Chapter 3
Urban Travel and Transportation System Characteristics

10601563

TRANSPORTATION PLANNING

Chapter Outline

Introduction

Transportation from a Systems Perspective

Transportation System Impacts

Characteristics of Urban Travel

Introduction

- At the level of the individual traveler or goods movement, transportation is it trip from an origin to a destination to accomplish some purpose.
- At the urban region level, transportation is the aggregate of thousands of individual trip-making decisions.
- A transportation system consists of the facilities and services that allow these travel movements to occur
- The relationship among **travel patterns** (determined by individual trip making behavior); **transportation facilities** (shaped by the transportation planning and DM processes); and the **economic, social, and environmental context of a region**, forms the basis of most transportation analysis and policy decisions.

Transportation from a Systems Perspective

- **A system** is a group of interrelated components that form a complex and unified whole intended to serve some purpose through the performance of its parts.
- **Characteristics of transportation systems:**
  - System Hierarchy
  - System Purpose
  - System Boundary
  - System Components
  - System Performance
  - System Capacity
  - System Control
  - System Feedback

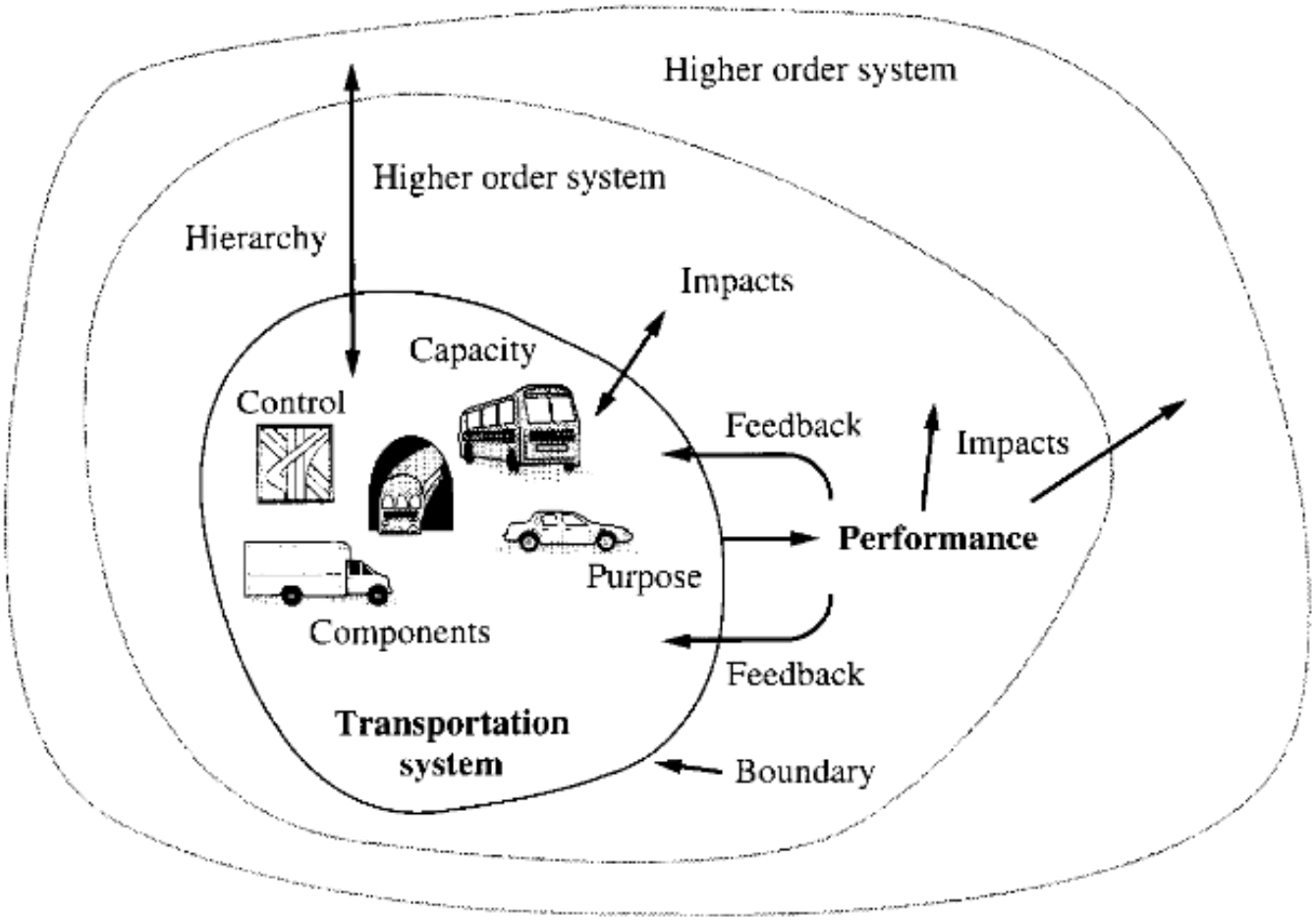

Figure 3.1 Important variables for a systems perspective of transportation

Transportation from a Systems Perspective …

- **System Hierarchy**
  - Every system is a part of another system
  - Focus on the linkages and relationships among these systems and on the overall relative importance
  - A system hierarchy provides order and function to the operation of the components within global system goals (defined.. views problems and conducts planning)
  - Functionally, the transportation system is just one of many systems that allow urban areas to exist
  - National, regional, and local hierarchy (MOP Study)
  - Roads, transit, pedestrian, .. facilities classification

