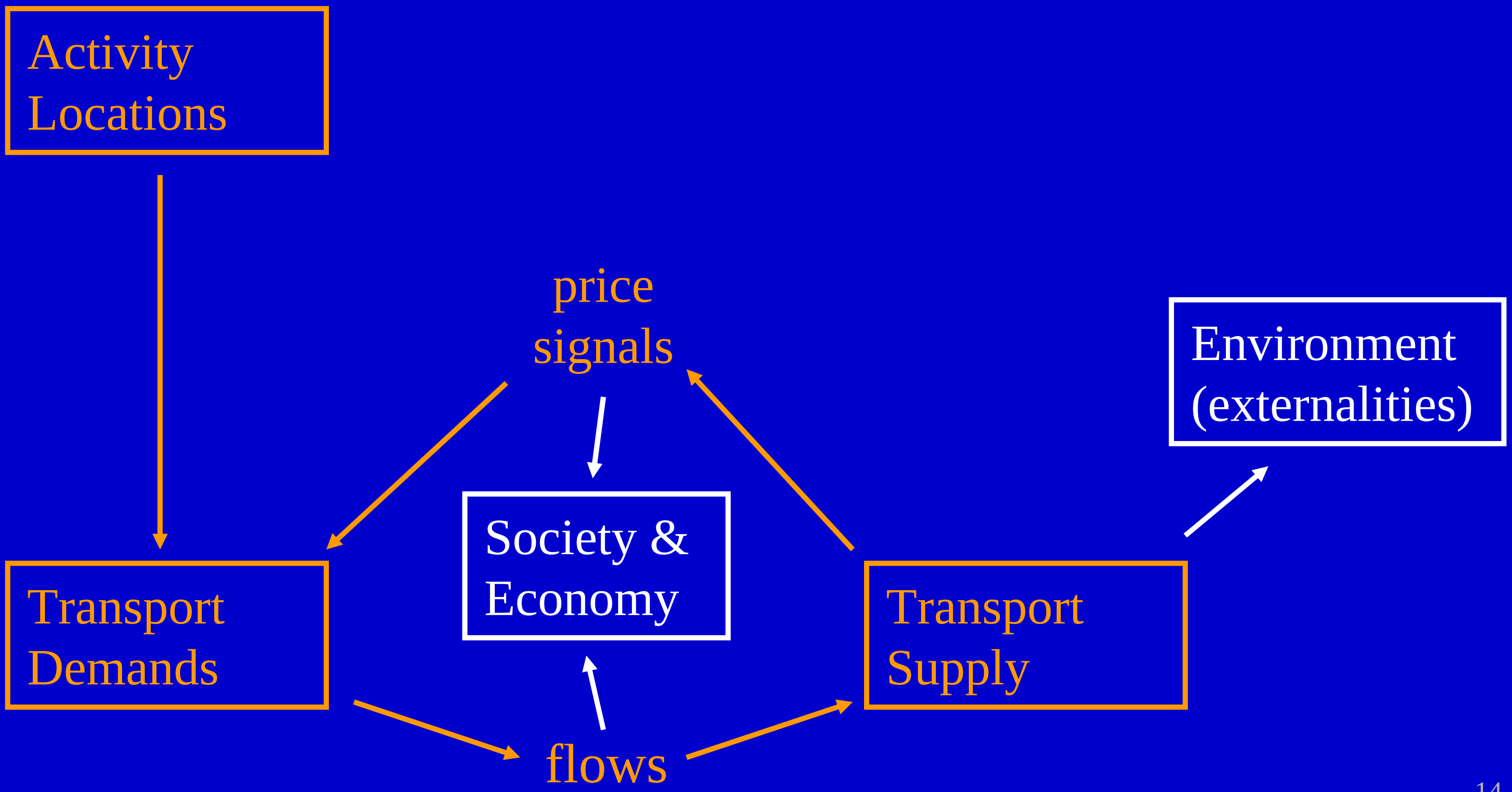
Demands
Transport
Supply
flows


Activity Locations
price signals
Environment (externalities)
Society & Economy
Transport Demands
Transport Supply
flows

Spatial Activity System Definition:

- includes entire set of actions of society and its various elements

- economic dimension

◊ production of goods & services

◊ consumption of other goods & services and labor

◊ occurs in space, thus locations consumed and distances overcome

- demographic dimension

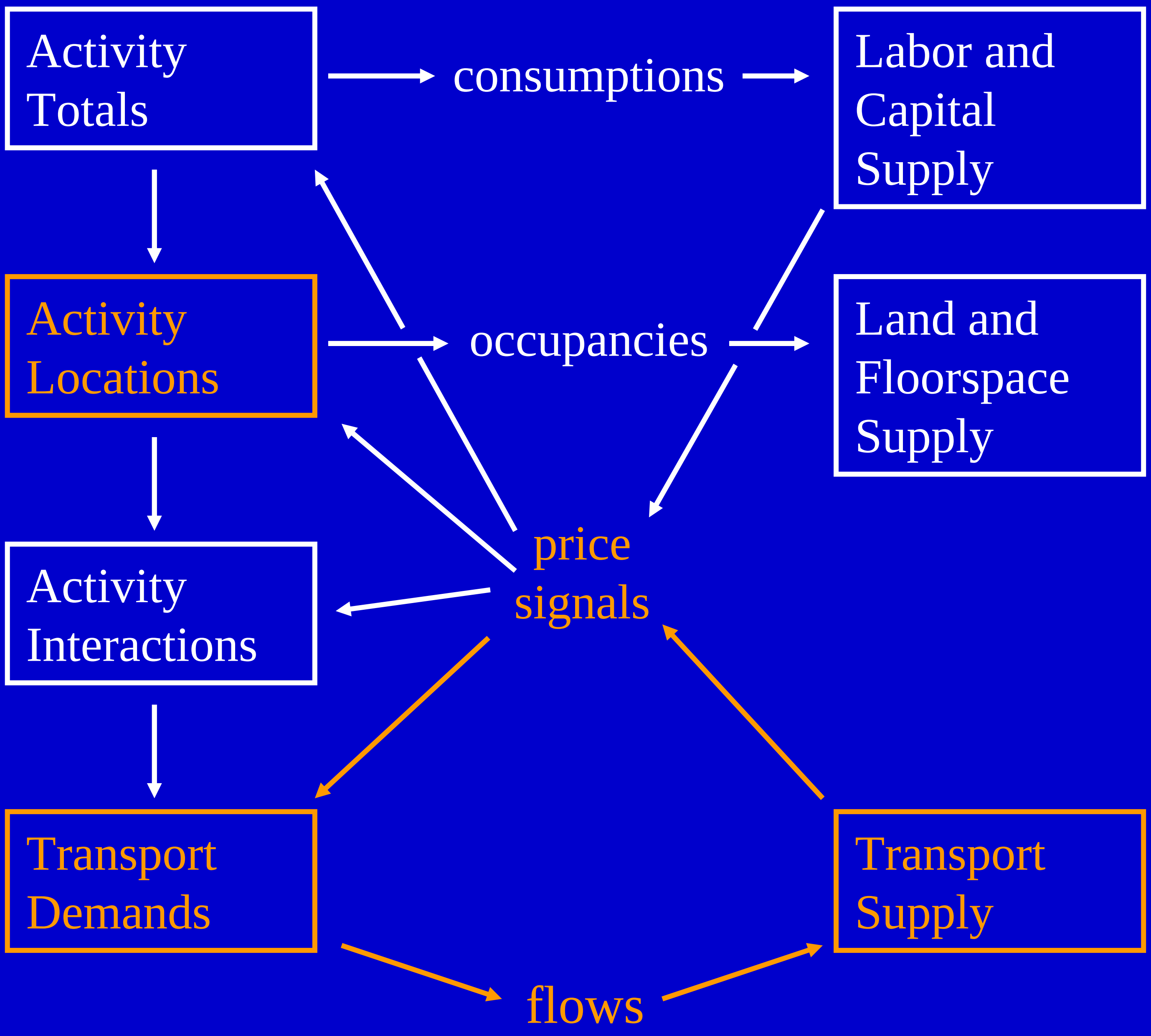
◊ people and households allocate activities to satisfy needs and wants

  - trading for call on resources
  - like production (typically labor) and consumption of required inputs
  - but motivation seems different

◊ occurs in space, thus locations consumed and distances overcome

- results in ‘chains’ of production and consumption and household activities causing:
  - ◊ flows of labor and goods & services from production to consumption
  - ◊ demands and resulting movements of people and goods & services in space
  - ◊ price signals (times & costs)
  - ◊ use of resources, including time, and occupation of space
  - ◊ degradation of environment in production of supply
  - ◊ transfer of resources (such as money) among groups

- spatial activity system models intended to represent aspects of this larger system, taking account of spatial dimension, includes
  - urban system models
  - regional spatial-economic system models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Labor and Capital Supply
Activity Locations
occupancies
Land and Floorspace Supply
Activity Interactions
price signals
Transport Demands
Transport Supply
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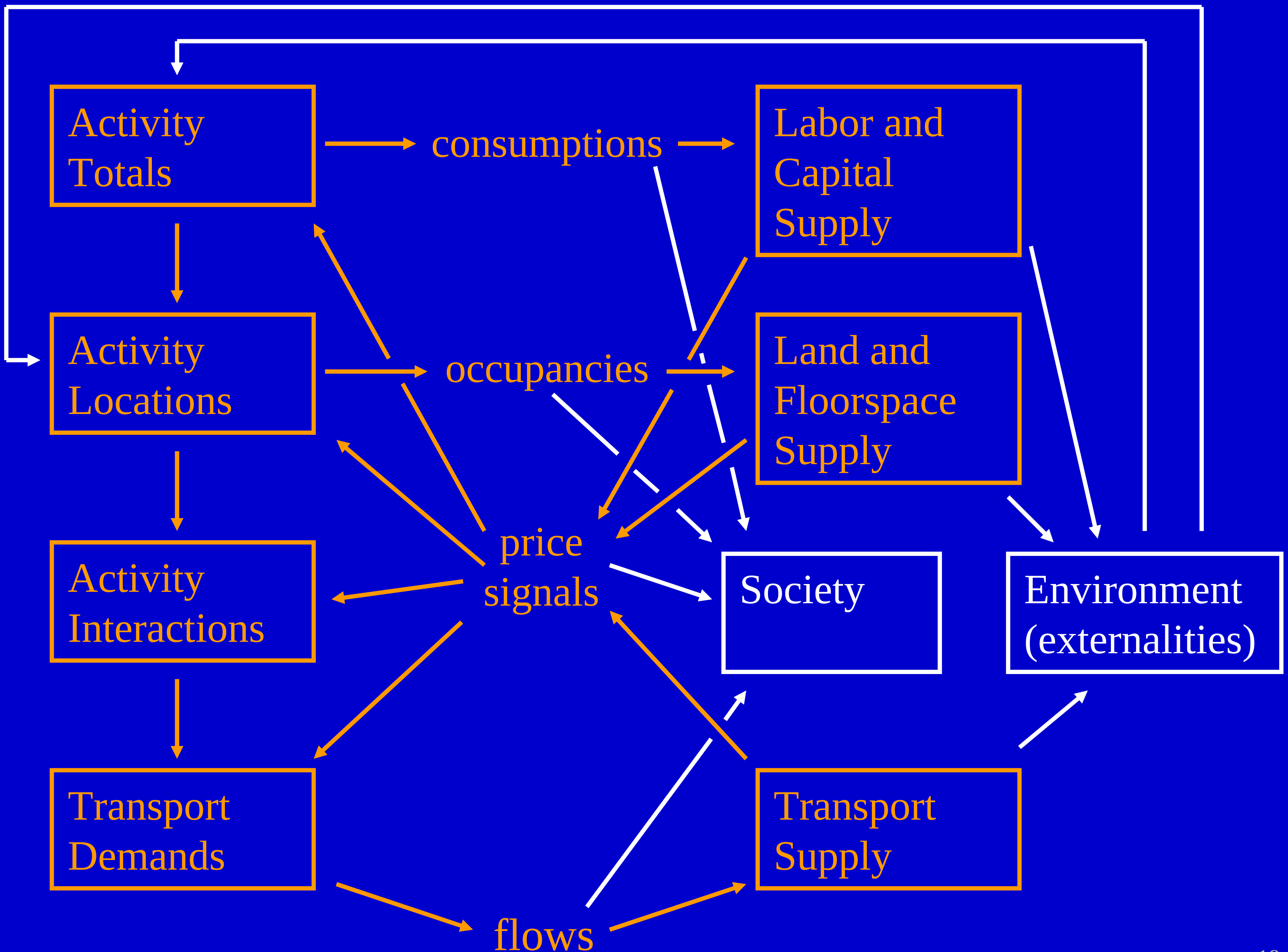
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Activity Interactions
price signals
Society
Environment (externalities)
Transport Demands
Transport Supply
flows