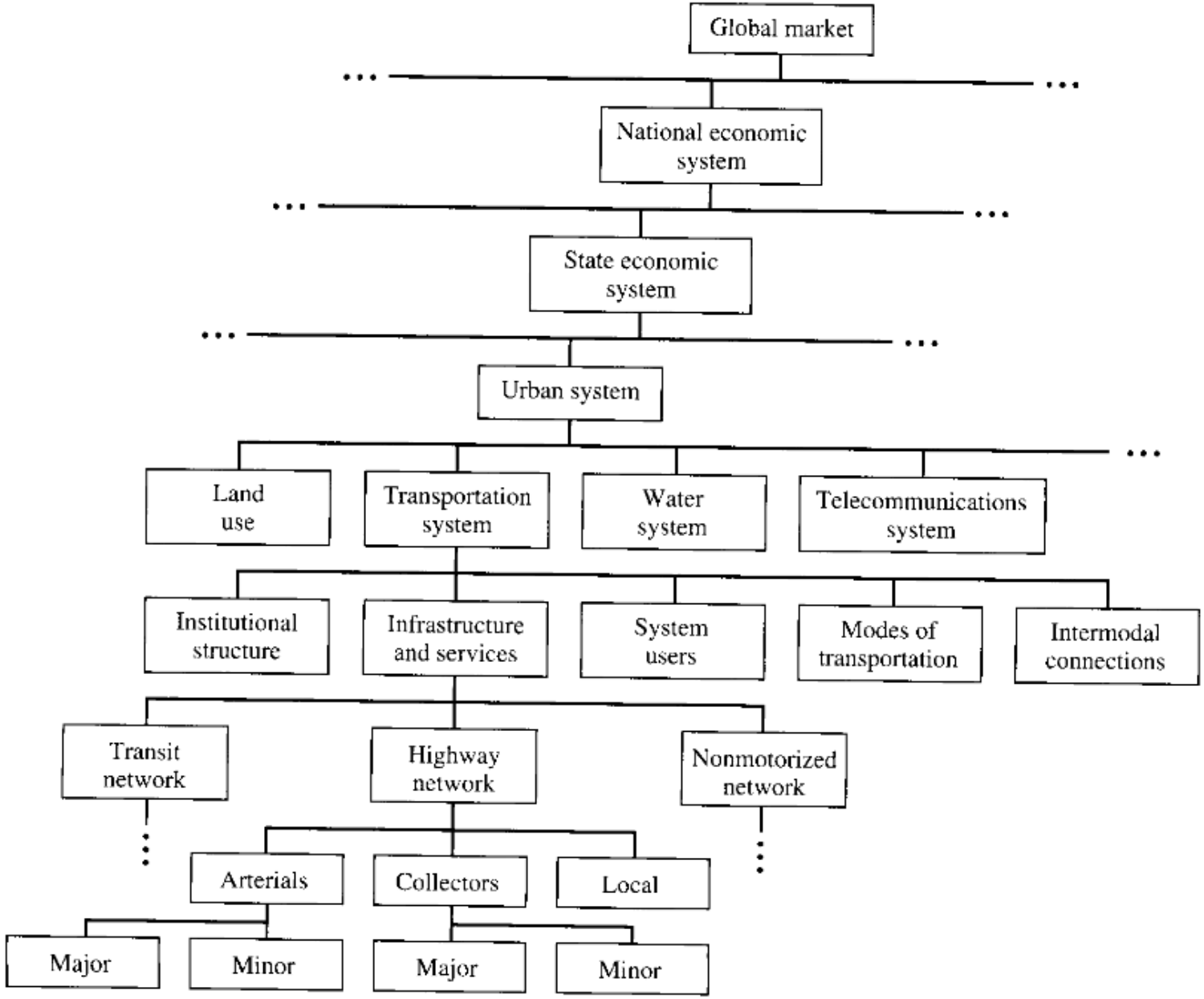

Figure 3.2 Transportation in a systems hierarchy

Transportation from a Systems Perspective …

- **System Purpose**
  - Purpose of a transportation system: providing opportunities for mobility and accessibility:
  - **Mobility:** The ability and knowledge to travel from one location to another in reasonable time and cost
  - **Accessibility:** The means by which an individual can accomplish an activity through access to that activity.
  - Broader system purpose, establish the linkage between transportation system performance and other systems
  - **Example:** Region's transportation policies should protect the economy, Improve safety, Provide access,...

Transportation from a Systems Perspective …

- **System Boundary**
  - Given that systems are parts of other systems, analysts often define a boundary to focus on key relations
  - The level of analysis within the boundary is usually quite detailed
  - Establish the appropriate definition of the system boundary, especially as it relates to the economic and environmental contexts of transportation and in defining impacts on other systems
  - **Example:** West-Bank and Gaza Trans Study for the World Bank

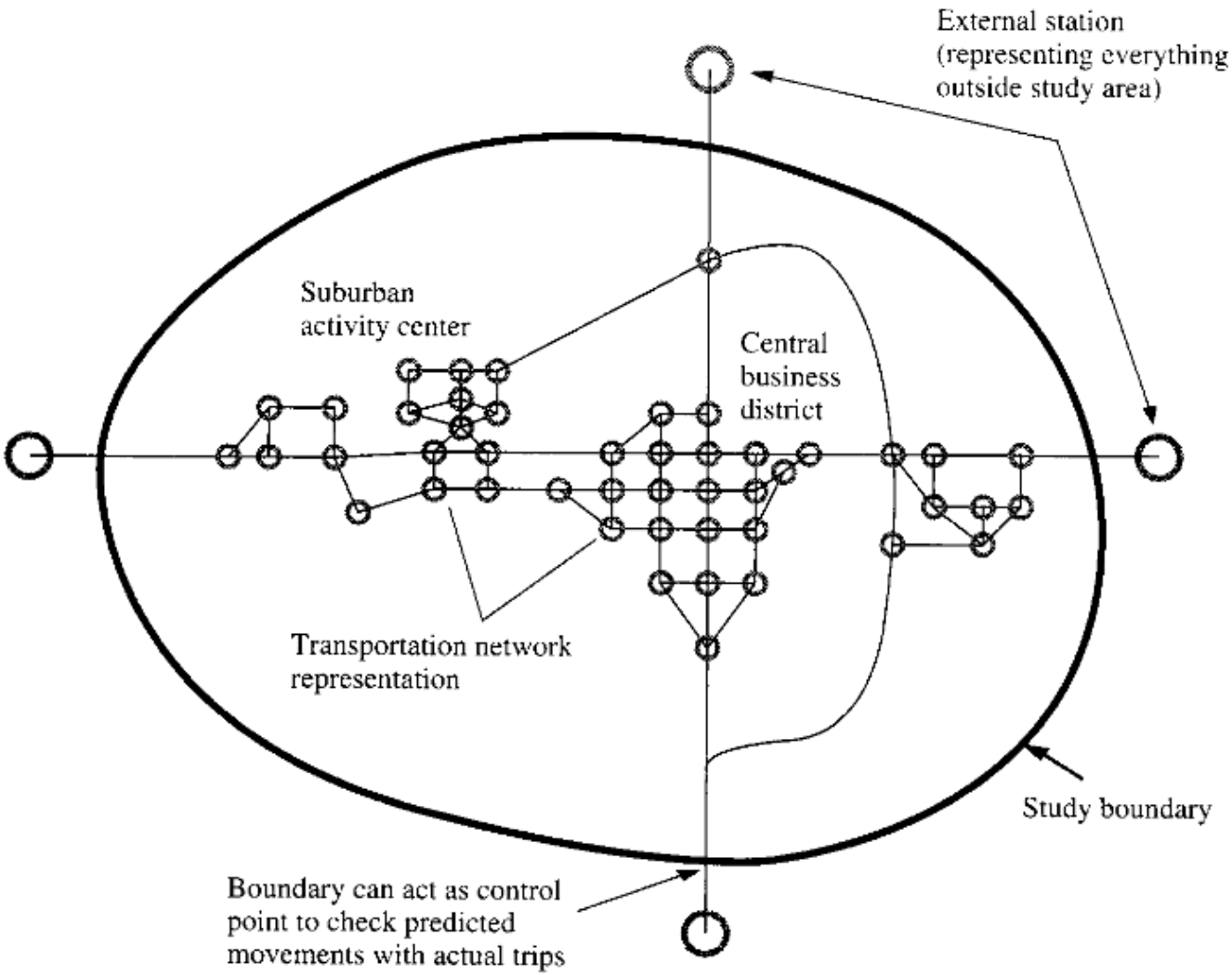

Figure 3.3 System boundary as defined for a study

Transportation from a Systems Perspective …

- **System Components**
  - Components are individual parts that, when interconnected, allow the system to perform
  - Five major system components:
    - ***System User***
    - ***Mode*** or means or transportation used
    - ***Infrastructure***
    - ***Intermodal connections***
    - ***Stakeholders***