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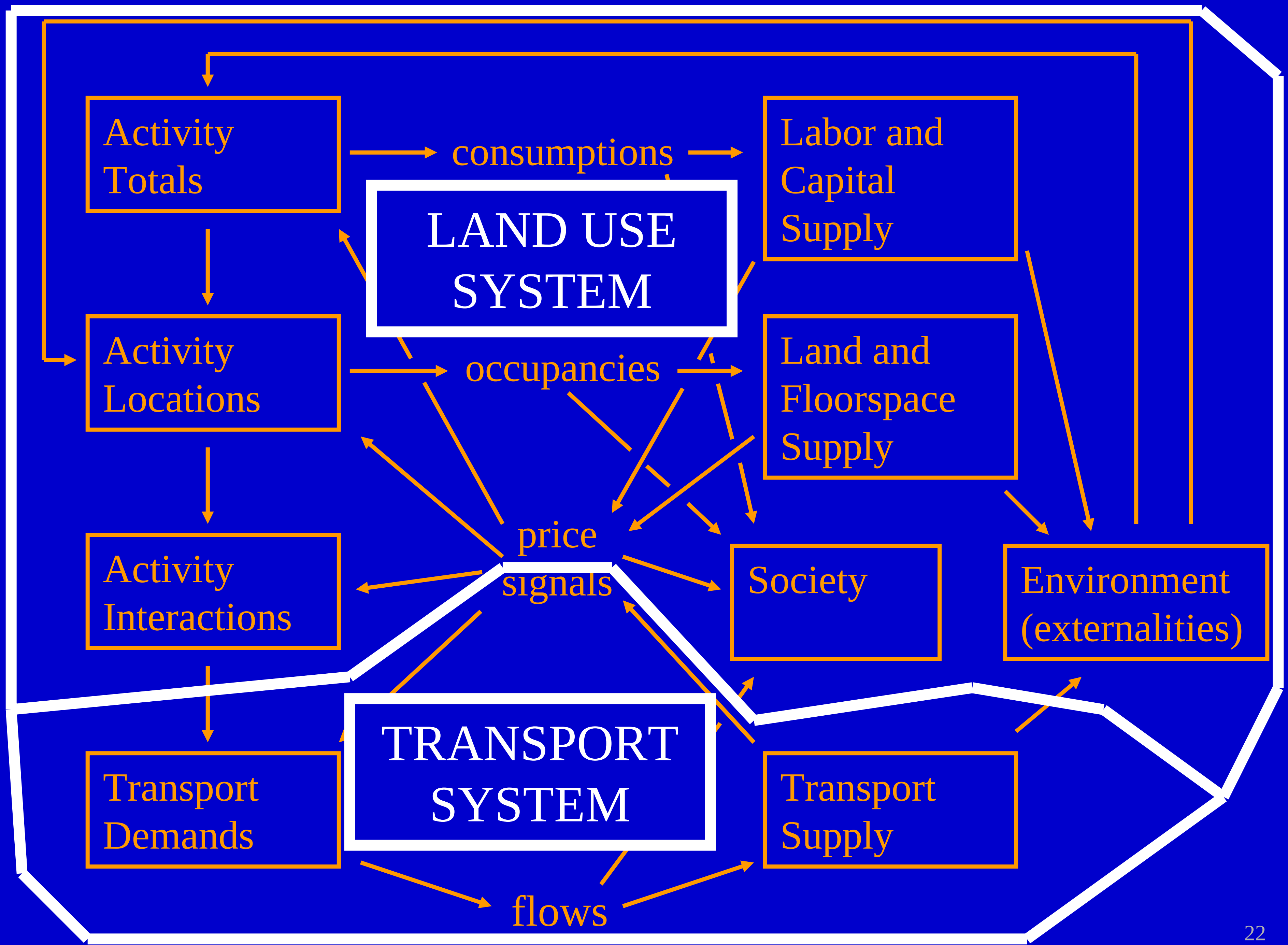
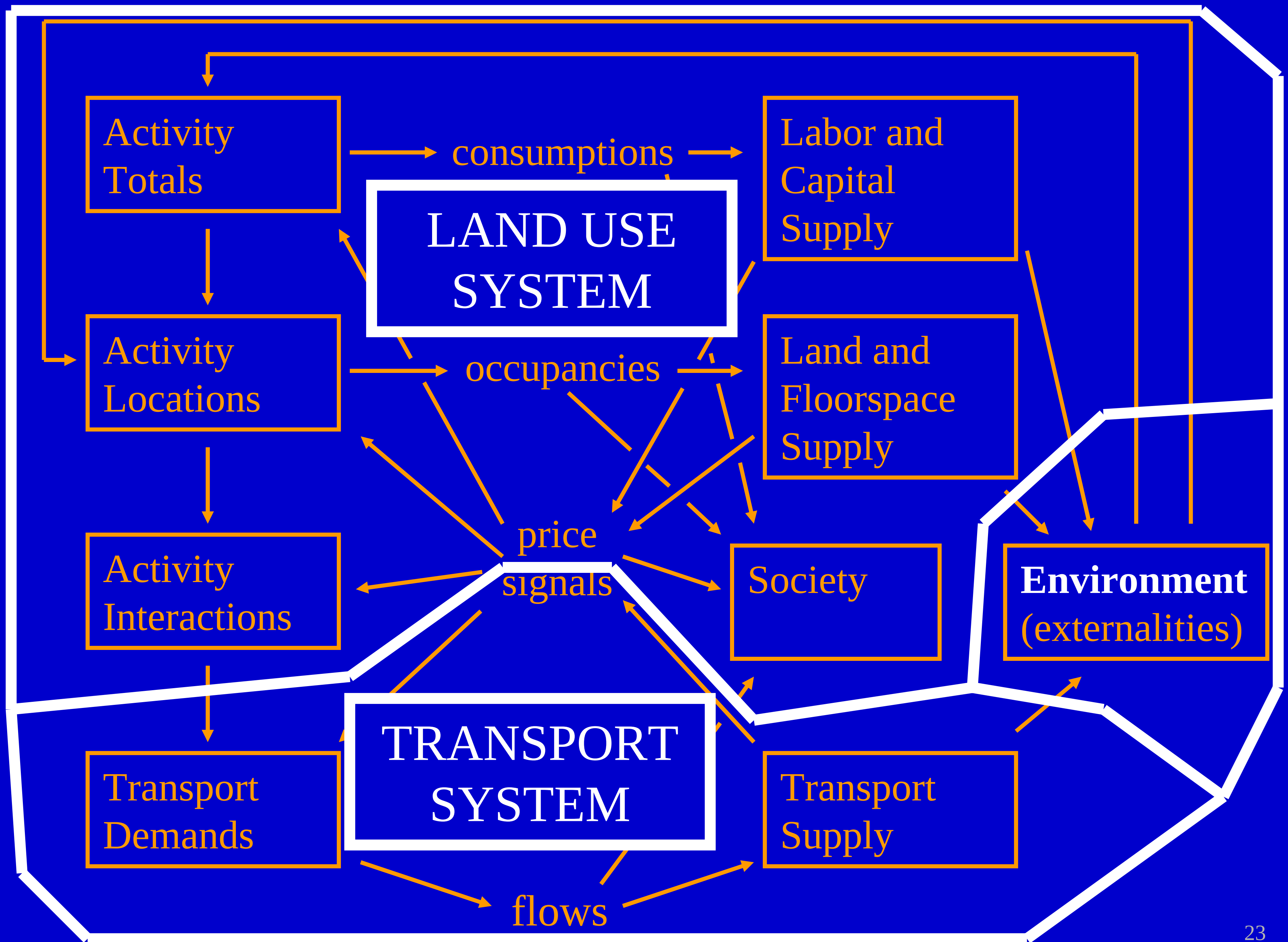
Land Use System Definition:

- ‘spatial activity system’ includes ‘transport system’ as a sub-system
- ‘land use system’ (rather loosely) refers to elements of ‘spatial activity system’ outside ‘transport system’
- sometimes ‘land use system’ and ‘environment system’ used to parse up non-transport components of ‘spatial activity system’


Activity Totals
consumptions
Labor and Capital Supply
LAND USE SYSTEM
Activity Locations
occupancies
Land and Floorspace Supply
price signals
Activity Interactions
Society
Environment (externalities)
Transport Demands
TRANSPORT SYSTEM
Transport Supply
flows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TRANSPORT SYSTEM
Transport Supply
flows

Land Use Transport 'Line Process' Modeling:

- occurs when signals between land use and transport all pass one way 'in a line'