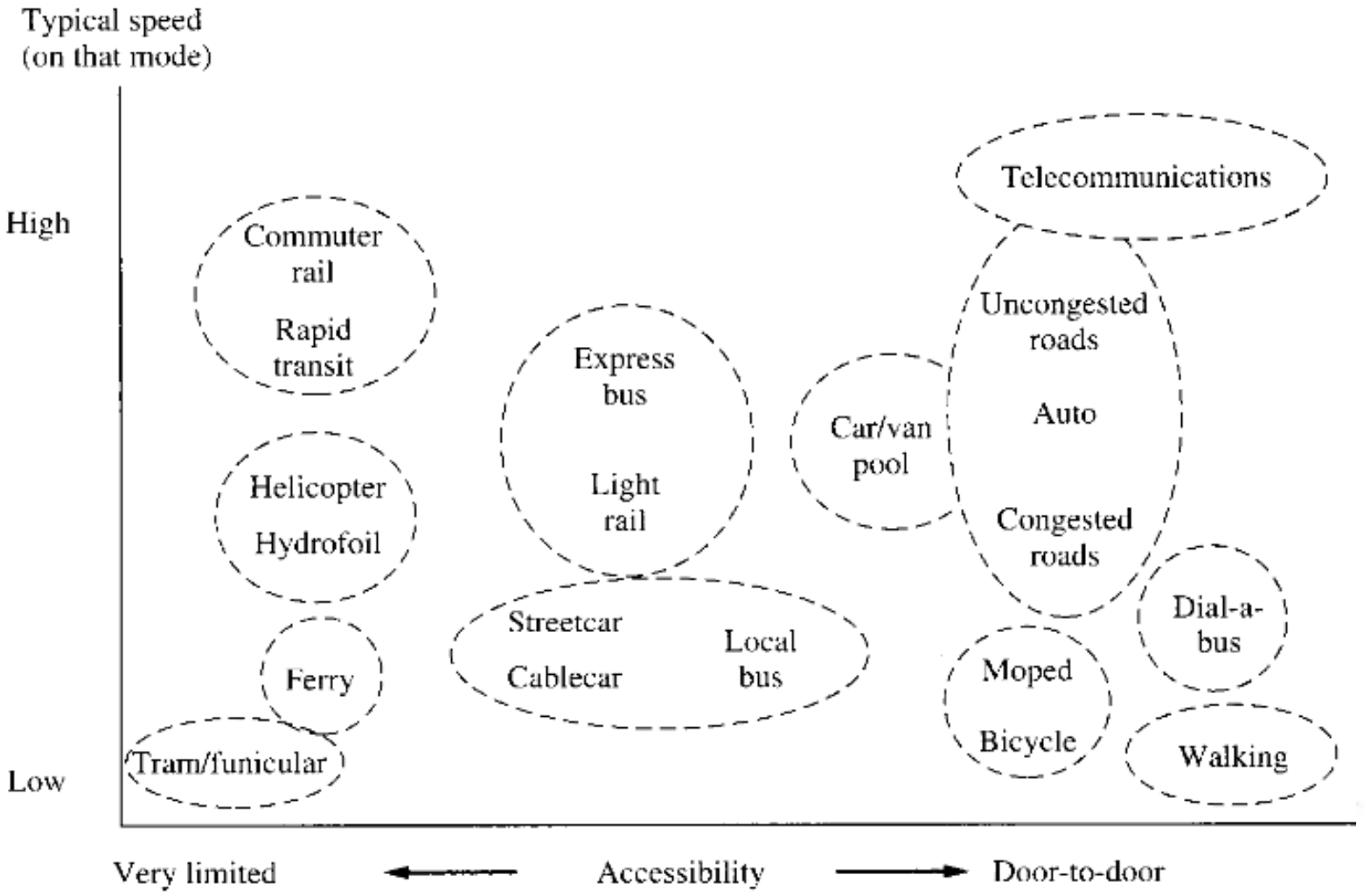

Figure 3.4 Typical urban transportation modes

Transportation from a Systems Perspective …

- **System Performance**
  - Links the success or effectiveness of a system to its performance
  - Performance can be related to the level and quality of the outputs being produced
  - Performance extends to these outputs ultimately affect society and the environment
  - Examples:

    - LOS

    - average travel delay, adherence to transit schedule ..

    - degree of on-time delivery for goods, …

Level of Service Criteria for Roads

Levels of service	Vehicle flow states	Average vehicle speed	V/C
Level A	Driving smoothly	>48km/h	0≦V/C<60%
Level B	Stable vehicle flow	>40km/h	60≦V/C<70%
Level C	Stable vehicle flow	>32km/h	70≦V/C<80%
Level D	Less stable vehicle flow	>24km/h	80≦V/C<90%
Level E	Unstable vehicle flow	≈24km/h	90≦V/C<100%
Level F	Traffic congestion	<24km/h	≧100%

Transportation from a Systems Perspective …

- **System Capacity**
  - A system can handle only a finite number of inputs in the process of producing desired outputs. This limit is called ***system capacity.***
  - Capacity of a ***facility*** is defined as the number of units passing a given point during a given time period
  - Capacity of components
  - Examples: on capacity of systems or its components:

    - Highway cap.
    - Transit cap.
    - Terminal cap.

Table 3.5 Factors affecting road and transit capacity

Transit Capacity	Road Capacity
Vehicle Characteristics	***Roadway Factors***
Allowable number of vehicles per transit unit	Number of lanes
Vehicle dimensions	Type of facility and surrounding land
Seating configuration and capacity	Lane widths
Number, location, and width of doors	Shoulder widths and lateral clearances
Number and height of steps	Design speed
Maximum speed	Horizontal and vertical alignments
Acceleration and deceleration rates	Turn lanes at intersections
Type of door actuation control	
Right-of-Way Characteristics	***Traffic Conditions***
Cross-section design (i.e., number of lanes/tracks)	Vehicle type and percentage in traffic
Degree of separation from other traffic	Lane and directional distribution of trucks/buses
Intersection design	
Horizontal and vertical alignment	
Stop Characteristics	***Control Conditions***
Spacing (frequency) and duration	Type of intersection control
Design (online or offline)	Signal phasing
Platform height	Signal cycle length and green time
Number and length of loading positions	Linkage to nearby control measures
Method of fare collection	Parking controls
Type of fare	Turn restrictions
Common or separate areas for boarding/alighting	Lane-use controls
Passenger accessibility to stops	One-way street routings
Operating Characteristics	
Intercity versus suburban operations at terminals	
Layover and schedule adjustment practices	
Time losses to obtain clock headways/driver relief	
Regularity of arrivals at given stop	
Passenger Traffic Characteristics	
Passenger concentrations and distribution at stops	
Peaking of ridership	
Street Traffic Characteristics	
Volume and nature of other traffic	
Cross traffic at intersections if at-grade	
Method of Vehicle Control	
Automatic or by driver/train operator	
Policy spacing between vehicles	

Transportation from a Systems Perspective …

- **System Control**
  - The interaction of the many different components of a system usually requires some means of system coordination
  - System coordination and ensure operation and safety
  - Institutional structure for transportation planning, operations, management, and decision making
- **System Feedback**
  - Dynamic nature of system behavior is often the result of responses to system outputs and the feedback to individual components

Transportation System Impacts

- **Context**
  - Transportation has impacts on other systems
  - First, physical impacts of the construction and operation of transportation facilities received increasing attention
  - Next, auto oil consumption impacts brought policies designed to improve environmental quality
  - Environment System impacts:
    - Natural environment impacts
    - Physical impacts
    - Social and cultural impacts
  - Some impacts are quantifiable, others are not

Table 3.7 Transportation system impacts of concern to transportation planners

Natural System Impacts	*Social and Cultural Impacts*
Terrestrial ecology (habitats and animals)	Historic and archaeological
Aquatic ecology (habitats and animals)	Displacement of people
	Community cohesion
Physical Impacts	Resource consumption
Air quality	Land use
Noise	Aesthetics
Vibration	Infrastructure effects
Water quality	Accessibility of facilities, services, and jobs
Hazardous wastes	Environmental justice
Storm water	Employment, income, and business activity
Energy consumption	
Erosion and sedimentation	
Farmland conversion	

Transportation System Impacts …

- **Important characteristics of impacts to planners**
  - Impacts can originate with the ***construction*** of the transportation facilities, others relate to the ***use***
  - Impacts that can be ***direct***, or they might occur later in time or farther removed in distance, called ***indirect***
  - ***Cumulative (incremental)*** impacts of indirect effects
  - Environmental analysis is linked to a determination of the ***significance of likely impacts (e.g., EIS, EA)***
  - ***Scope of the proposed action*** very much influences the types of impacts that will be of concern to planners

    both in context (extent) or intensity

Transportation System Impacts …

- **Natural environment impacts**
  - Focus on environment components and the direct relationship between transportation system and the components' function in the ecosystem
  - Land, as a natural state, determines the physical and ecological characteristics of a region

    - Physical include soil and topography, and the erosion and sediment processes

    - Biological involve local plant and wildlife communities and the processes comprising the ecological system
  - Consider –ve impacts on the ecosystem **(Nablus-Jenin HW)**

Table 3.8 Example of the role of "function" in environmental analysis: Functions and effects of wetlands

Function	Effects	Societal Value	Indicator
Hydrologic			
Short-term surface water storage	Reduced downstream flood peaks	Reduced damage from floodwaters	Presence of floodplain along river corridor
Long-term surface water storage	Maintenance of base flows, seasonal flow distribution	Maintenance of fish habitat	Topographic relief of floodplain
Maintenance of high water table	Maintenance of hydrophytic community	Maintenance of biodiversity	Presence of hydrophytes
Biogeochemical			
Transformation, cycling of elements	Maintenance of nutrient stocks within wetlands	Wood production	Tree growth
Retention, removal of dissolved substances	Reduces transport of nutrients downstream	Maintenance of water quality	Nutrient outflow lower than inflow
Accumulation of peat	Retention of nutrients, metals, other substances	Maintenance of water quality	Increase in depth of peat
Accumulation of inorganic sediments	Retention of sediments, some nutrients	Maintenance of water quality	Increase in depth of sediment
Habitat and Food-Web Support			
Maintenance of characteristic plant communities	Food, nesting, cover for animals	Support for furbearers, waterfowl	Mature wetland vegetation
Maintenance of characteristic energy flow	Support for populations of vertebrates	Maintenance of biodiversity	High diversity of vertebrates

Transportation System Impacts …

- **Physical impacts**

  Effects of transportation systems and facilities that are often the most visible include:

  - Air quality
  - Noise
  - Energy consumption
  - Storm-water runoff

  Others include sediments, erosion, etc.

Transportation System Impacts …

- **Air quality**

  UT system.. a major source of air pollution. Most important vehicle pollutants:

  - **Carbon Monoxide (CO)** .. incomplete fuel combustion .. near congested roads.. interferes with O2 transfer in the bloodstream
  - **Hydrocarbon (HC)** .. unburned fuel .. smog formation
  - **Oxides of Nitrogen (NO)x** .. high-temperature combustion .. smog, & can irritate the eyes, nose, lungs
  - **Sulfur Oxides (SO)x** .. combustion ..sulfates..irritates
  - **Particulates ..** unburned C.. breathing .. Pb toxic

Table 3.9 Highway vehicle emissions as a percentage of total emissions in selected North American metropolitan areas, 1998

Area	NO_x	HC/VOC	CO
Atlanta	49	47	74
Boston	45	32	67
Chicago	32	27	59
Cincinnati	25	36	66
Cleveland	39	35	64
Dallas	50	47	68
Detroit	32	54	73
Houston	21	29	57
Los Angeles	47	47	63
Milwaukee	43	29	67
Minneapolis	38	30	63
New York	43	29	61
Philadelphia	41	33	65
Pittsburgh	40	37	72
St. Louis	37	36	72
San Diego	49	45	56
San Francisco	49	44	60
Seattle	55	38	63
Washington, D.C.	40	36	56

Table 3.10 Ambient air quality standards, United States

	Primary (Health Related)		Secondary (Welfare Related)
Pollutant	**Type of Average**	**Standard**	
CO	8 hour	9 ppm	No secondary standard
	1 hour	35 ppm	
NO_2	Max quarterly average	1.5 $\mu g/m^3$	Same as primary standard
O_3[a]	8 hour	0.08 ppm for 3-year average of annual 4th highest daily max 8-hour concentration	Same as primary standard
	Max 1-hour average	0.12 ppm	
PM_{10}	Annual	50 $\mu g/m^3$	Same as primary standard
	24 hour	150 $\mu g/m^3$	
$PM_{2.5}$[a]	Annual	15 $\mu g/m^3$	
	24 hour	65 $\mu g/m^3$	

Transportation System Impacts …

- **Noise**
  - Noise and vibration are of the most apparent physical impacts of a transportation facility's operation
  - Exposure to high levels of noise over an extended period can have detrimental effects on the physical and mental health of human beings
  - Noise measurement is the decibel (dB), a logarithmic measure of sound pressure
  - Affected by **vehicle type, traffic volume, and distance to receptor**
  - Some land uses are particularly sensitive