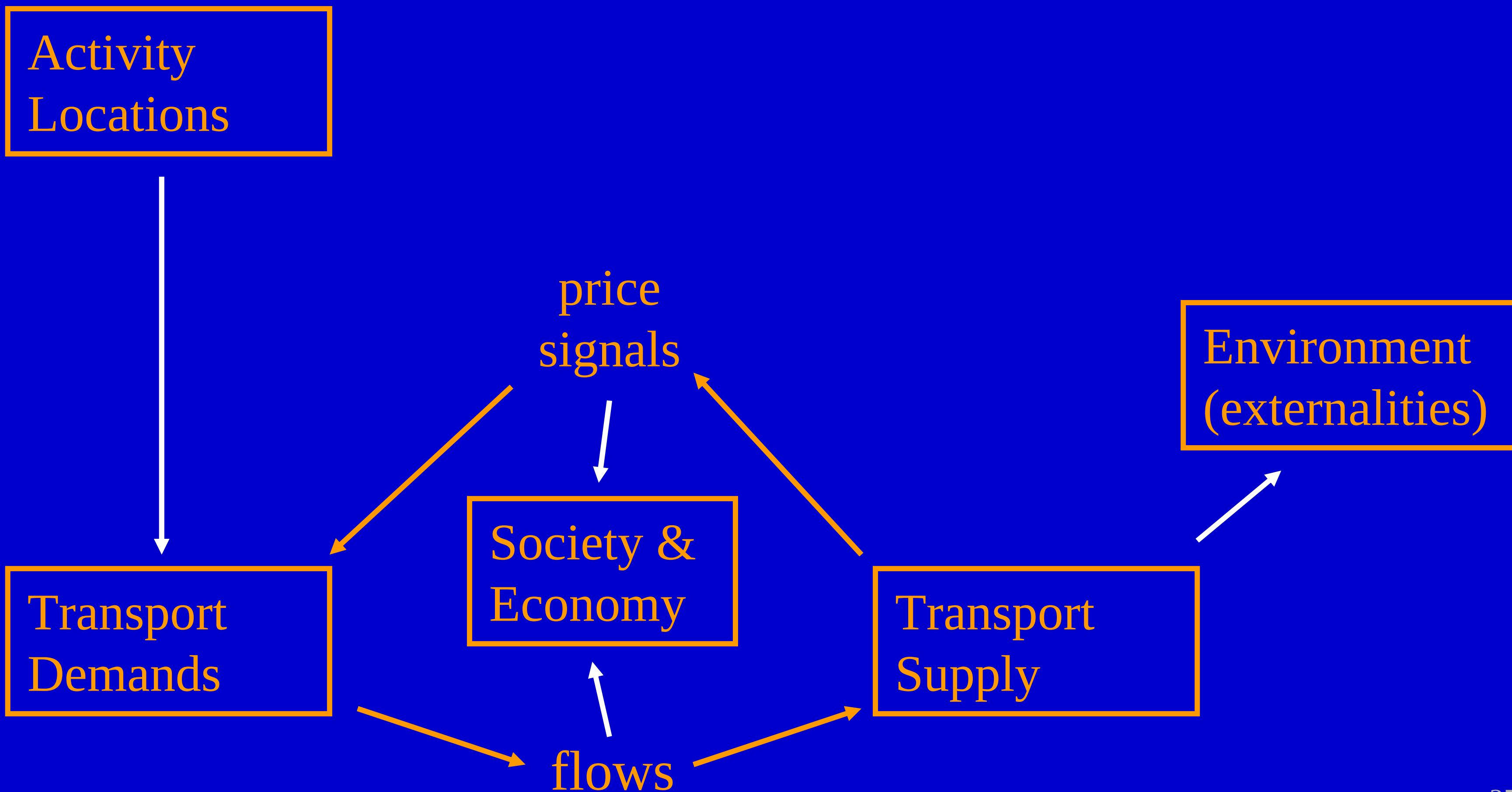
- from activity locations (land use) to transport (trip generation)

- possibly also from transport to assessment of impacts

- but NO circular interaction from transport back to activity locations

- reinforces planning approaches:

- transport system designed to satisfy transport demand arising with set land use plans (because impacts on land use plans ignored)
- transport activity to be minimized in order to minimize negative impacts on costs, times and pollutants (when certain beneficial impacts of transport ignored)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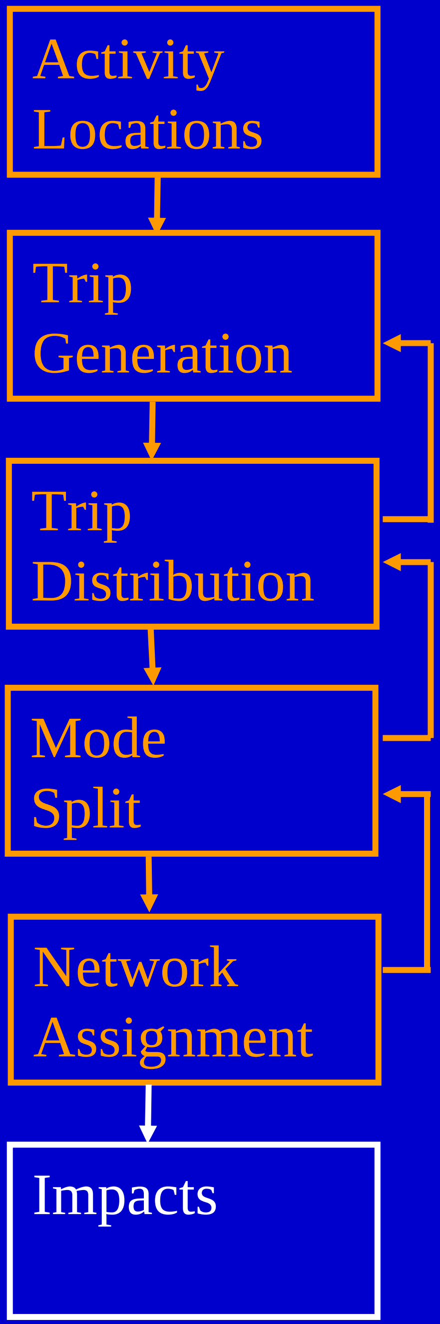
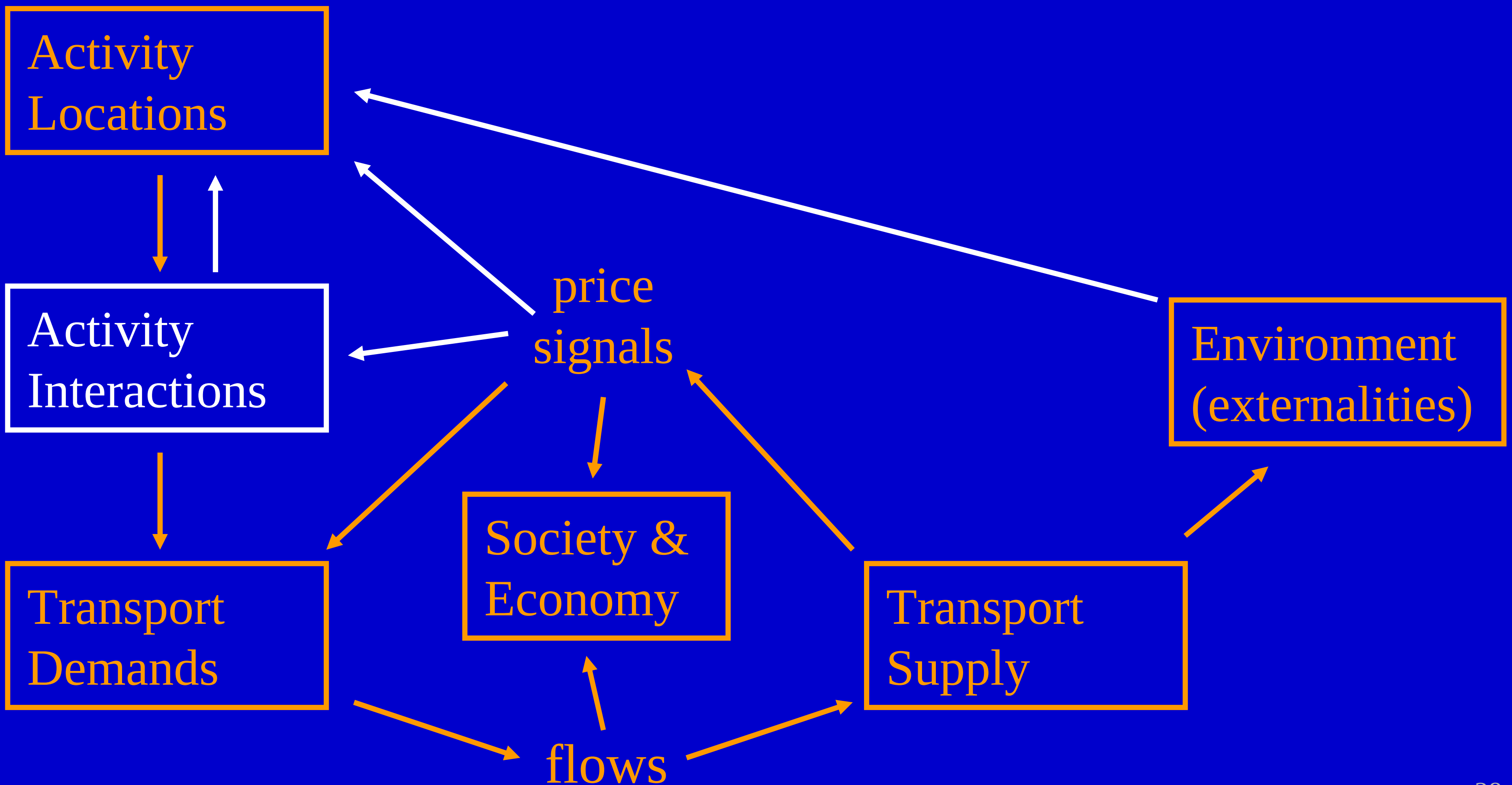

Activity Locations
Trip Generation
Trip Distribution
Mode Split
Network Assignment
Impacts

Land Use Transport Interaction Modeling:

- beyond ‘line-process’ approach
- includes signals in ‘line-process’ approach
- AND circular interaction ‘feedback’ from transport back to activity locations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(externalities)
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flows

- feedback from land use to transport has several forms:

- location accessibilities
- interchange disutilities
- transport money costs
- other secondary impact signals

location accessibilities:

- ‘accessibility’ indicates attractiveness of location

\- sum of opportunities times proximity
such as:

$$A_i = \Sigma_j O_j e^{\lambda u_{ij}}$$

- feedback from transport model to activity location choice or allocation model

- concerns locations

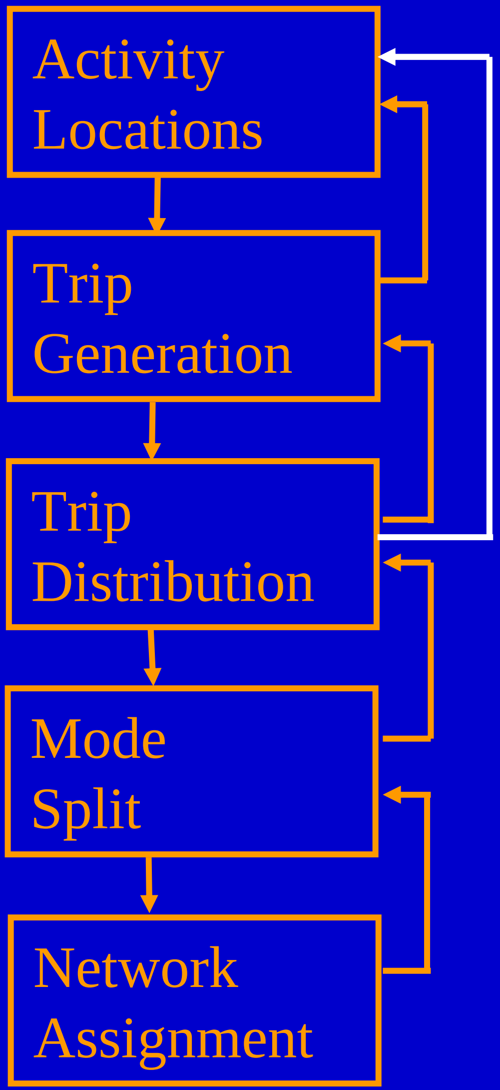
- typically sum across destinations (from distribution)

- ultimate form consistent with nested logit:
  composite utility from top level choice, generation in 4-steps

- usually some form of compromise from ultimate form:
  - just one mode (auto) considered
  - just travel times considered
  - accessibility expression defined independent of choice model or in absence of choice model
  - accessibility expression does not relate to the top level of choice model

- resulting model system sometimes called ‘connected’

- last two compromises can lead to inconsistencies in model system between:
  - activity interactions one based on land use model
  - trip distribution based on transport model


Activity
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Generation
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Distribution
Mode
Split
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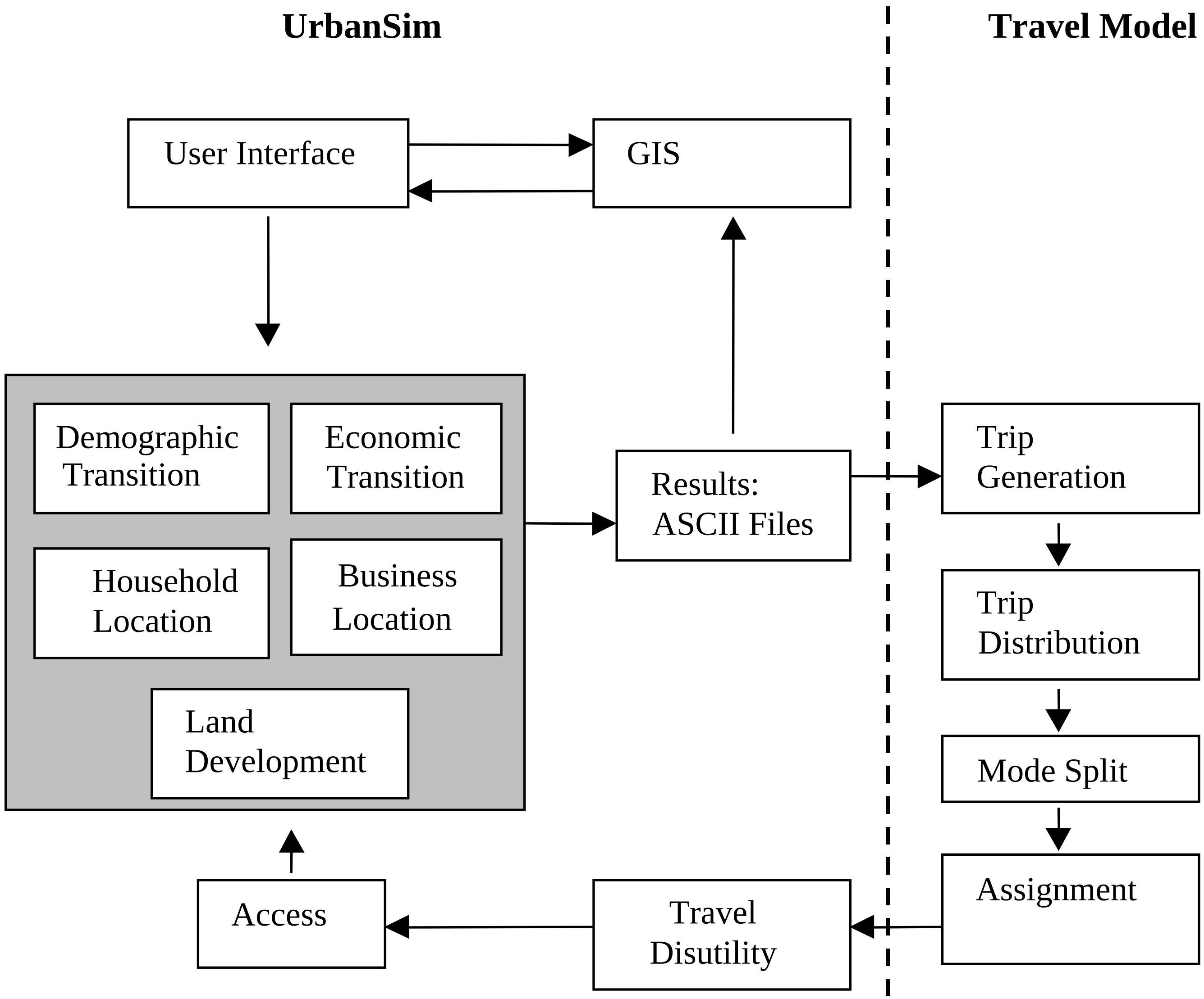
Assignment

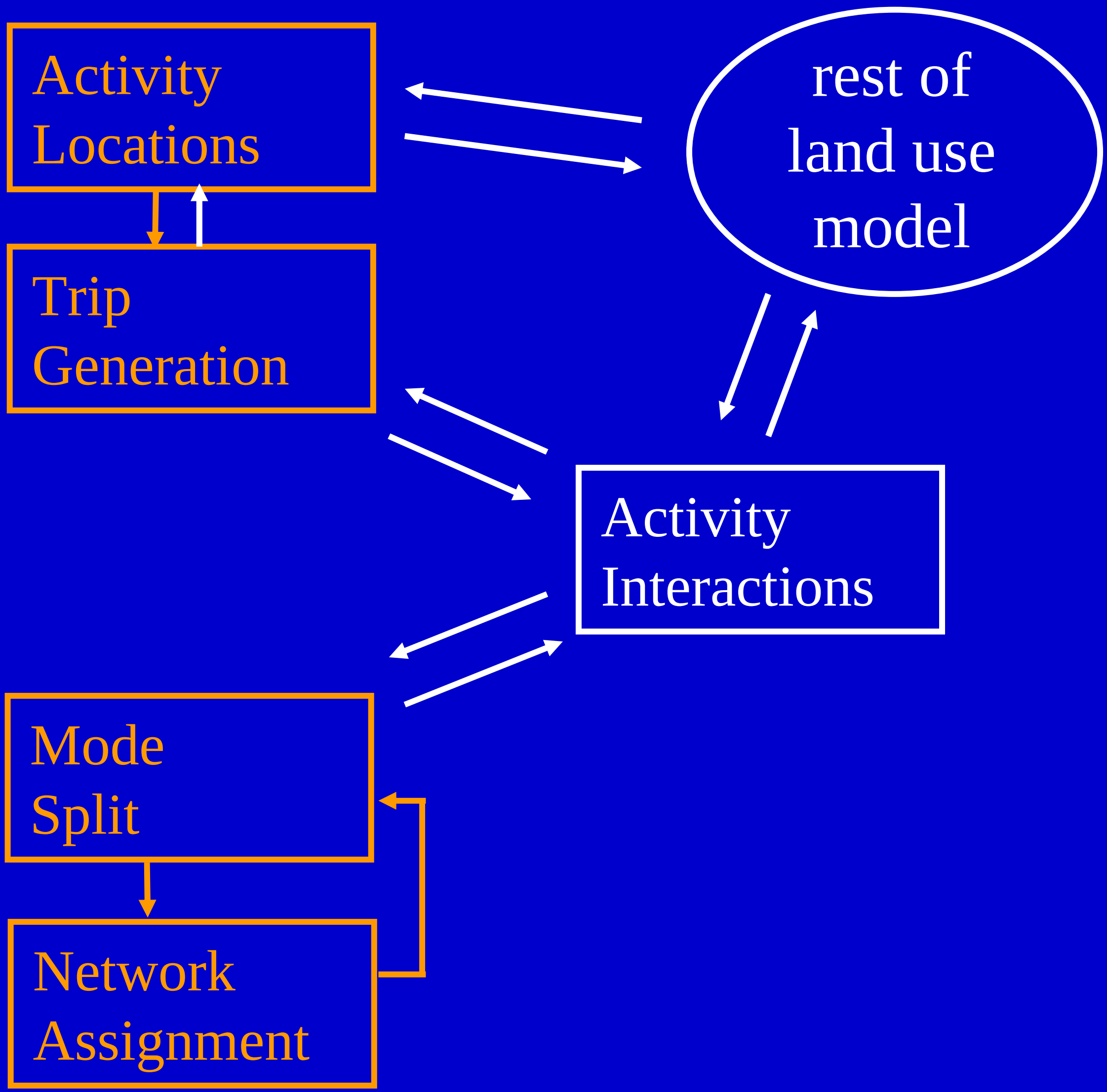

UrbanSim
Travel Model
User Interface
GIS
Demographic Transition
Economic Transition
Household Location
Business Location
Land Development
Results: ASCII Files
Trip Generation
Trip Distribution
Mode Split
Assignment
Access
Travel Disutility

interchange disutilities:

- ‘transport disutility’ indicates difficulty of movement from i to j
- feedback from transport model to some form of activity interaction simulation in land use model
- generation and distribution steps removed from transport model
- concerns interchanges
- ultimate form consistent with nested logit:
  composite utility from mode choice
- sometimes some form of compromise from ultimate form:

- just one mode (auto) considered;
- just travel times considered

- resulting model system sometimes called ‘integrated’
- land use model sometimes viewed as ‘complicated gravity model’
- above compromises do not lead to inconsistencies in model system regarding activity interactions


Activity Locations
rest of land use model
Trip Generation
Activity Interactions
Mode Split
Network Assignment

transport money costs:

- transport money cost added total production cost at location

- sum of purchase prices plus transport costs
  such as:

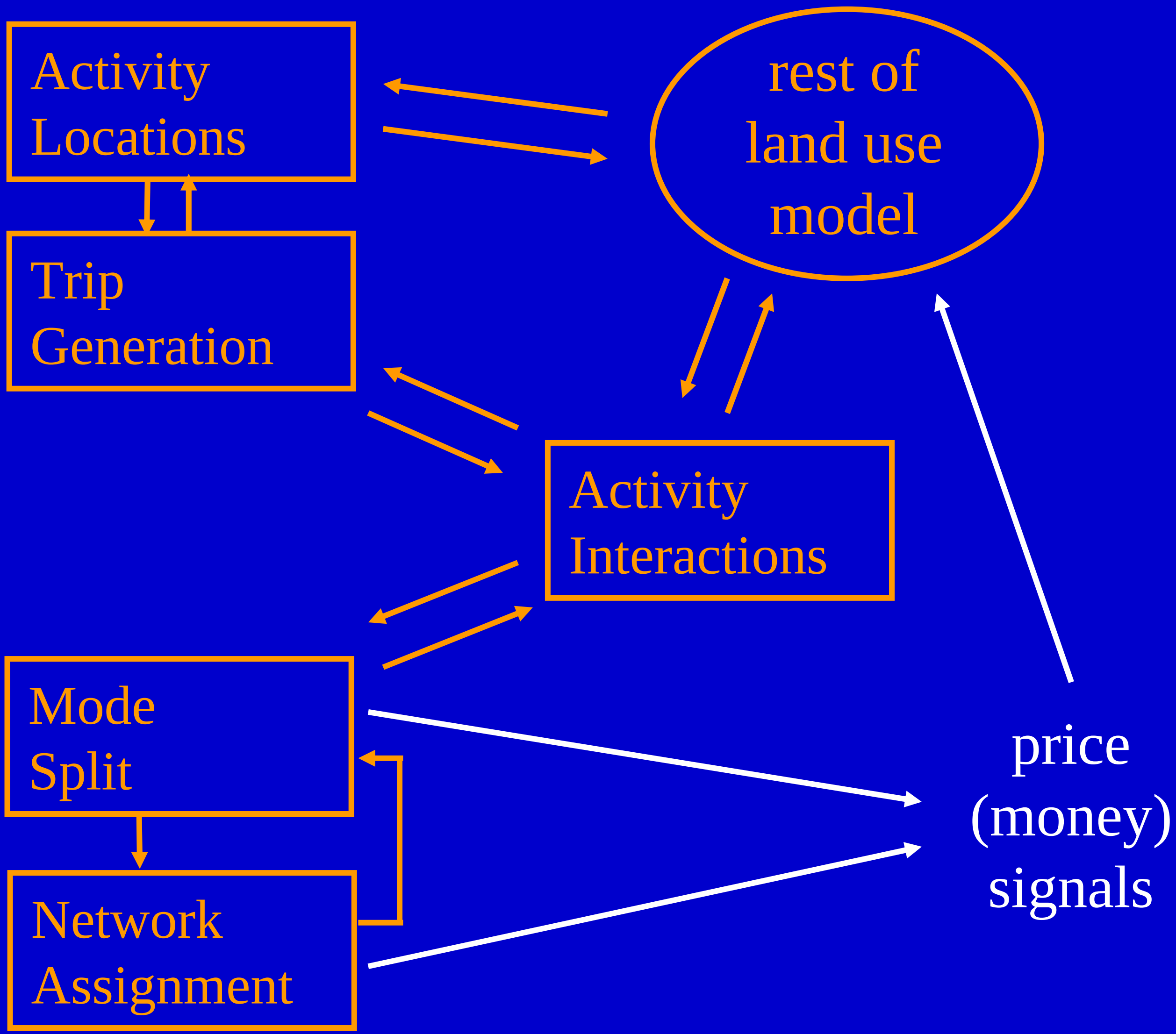
$$PC_{mi} = \Sigma_n \, a_{nm}\Sigma_j(PP_{nj}+TC_{nij})$$