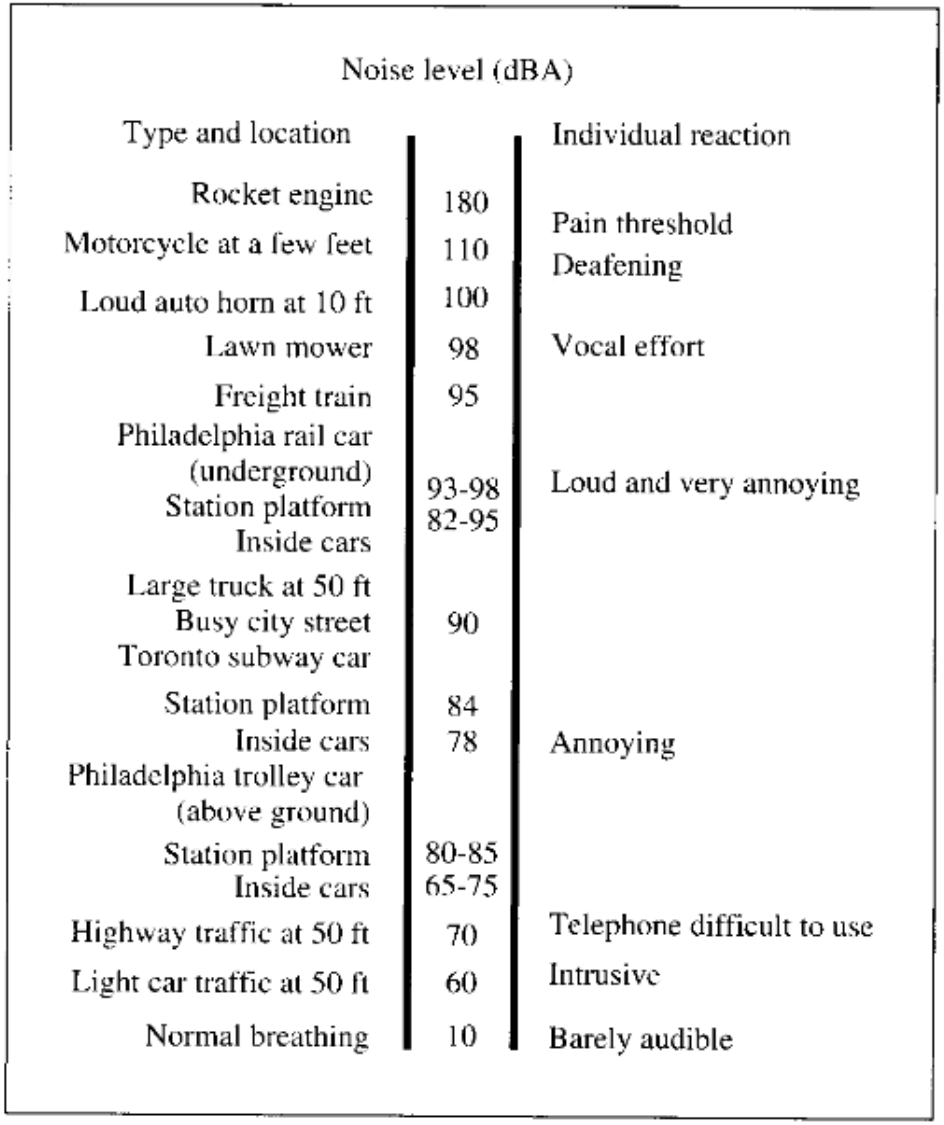

Figure 3.6 Transportation noise in urban areas

Transportation System Impacts …

- **Energy consumption**
  - Vehicles are the largest single consumers of petroleum
  - Concern for transportation energy consumption has been an important transportation policy issue
  - Economic burden on a country
  - National policies (dependant on others, emargo)
  - Policies of alternative fuel vehicles, vehicle cons. red., travel demand management

Table 3.13 Energy consumption of passenger and freight transportation modes

Mode	Passengers	Vehicle Miles Per Gallon	Passenger (pax) Miles Per Gallon	Fuel Energy BTU/Gal	Energy Use BTU/Pax-Miles Per Gallon
Bicycle	1	50 kcal/mile	650 (equiv)		200
Walking	1	70 kcal/mile	450 (equiv)		300
Auto—fuel efficient	4	100	400	125,000	300
Bus—intercity	45	5	225	138,700	600
Auto-high econ	4	50	200	125,000	600
Maglev vehicle	140				800
10-car commuter train	800		160	138,700	900
10-car subway train	1,000		150	138,700	900
Auto	4		120	125,000	1,000
Bus—local	35	30	105	138,700	1,300
4-car intercity train	200	3	80	138,700	1,700
A300 jet plane	267		80	135,000	1,700
Motorcycle	1	60	60	125,000	2,100
Auto—luxury	4	12	48	125,000	2,600
747 jet plane	360		36	135,000	3,800
Light plane—2 seat	2	15	30	120,200	4,000
Executive jet plane	8	2	16	135,000	8,400
Concorde SST	110		13	135,000	10,400
Snowmobile	1	12	12	125,000	10,400
Ocean liner	2,000		10	150,000	15,000

Mode	Mileage (ton-miles/gal)	Energy consumption BTU/Ton-Mile
Oil pipelines	275	450
Railroads	185	670
Waterways	182	680
Truck	44	2,800
Airplane	3	42,000

Transportation System Impacts …

- **Water Quality (Storm-water runoff)**
  - Vehicles movement on facilities contribute to degradation of water resources, as water runoff and drainage have impervious surfaces
  - A related issue is the inappropriate disposal of motor fuel oil
  - The most common contaminants of highway runoff are heavy metals
  - Surface water and groundwater are the most susceptible to runoff contaminants

Table 3.14 Constituents and sources of highway runoff

Constituent	Primary Sources
Particulates	Pavement wear, vehicles, atmosphere, maintenance
Nitrogen, phosphorus	Atmosphere, roadside fertilizer application
Lead	Leaded gasoline (auto exhaust), tire wear (lead oxide filler material), lubricating oil and grease, bearing wear
Zinc	Tire wear (filler material), motor oil (stabilizing additive), grease
Iron	Autobody rust, steel highway structures (e.g., guard rails), moving engine parts
Copper	Metal plating, bearing and bushing wear, moving engine parts, brake-lining wear, fungicides
Cadmium	Tire wear (filler material), insecticide application
Chromium	Metal plating, moving engine parts, brake-lining wear
Nickel	Diesel fuel and gasoline (exhaust), lubricating oil, metal plating, bushing wear, brake-lining wear, asphalt paving
Manganese	Moving engine parts
Bromide	Exhaust
Cyanide	Anticake compound (ferric ferrocyanide, Prussian Blue or sodium ferrocyanide, Yellow Prussiate of Soda) used to keep deicing salt granular
Sodium, calcium	Deicing salts, grease
Chlorine	Deicing salts
Sulfate	Roadway beds, fuel, deicing salts
Petroleum	Spills, leaks or blow-by of motor lubricants, antifreeze and hydraulic fluids, asphalt surface leachate
Polychlorinated biphenyls, (PCBs), pesticides	Spraying of highway rights-of-way, background atmospheric deposition, PCB catalyst in synthetic tires
Pathogenic bacteria	Soil, litter, bird droppings, and trucks hauling livestock and stockyard waste
Rubber	Tire wear