- total production cost influences allocation of production

- feeback from transport model to price determination in land use model

- typically part of ‘integrated’ structure

- disutility rather than money cost for consistency


Activity Locations
rest of land use model
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Mode Split
Network Assignment
price (money) signals

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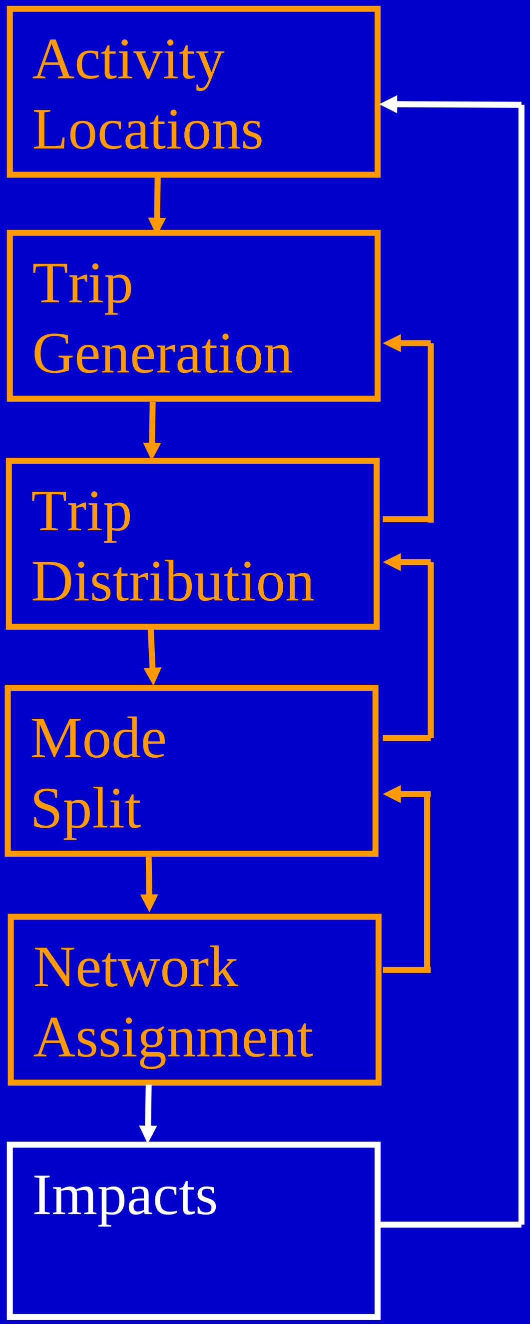
other secondary impact signals:

- influences made ‘circular’ via other another part of the land use system

- examples:
- air quality reducing activity
- noise impacts altering activity locations

- typically included with other signals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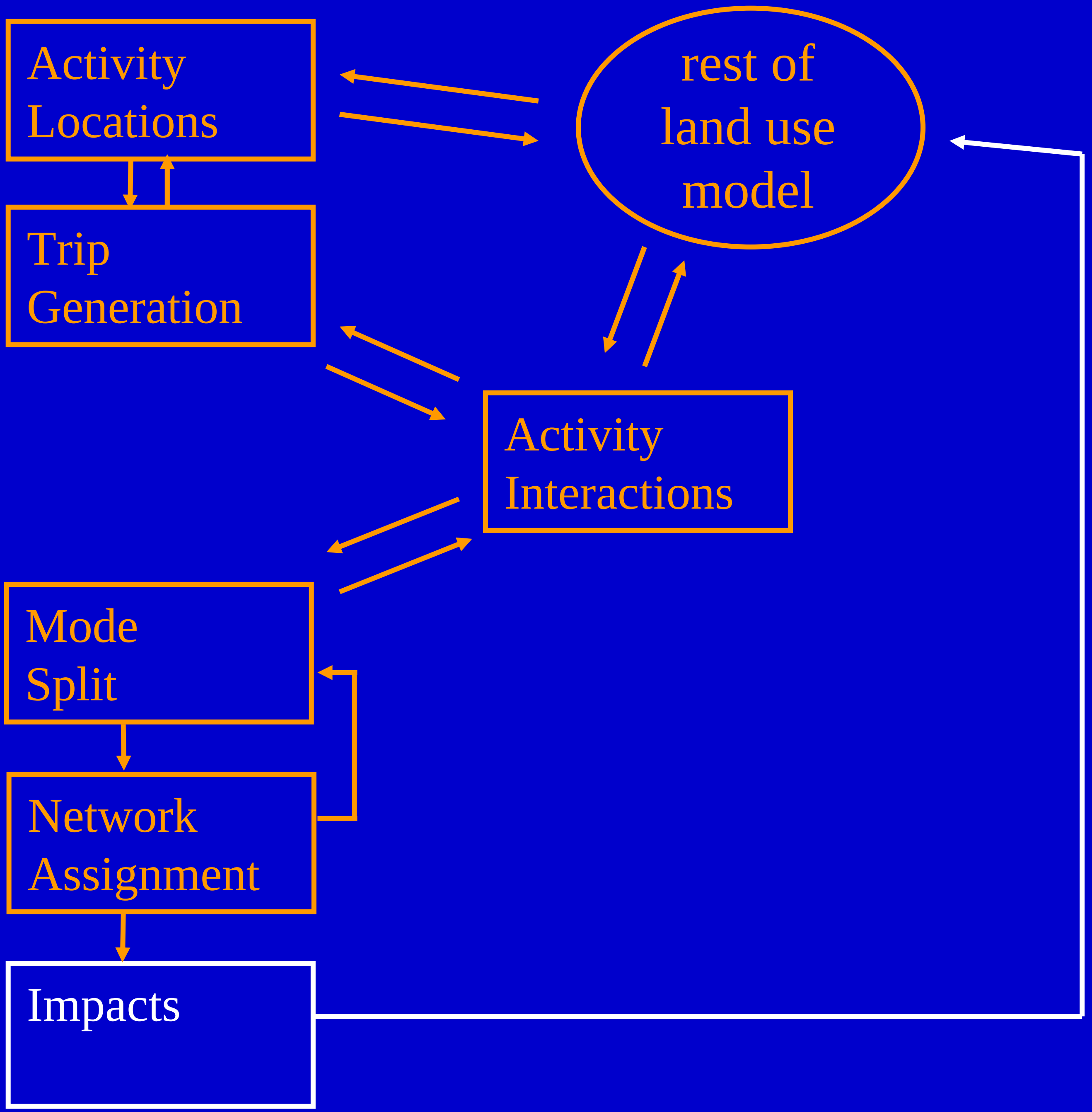
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summary:

- essential element of land use transport interaction: ‘circular’ feedback from transport to activity location

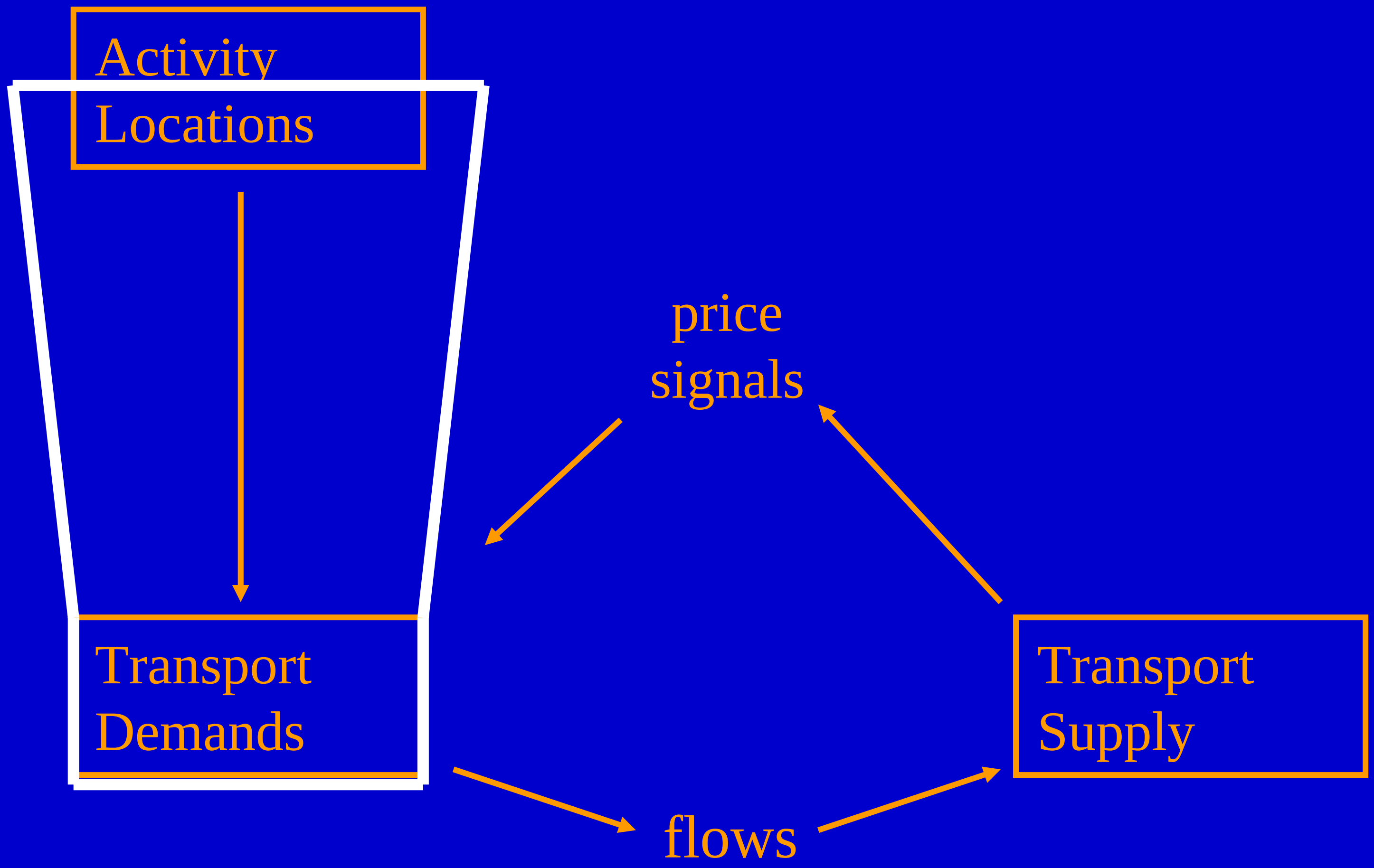
- location accessibilities vs interchange disutilities
- split between transport model and land use model
- treatment of activity interaction
- consistency relates to adherence to behavioral theory

- transport money costs
- part of interchange disutilities
- disutilities rather than money costs for consistency

- other secondary impacts part of location disuility

Implicit Representations of Transport Effects on Land Use:

- argue: 4-step transport models include representation of transport effects on land use
  - trip generation elastic wrt travel conditions:
    - ◊ changes in trips attributable to changes in activity level rather than changes in travel rates
    - ◊ departing from travel demand, adding activity system
  - trip distribution constrained:
    - ◊ adjustments in weights to satisfy constraints are ‘price-like’ signals
    - ◊ again, changes in activity levels rather than changes in travel rates
- implicit at best, requiring (imposing?) interpretations
- confusing transport demand and activity system
- not considered further, remain explicit


Activity
Locations
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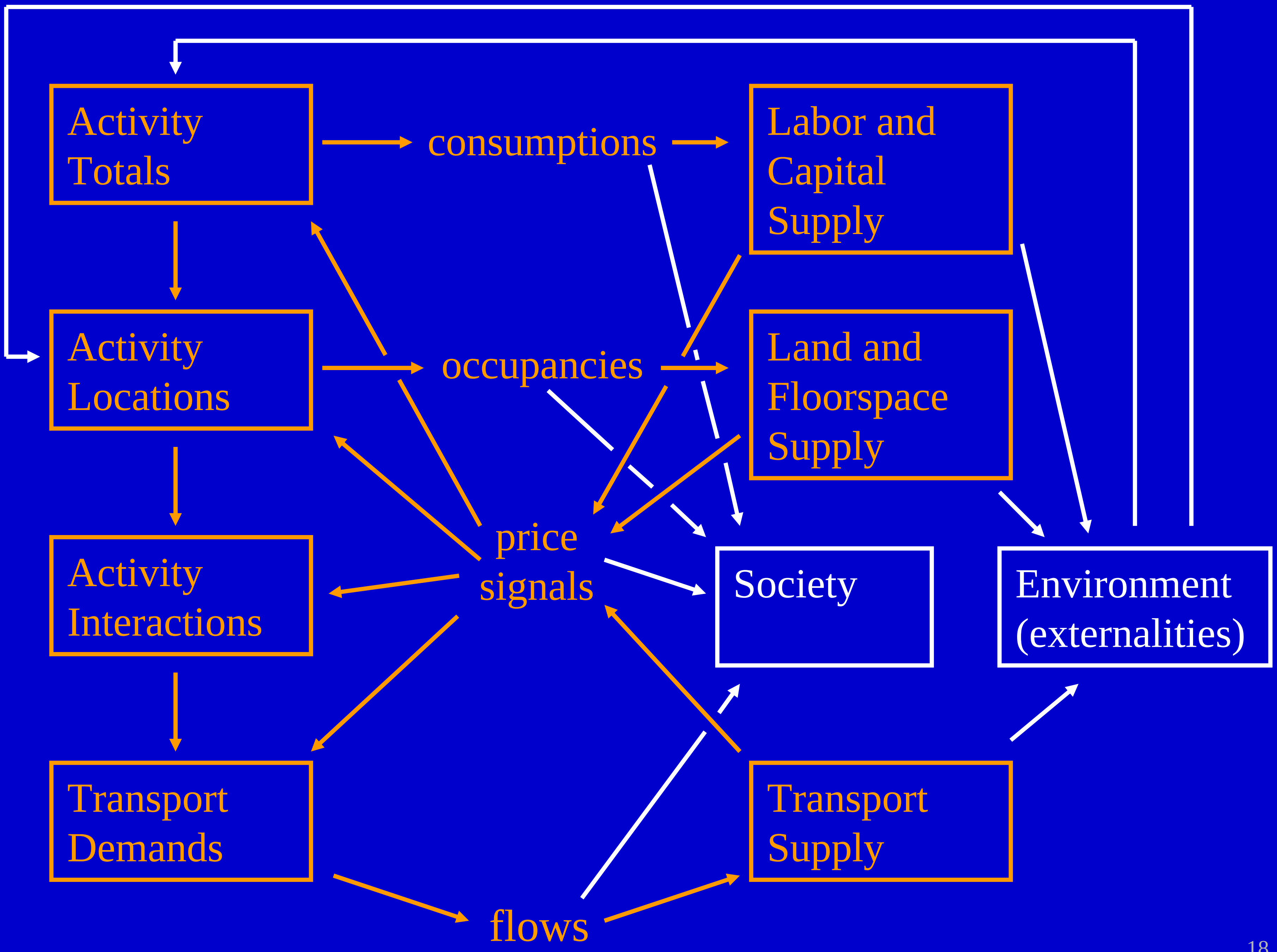
Spatial Activity System Modeling:

- includes more than just ‘circular’ interaction feedback

- explicit representation of various components of full system
  - depends on context
  - usually space constraints
  - urban system models
    - ◊ one city
    - ◊ employment flows
    - ◊ floorspace supply
  - regional spatial-economic system models
    - ◊ cities and intercity
    - ◊ land supply
    - ◊ goods & services movements
    - ◊ break-in-bulk and terminal costs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- draws on very wide range of concepts and techniques, including:
  - discrete choice behavior / logit and probit and other variations
  - utility maximization / Stone-Geary
  - continuous choice behavior / Cobb-Douglas
  - search processes, ‘satisficing’ behavior and information costs
  - classic microeconomics / markets with supply and demand and ‘price’ signals, with and without equilibration
  - bid-rent and bid-choice frameworks
  - central place theory
  - agglomeration economies
  - aggregation economies
  - production and consumption / production functions, input-output, social accounting matrix
  - economic base theory / basic and non-basic sectors with basic as ‘driving force’ of economy
  - spatially-disaggregated input/output or social accounting matrix
  - optimization / linear programming; mathematical programming
  - econometric modeling / regression analysis

- entropy maximization / information theory
- cellular automata
- cohort survival population models
- population migration models
- time-space trajectories; ‘diamonds and pipes’
- quasi-dyanmics, steps between equilibria
- evolutionary processes; states and transitions / Markov Chain representations Leontief Matrix representations, genetic searches
- microsimulation
- catastrophe theory and discontinuous change dynamics, multiple development paths, strange attractors and chaos theory
- systems behavior, including self-organization, emergent behavior, spontaneity, cooperative synergy and increasing returns
- Dialectics / Marxist interpretations of urban processes

3: WHY develop and use land use transport interaction models:

- involves two questions:
- why modeling in general
- why land use transport interaction modeling in particular

- areas of concern

Why Model?

- concerns <u>formal</u> model of system:
- computer-based mathematical formulation

- two tasks in general:

- develop policy regarding system: selecting from alternative policy options

- forecast demands: facility and system design (road capacity, airport size, public housing needs, etc)

first task: basis for selecting policy options

- intention:
  - get desirable outcomes in system
  - essence of government: planning as management

- use some form trial and retrial experimental analysis
  - alternative policy options input
  - outcomes determined
  - outcomes evaluated
  - search for ‘best’ policy option;

- options for determining outcomes:
  - real world
  - some form of representation

- with real world:
  - often prohibitively expensive; many times model development cost
  - could irreparably damage real world
  - ruin reputation and credibility of planning, spoil future potential
  - unreasonable

- with representation:
  - formal model
  - mental model, based on
    - ◊ understanding
    - ◊ impressions
    - ◊ imaginations

- mental models limitations:
  - lack of understanding
  - lack of rigor
  - ineffectively communicated
    - ◊ not explicit

  - ◊ difficult to evaluate
- personnel dependent, so staff departures a problem

- above limitations apply even with expert panel
- along with group dynamics problems

- formal model much more effective:
  - precise
  - effectively communicated
    - ◊ explicitly stated
    - ◊ can be evaluated - sensitivity tests
  - reflects current understanding
  - calculation process as rigorous as appropriate
  - stands alone, not so personnel dependent

second task: forecast demands:

- options for developing forecasts:
  - extrapolate trends
  - mental models
  - formal model

- trend extrapolation not policy sensitive

- mental models, same problems as above

- formal model
  - consistent forecasts
  - multiple runs for ranges
  - uncertainty handled more explicitly

- forecasting inherently inaccurate
  - attempting: forecast
    - ◊ number of cars
    - ◊ pass certain point on roadway
    - ◊ during certain hour 20 years hence
  - very ambitious
  - not to expect too much
  - make uncertainty explicit

- use of formal model most appropriate

Why Develop and Use a Land Use Transport Interaction Model in Particular?

- above concerning formal model applies

- what is it about this system and planning regarding it
  - ISTEA recommendation – mundane on its own
  - potential legal challenge: some transport impacts ignored
    - ◊ California
    - ◊ Illinois
  - interactions exist in real world, model incomplete and inconsistent without such effects
    - ◊ avoid incomplete and inconsistent policy analysis
    - ◊ include
      - land use effects of transport policy
      - transport effects of land use policy
      - along with direct policy effects

some apparent arguments against:

- not too common
- system too complex, so model too inaccurate
- our city or region is ‘special’, so standard models do no apply

‘not too common’ argument:

- land use transport interaction models not too common in US
- many places ‘getting by’ using ‘line-process’ or less
- reasons:

- professional separation
  - ◊ separate disciplines
  - ◊ different training, jargon, perspectives, philosophies and allegiances

- organizational separation
  - ◊ separate departments
  - ◊ ‘turf wars’ at interface

- political separation
  - ◊ greater acceptance of intervention into transport system

- experience and history
  - ◊ original land use transport interaction modeling done in US
  - ◊ expectations unreasonably high
  - ◊ models failed to deliver
  - ◊ result: disenchantment and disillusionment

- conviction about nature of actual relationships
  - ◊ some feel transport cannot influence land use to any meaningful extent
  - ◊ surprising

- magnitude of required effort
  - ◊ big job
  - ◊ much more than for transport model alone
  - ◊ understandable reluctance

- • not good technical reasons not to model, just historical reasons

‘system too complex’ argument:

- reality so complex, resulting model
  - ‘too inaccurate’
  - ‘doesn’t work well enough’

- still appropriate to be explicit about our understanding such as it is

- formal model still best, mental model even more questionable

- must be cautious, confidence lower when system complex

‘standard models do not apply’ argument:

- every place is different and special at some level
- but underlying tendencies are common
- seek to use these
- calibration is to develop representations that work in context

Some Concerns:

- ‘culture clash’ between science and practice of planning
- limits to planning activity
- fitting models into planning agencies

‘culture clash’ concern:

- gap between
- available theory for practical models
  - many planning tasks

- can lead to:
- modeler focus on scientific questions (particularly academics)
- practitioner focus on professional issues: just want ‘reasonable looking results’

- cultures merge in long run
- assuming adequate theory can be developed

- in short run sharing resources leads to tensions

- long range viewpoint sometimes appropriate
  - exists in Oregon DOT, laudable

‘limits to planning’ concern:

- ideal plan development:
- consider all possible policy options from all possible sources and interest groups in society
- submit options to appropriate analysis with modeling support

- assumes
- total set possible policy options manageable
- process will converge to a single ‘best’ option

- reality is:

- very broad range of issues
  - ◊ economic vitality
  - ◊ safety and security
  - ◊ accessibility and mobility
  - ◊ environmental protection