Transportation System Impacts …

- **Social and cultural impacts**
  - Impacts of transportation systems on a community reflect their influence on land development and the potential disruption to community relationships
  - Location theory, land-use and transportation models rely on measures of accessibility
  - Focus on the most prominent of these impacts:
    - Land use
    - Economic activity
    - Community/social/cultural impacts

Transportation System Impacts …

- **Land use and Urban Form**
  - Trip-making characteristics of a region travel patterns and modal distributions function of land use, & land use pattern is influenced by the level of accessibility
  - Auto, road, transit dev. impacts on shaping land uses
  - Short run vs. long run interrelations
  - Strategies of land-use vs. transportation
  - ***Transportation is a factor influencing develop. decisions***
  - ***TP & investment should be coordinated w/land-use***
  - ***Land dev. is responsibility of private developers***
  - ***Land-use impact involves changes in activity dist'n***

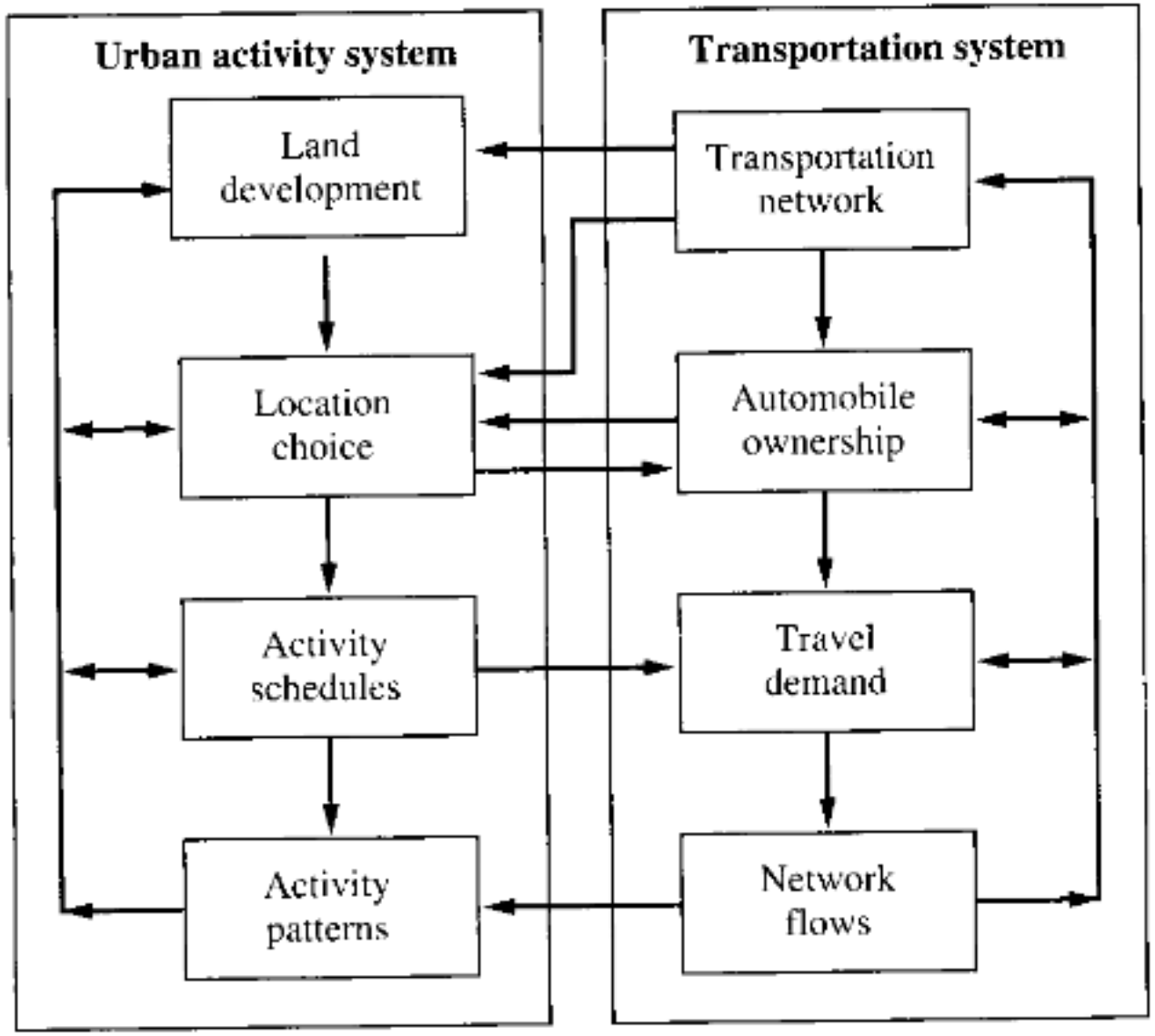

Figure 3.7 Urban activity and transportation systems interaction

Transportation System Impacts …

- **Economic activity**
  - Transportation investment impacts on the regional or community economy is of utmost importance to DM
  - Examples: jobs, overall economic health, funds to the region, and industrial productivity
  - Trans. share of GDP, trans. hh expenditures
  - Economic benefits:
    - ***Generative*** impacts produce net economic growth
    - ***Redistributive*** impacts account for locational shifts
    - ***Transfer*** impacts involve the transfer of moneys
  - Economic costs (-ve): e.g., relocating, congestion

City	*Scenario*	*Economic Impacts*
Chicago	Restore system to good repair	41,209 gain in jobs $4.6 billion in business sales in 2020
New York	System disinvestment	319,800 loss in jobs (2016) $18.9 billion loss in business sales (2016)
Los Angeles	System investment with rail/bus improvements	131,200–261,700 increase in jobs (2020) $8.9–16 billion increase in personal income
Dayton, OH	Immediate shutdown	$3.8 million loss in direct/indirect spending 985 loss in direct/indirect jobs
Commuter rail services in U.S.	Value of current services	420,000 increase in jobs (1986–1996) $3.5 billion increase in tax revenue $300–450 million time savings to trucks $247–865 annual time/fuel savings to riders