- ◊ integration of the transport system
- ◊ efficient management
- ◊ equity

- very broad range of possible policy options
  - ◊ infrastructure development
    - build or widen roads
    - build rail systems
    - build walking and cycling systems
    - provide land servicing
    - develop public housing
  - ◊ services provision
    - policing
    - transit
    - social assistance
    - emergency services
  - ◊ pricing
    - transit fares structures

    - gas taxes
    - toll roads
    - land taxes or subsidies
  - ◊ regulation
    - land use designations
    - vehicle movement and access restrictions
    - emission controls
    - rent controls
    - taxi regulations

- search for ‘best’ option a very large task

- also, relative emphasis among issues constantly changing

- making assumptions about process questionable

- in reality:
  - policy selected under considerable uncertainty it is ‘best’
  - often mixed with blurring between political and technical arenas:
    - ◊ politician seek to unduly influence technical considerations
    - ◊ analysts seek to anticipate political feasibility and interest group dynamics
    - ◊ finesse appearance of public acceptance via ‘public participation’ exercise

‘fitting models into planning agencies’ concern:

- want planning organizations to use models effectively

- not the technical knowledge, which can be developed with ‘will’

- rather, getting organization to
  - appreciate possibilities
  - embrace the technology
  - organize around using technology appropriately

- often resistance to models for various reasons:
  - uncertainty of ‘revolutionary’ step disturbing
  - concern about giving up control – often related to blurring between political and technical arenas
  - added time required
  - failure to appreciate potential benefits

summary:

why develop and use <u>formal</u> land use transport interaction models:

- learn about system

- inform planning without real-world experimentation, modeling being much less expensive than real world mistakes

- use our understanding in consistent manner

- establish record that stands alone, lasts and allows debate

and we need to be aware of certain ‘concerns’

4: The WHEN, WHERE and WHO of land use transport interaction modeling

- general terms: which sorts of agencies under what circumstances
- brief history
- specific terms: what models, where and by whom

land use transport interaction modeling done in situations:

- by larger public authorities (MPOs and States)
  - recognized transport system has circular influence on land use system
  - acknowledged need for explicit formal modeling
  - desire consistent and defensible policy analysis and/or forecasts
  - specialist consulting team engaged

- at research institutions (universities and research centers)
  - academic interest in system behavior
  - recognition that ‘line process’ missing important components
  - researchers investigation/development work

- for commercial firms (developers or real estate investors)
  - recognized transport system influences market values
  - specialist consulting team engaged to develop and apply model

history:

- draws considerably from Batty (1994)
  see for more complete discussion

in mid 1950s:

- work started on computer-based models of land use transport interaction:

- following:
- successes of Operations Research and management science
- availability of computers

- see special issues of APA Journal:
- 1959: transport models (Voorhees, 1959)
- 1965: urban development models (Harris, 1965)

by end of 1960s:

- several 'styles' had emerged:

- activity location as a function of spatial interaction, within macro-economics and cohort-survival frameworks; example by (Lowry, 1964)

- linear statistical relationships using econometrics; example by (Hill, 1965)

- simulations of urban land markets; examples by (Herbert-Stevens, 1960) and Harris (1972)

- simulations using eclectic sets of decision-rules; example by Chapin and Weiss (1968)

- aggregate optimization problems using linear programming, sometimes prescriptive; example by Schlager (1965)

- individual utility optimization within micro-economics; example by Ingram, Kain and Ginn (1972) and Harris (1972)

prescriptive approach seems well-suited to planning:

- model identifies the ideal

- but it has not been developed to any great extent

- apparently:
  - reduces the role of the planner
  - requires too much simplification to work

at start of 1970s:

- major problems acknowledged by some:
  - large-scale resource requirements:
    - ◊ data
    - ◊ computing
    - ◊ personnel
  - lack of theory
  - lack of relevant technical and scientific knowledge and skill

- problems and their symptoms outlined by Lee (1973)

research in early 1970s:

- relatively small and scattered

- reflecting:
  - reliance on practical work for resources
  - highly interdisciplinary nature of topic

- was not abandoned

- more scientific approach taken as work progressed

through 1970s:

- refinements to practical application techniques,
  - calibration
  - estimation techniques
  - spatial definition
  - disaggregation

- development of a consistent theory (CTL Theory)
  - linked transport and location behavior
  - concepts of choice behavior and individual utility maximization from a disaggregate perspective
  - concepts of macroscopic spatial interaction / distribution and statistical optimization from an aggregate perspective
  - theoretical basis for (very common) use of logit and ‘feedback’ using composite utility (logsum) information signals

- allowed synthesis of ideas from two ‘styles’
  - ◊ ‘treating activity location as a function of spatial interaction, within macro-economics’
  - ◊ ‘individual utility optimization within micro-economics
- range of important contributions resulted; Harris (1985) provides summary

- ideas regarding discontinuous change and ‘catastrophe theory’ as alternative to equilibrium treatments and ‘quasi-dynamic’ approaches

by mid-1980s:

- research and application activity somewhat polarized, subset of the groups involved previously

- development and application of spatially-disaggregated input-output representation:
  - drawing on CTL Theory
  - logit and nested logit in mode and route choice
  - addition of land and floorspace markets with price signals and clearing
  - examples:
    - ◊ precursor to MEPLAN (Hunt and Simmonds, 1993)
    - ◊ TRANUS (de la Barra, 1984)
    - ◊ TOMM-D (Picard and Nguyen, 1987)
    - ◊ Costa (1987)

- additional modeling efforts emerged:
  - variations on existing approaches
  - some new approaches
    - ◊ IRPUD (Wegener, 1982);
    - ◊ LILT (Mackett, 1983)

- other work continued in US:
  - developing and applying land use models based on just CTL Theory: DRAM/EMPAL (Putman, 1983);
  - combining CTL Theory with micro-economic market representation: precursors to METROSIM (Anas, 1994)
  - seeking to develop and apply aggregate optimization approaches: (Kim, 1983; Prastacos 1986; Brochie, Dickey and Sharpe, 1980)

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in mid-1980s:

- ISGLUTI set up
- compare existing model frameworks on a consistent basis
- proved difficult
- highlighting idiosyncratic nature of each framework
- second stage in late 1980s
  - ◊ considered just three frameworks (MEPLAN, LILT, IRPUD)
  - ◊ made greater progress

start of 1990s:

- Wegner (1994) provides a summary of the state of the art
- work integrating elements of Alonso (1964) urban land market theory into CTL Theory; bid-choice
- further refinements and applications of spatially-disaggregated input-output representation

- MEPLAN
- TRANUS

since early 1990s:

- developments in several areas

- temporal dynamics and chaos, and linking these with CTL Theory: (Bertuglia et al, 1987; 1990)

- microsimulation, where location and transport flows and market interactions arise as emergent behaviors:
  (Mackett, 1990; Miller and Salvini 1998)

- GIS-based systems: (Klosterman, 1992)

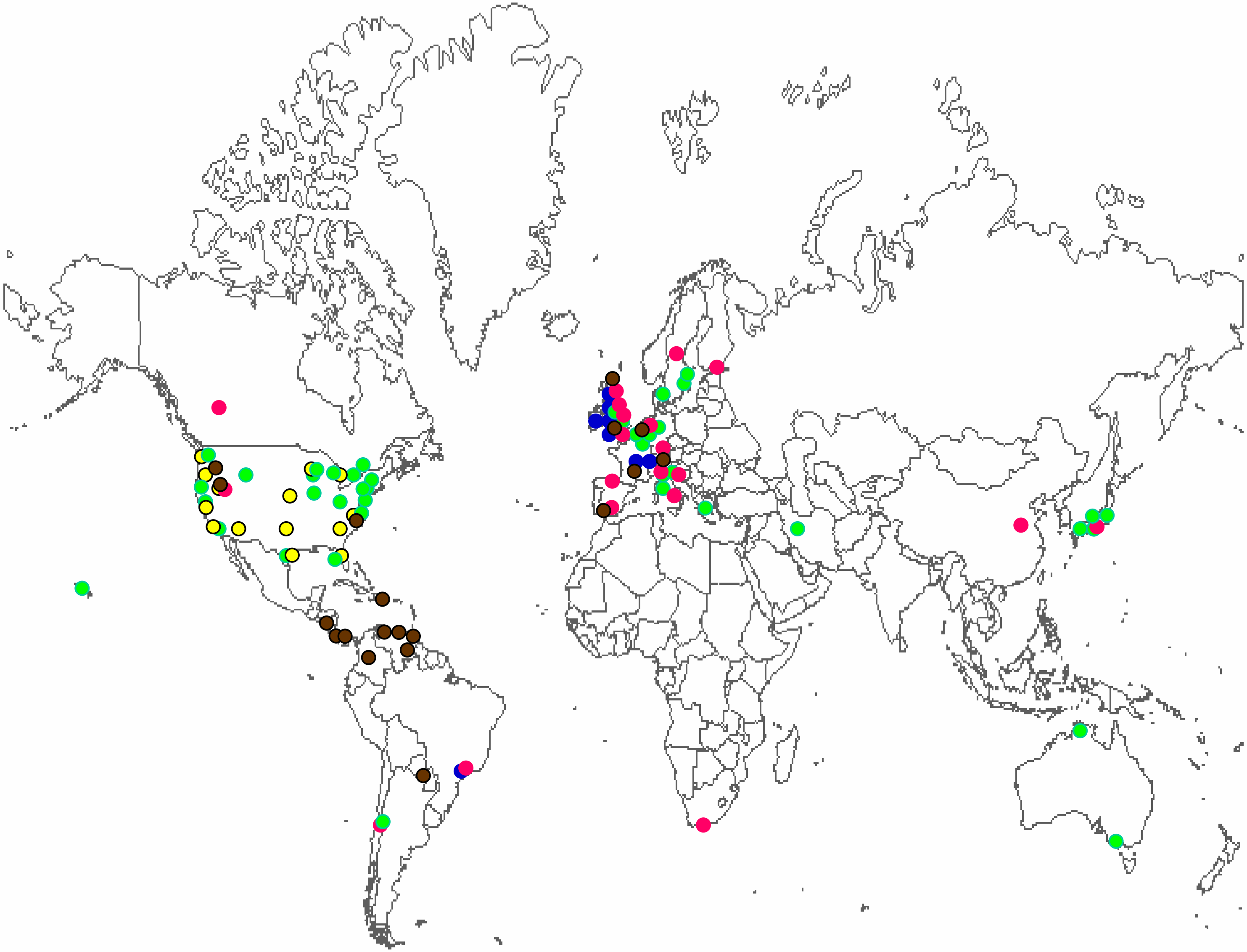
- activity scheduling with travel as a consequence in the modeling of person and household spatial behavior

- application of more disaggregate expressions of CTL Theory: (Martinez, 1997)

- application of CTL Theory together with various temporal and microsimulation elements: (Simmonds, 1996; Waddell, 1998)

Specific Land Use Transport Models:

- shown in map and accompanying chart



	Location	Land Use Framework	Transport Framework	Spatial Scope	For	Citations
1	Amersfoort, Netherlands	AMERSFOORT		Urban		Floor and de Jong, 1981
2	Leeds, UK	AMERSFOORT		Urban		
3	Utrecht, Netherlands	AMERSFOORT		Urban		
4	Hamilton, Ontario, Canada	Anderson et al		Urban	Research	Anderson et al, 1994; 1995
5	Rome, Italy	Bertuglia et al		Urban		Bertuglia et al, 1987
6	Turin, Italy	Bertuglia et al		Urban		Bertuglia et al, 1981
7	Chicago, Illinios, USA	BOYCE	BOYCE	Urban		Boyce et al, 1992; 1993
8	Nagoya, Japan	CALUTAS	CALUTAS	Urban		
9	Okayama, Japan	CALUTAS	CALUTAS	Urban		
10	Tokyo, Japan	CALUTAS	CALUTAS	Urban		Nakamura et al, 1983
11	Chicago, Illinois, USA	CATLAS	CATLAS	Urban		Anas, 1983b; Anas and Duann, 1986
12	Chicago, Illinios, USA	CPHMM		Urban		
13	Houston, Texas, USA	CPHMM		Urban		
14	Pittsburg, Pennsylvania, USA	CPHMM		Urban		
15	San Diego, California, USA	CPHMM		Urban		
16	San Francisco Bay Area, USA	CUFM		Urban	Research	
17	Alsace Region, France	DCSMOD	MinUTP	Regional	Public Planning	
18	Bristol, UK	DCSMOD	START	Urban	Public Planning	
19	Bristol, UK	DCSMOD	TRAM	Urban	Public Planning	
20	Dublin, Ireland	DCSMOD	SDG Model	Urban	Public Planning	
21	Edinburgh, UK	DCSMOD	START	Urban	Public Planning	
22	Merseyside, UK	DCSMOD	START	Urban	Public Planning	
23	San Paulo, Brazil	DCSMOD	START	Urban	Public Planning	
24	Western Europe	DCSMOD	DCSMOD	Regional	Public Planning	
25	Edinburgh, UK	DELTA	START	Urban	Public Planning	
26	Manchester, UK	DELTA	START	Urban	Public Planning	
27	Trans-Pennine Region	DELTA	START	Regional	Public Planning	
28	Sacramento, California, USA	DRAM/EMPAL	TRANPLAN	Urban	Public Planning	
29	Atlanta, Georgia, USA	DRAM/EMPAL	TRANPLAN	Urban	Public Planning	Putman, 1995
30	Chicago, Illinios, USA	DRAM/EMPAL	CATS	Urban	Public Planning	Putman, 1995

	Location	Land Use Framework	Transport Framework	Spatial Scope	For	Citations
31	Dallas, Texas, USA	DRAM/EMPAL	TRANPLAN	Urban	Public Planning	
32	Detroit, Michigan, USA	DRAM/EMPAL		Urban	Public Planning	Putman, 1995
33	Houston, Texas, USA	DRAM/EMPAL	UTPS-type	Urban	Public Planning	Putman, 1995
34	Kansas City, Mussori, USA	DRAM/EMPAL		Urban	Public Planning	Putman, 1995
35	Los Angeles, California, USA	DRAM/EMPAL		Urban	Public Planning	Putman, 1995
36	Orlando, Florida, USA	DRAM/EMPAL		Urban	Public Planning	
37	Phoenix, Arizona, USA	DRAM/EMPAL		Urban	Public Planning	Putman, 1995
38	Portland, Oregon, USA	DRAM/EMPAL		Urban	Public Planning	
39	San Francisco Bay Area, USA	DRAM/EMPAL		Urban	Public Planning	
40	Seattle, Washington, USA	DRAM/EMPAL	EMME/2	Urban	Public Planning	
41	Washington DC, USA	DRAM/EMPAL		Urban	Public Planning	
42	Boston, Massachusetts, USA	EMPIRIC		Urban	Public Planning	Hill, Brand and Hansen, 1965+I94
43	Tehran, Iran	Garnett		Urban	Public Planning	Garnett, 1980
44	Toronto, Ontario, Canada	ILUTE	ILUTE	Urban	Research	
45	Denmark-Sweden Oresund Crossing	IMREL		Regional	Public Planning	
46	Stockholm, Sweden	IMREL		Urban	Public Planning	Anderstig and Mattson, 1991; 1994
47	Dortmund, Germany	IRPUD	IRPUD	Urban	Research	Wegener, 1982a; 1982b
48	Chicago, Illinios, USA	KIM	KIM	Urban	Research	Kim, 1989
49	Athens, Greece	LILT	LILT	Urban	Research	Pitsiava-Latinopolou, 1984
50	Dortmund, Germany	LILT	LILT	Urban	Research	Mackett, 1990a
51	Leeds, UK	LILT	LILT	Urban	Research	Mackett, 1990a; 1991b
52	Tokyo, Japan	LILT	LILT	Urban	Research	Mackett, 1990a; 1991a
53	Pittsburg, Pennsylvania, USA	Lowry-type		Urban	Research	Lowry, 1964
54	Venice, Italy	Lowry-type	stated values	Urban	Public Planning	Foot et al, 1978
55	Leeds, UK	MASTER		Urban	Research	Mackett, 1990b; 1990c
56	London, UK	MASTER		Urban	Research	
57	Bejing, China	MEPLAN	MEPLAN	Urban	Research	
58	Bilbao, Spain	MEPLAN	MEPLAN	Regional	Public Planning	Echenique et al, 1990
59	Bolzano, Italy	MEPLAN	MEPLAN	Urban	Public Planning	
60	Cambridgeshire, UK	MEPLAN	MEPLAN	Urban	Commercial	Hunt and Simmonds, 1993

	Location	Land Use Framework	Transport Framework	Spatial Scope	For	Citations
61	Capetown, South Africa	MEPLAN	MEPLAN	Urban	Public Planning	
62	Central Chile	MEPLAN	MEPLAN	Regional	Public Planning	
63	Dortmund, Germany	MEPLAN	MEPLAN	Urban	Research	Echenique et al, 1990
64	Edmonton, Alberta, Canada	MEPLAN	MEPLAN	Urban	Public Planning	
65	Europe	MEPLAN	MEPLAN	Regional	Public Planning	
66	Helsinki, Finland	MEPLAN	MEPLAN	Urban	Public Planning	
67	Leeds, UK	MEPLAN	MEPLAN	Urban	Public Planning	Echenique et al, 1990
68	London and South East England	MEPLAN	MEPLAN	Urban	Public Planning	Williams, 1994
69	Malaga, Spain	MEPLAN	MEPLAN		Commercial	
70	Naples, Italy	MEPLAN	MEPLAN	Urban	Public Planning	Hunt, 1994
71	Sacramento, California, USA	MEPLAN	MEPLAN	Urban	Research	
72	San Paulo, Brazil	MEPLAN	MEPLAN	Urban	Public Planning	
73	Scottish Borders	MEPLAN	MEPLAN	Regional	Public Planning	
74	Sweden	MEPLAN	MEPLAN	Regional	Public Planning	
75	Tokyo, Japan	MEPLAN	MEPLAN	Urban	Commercial	
76	Vicenza, Italy	MEPLAN	MEPLAN	Urban	Public Planning	
77	New York Region, USA	METROSIM		Urban	Public Planning	Anas, 1994
78	Santiago, Chile	MUSSA		Urban	Public Planning	
79	Detroit, Michigan, USA	NBER		Urban	Research	Ingram et al, 1972
80	New York Region, USA	NYSIM	NYSIM	Urban		Anas, 1992
81	Osaka, Japan	OSAKA		Urban		Amano and Abe, 1985
82	San Francisco Bay Area, USA	BEMOD/PLUM		Urban	Public Planning	Goldner, 1983
83	San Francisco Bay Area, USA	POLIS	POLIS	Urban	Public Planning	Prastacos, 1986a; 1986b+I39+I39
84	Seattle, Washington, USA	PSCOG		Urban	Public Planning	
85	Burlington, Vermont, USA	RSG Model	RSG Model	Urban	Public Planning	
86	Pease/Seacoast, New Hampshire, USA	RSG Model	RSG Model	Urban	Public Planning	
87	Tampa Bay, Florida, USA	RSG Model	RSG Model	Urban	Public Planning	Marshal and Lawe, 1993
88	San Francisco Bay Area, USA	STEP		Urban		
89	Darwin, Australia	TOPAZ		Urban		
90	Melbourne, Australia	TOPAZ		Urban		

	Location	Land Use Framework	Transport Framework	Spatial Scope	For	Citations
91	Prince William County, Virginia, USA	TOPAZ		Urban		Dickey and Leiner, 1983
92	Stockholm, Sweden	TRANSLOC	TRANSLOC	Urban		
93	Inverness, UK	TRANUS	TRANUS	Urban	Public Planning	
94	La Victoria, Venezuela	TRANUS	TRANUS	Urban	Public Planning	
95	Oregon, USA	TRANUS	TRANUS	Regional	Public Planning	
96	Panama City	TRANUS	TRANUS	Regional	Public Planning	
97	Darien Province, Panama	TRANUS		Regional	Public Planning	
98	Bogota, Columbia	TRANUS		Urban	Public Planning	
99	Swindon, UK	TRANUS	TRANUS	Urban	Public Planning	
100	Sacramento, California, USA	TRANUS	TRANUS	Urban	Research	
101	Santo Domingo, Dominican Republic	TRANUS		Urban	Public Planning	
102	Guatemala	TRANUS	TRANUS	Regional	Public Planning	
103	Valencia, Venezuela	TRANUS	TRANUS	Urban	Public Planning	
104	Caracas, Venezuela	TRANUS	TRANUS	Urban	Public Planning	
105	Venezuela	TRANUS	TRANUS	Regional	Public Planning	
106	Leon, France	TRANUS		Urban	Public Planning	
107	Brussels, Belgium	TRANUS	TRANUS	Urban	Public Planning	
108	Baltimore, Maryland, USA	TRANUS	TRANUS	Urban	Public Planning	
109	Paraguay	TRANUS	TRANUS	Regional	Public Planning	
110	Zurich, Switzerland	TRANUS		Urban	Public Planning	
111	Valencia, Spain	TRANUS		Urban	Public Planning	
112	Eugene/Springfield, Oregon, USA	URBANSIM		Urban	Public Planning	
113	Honolulu, Hawaii, USA	URBANSIM		Urban	Public Planning	
114	Salt Lake City, Utah, USA	URBANSIM		Urban	Public Planning	
115	Eindhoven, Netherlands	Van Est		Urban		Van Est, 1979
116	Lafayette, Indiana, USA	Yen Model	TRANPLAN	Urban	Research	Yen, 1996

5: CONCLUDING REMARKS

- context of Oregon work
- apparent future directions
- important issues

Oregon Work in Context:

- considered 5 Ws of land use transport interaction modeling:
- provided background on land use transport interaction modeling;
- explained basic concepts and defined terminology;
- indicated why work is important
- start at describing Oregon work
- start at setting Oregon work against work elsewhere

- shown where frameworks used in work thus far fit
- TRANUS for statewide model
- URBANSIM for metropolitan model

- Oregon Staff training, several objectives:
- relevant terms and concepts
- use of first generation models
- contribution to development of second generation models

Apparent Future Directions:

- microsimulation, getting emergent behavior and integration of different spatial levels and full dynamics within CTL Theory

- activity modeling as basis for person trip modeling

- spatial disaggregation with GIS, alternative treatments of spatial distributions, full network representations

- expert systems shells with full GIS capabilities

- new presentations and ways of thinking regarding results
  - distributions
  - trajectories and strange attractors
  - not single numbers

Important Issues:

- important issues in current practice include:
  - lack of market representation complete with ‘price’ signals, particularly with regard to land and floorspace
  - lack of consistency between location and distribution, departures from CTL Theory
  - focus on automobile
  - reliance on equilibrium
  - low geographic resolution

- issues for Oregon work in particular covered in subsequent presentations