Table 3.17 Overview of potential effectiveness of transportation policies in achieving alternative economic objectives

	Potential Effectiveness Relative to Nontransportation Policies	**Potential Effectiveness Relative to Status Quo or Base Case**
Distributional Objectives		
Employment	Low	Low/moderate
Personal income	Low	Low/moderate
Regional output	Low	Low/moderate
Sectoral output	Low/moderate	Moderate/high
Growth Objective		
Productivity	Moderate/high	High
Output	Moderate/high	High
Welfare/living standards	High	High

Transportation System Impacts …

- **Community/social/cultural impacts**
  - Transportation impacts community quality of life, and ability to interact, to enjoy the cultural/recreational benefits and access services of living in an urban area
  - **Community impacts**
    - Effects of trans. investment on neighborhoods
    - Displacement of people: family ties, attitudes and behavior, disruption of neighborhoods
  - **Equity/environmental justice**
    - Changes in UT system may benefit some/hurt others
    - Equity analysis, special groups (elderly, low income)

Table 3.19 Questions for community impact analysis

Social and Psychological Aspects
Will the project cause redistribution of the population or an influx of population?
How will the project affect interaction among persons and groups?
How will it change social relationships and patterns?
Will certain people be separated or set apart from others?
Will the project cause a change in social values?
What is the perceived impact on quality of life?
Physical Aspects
Is a wall or barrier effect created (such as from noise walls or fencing)?
Will noise or vibration increase?
Will dust or odor increase?
Will there be a shadowing effect on property?
Visual Environment
Will the community's aesthetic character be changed?
Is the design of the project compatible with community goals?
Has aesthetics surfaced as a community concern?
Land Use
Will there be loss of farmland?
Does it open new areas for development?
Will it induce changes in land use and density? What changes might be expected?
Is the project consistent with local land-use plans and zoning?
Economic Conditions
Will the proposed action encourage businesses to move to the area, relocate to other locations within the area close by, or move out of the area?
What is the economic impact on both the region and individual communities?
How is the local economy affected by the construction activities?
Are there both positive (jobs generated) and negative (detours and loss of access) impacts?
Will the proposed action alter business visibility to traffic-based businesses?
How will visibility and access changes alter business activity?
What is the effect on the tax base (from taxable property removed from base, changes in property values, changes in business activity)?
What is the likely effect on property values caused by relocations or change in land use?

Mobility and Access

How does the project affect nonmotorist access to businesses, public services, schools, and other facilities?

Does the project impede or enhance access between residences and community facilities and businesses? Does it shift traffic?

How does the project affect access to public transportation?

How does the project affect short- and long-term vehicular access to businesses, public services, and other facilities? Does it affect parking availability?

Provision of Public Services

Will the proposed action lead to or help alleviate overcrowding of public facilities (i.e., schools and recreational facilities)? Will it lead to or help alleviate underuse?

How will it affect the ability to provide adequate services?

Will the project result in relocation or displacement of public facilities or community centers (e.g., places of worship)?

Safety

Will the proposed action increase or decrease the likelihood of accidents for nonmotorists?

Will the proposed action increase or decrease crime?

Will there be changes in emergency response time (fire, police, and emergency medical)?

Displacement

What are the effects on the neighborhood from which people move and into which people are relocated?

How many residences will be displaced? What types—multiunit, single family, others?

Are there residents with special needs (disabled, minority, elderly) being displaced?

How many businesses and farms will be displaced? What types? Do they have unique characteristics, such as specialty products or a unique customer base?

Are there available sites to accommodate those displaced?

Mode	Household Income					
	<$15,000	$15,000–$29,000	$30,000–$49,999	$50,000–$79,999	$80,000 and over	All
Total auto	75.9%	87.0%	90.1%	91.2%	91.1%	88.3%
2+ occupants	40.7	43.6	46.0	47.4	48.1	45.5
Only driver	35.1	43.3	44.0	43.7	42.9	42.4
Total transit	6.8	2.5	1.5	1.2	1.2	2.1
Bus/LRT	5.6	1.7	1.0	0.5	0.5	1.4
Heavy rail	0.9	0.6	0.4	0.4	0.5	0.5
Commuter rail	0.3	0.2	0.2	0.2	0.2	0.2
School bus	1.8	1.8	1.9	1.7	1.5	1.8
Taxicab	0.5	0.2	0.1	0.2	0.3	0.2
Bicycle	1.6	1.1	0.7	0.9	0.5	0.9
Walk	12.8	7.1	5.4	4.2	5.0	6.2
Other	0.6	0.4	0.5	0.5	0.5	0.5
All	100	100	100	100	100	100

SOURCE: Pucher et al. 1998

Characteristics of Urban Travel

- **Trip Purpose**
  - Common trip types: ***Work, Shopping, Social or recreational, Business, School trips***
  - Home as base: home-based work, home-based shop, home-based school, home. based other, and non home based
  - Trips affected by socio-economic char.
  - Chain trips
  - Urban goods movement trips

Table 3.24 Trip purpose characteristics in San Francisco Bay Area

Trip Purpose	Person Trips	Average Distance (miles)	Average Time (mins)	Total Distance (miles)
Home-based work				
First income quartile	534,639	9.47	18.8	5,063,031
Second income quartile	1,124,801	11.43	21.3	12,856,475
Third income quartile	1,620,069	12.91	23.2	20,915,091
Fourth income quartile	1,284,902	13.31	23.9	17,102,046
Total home-based work	4,564,411	12.25	22.4	55,936,643
Home-based shop/other	4,259,935	5.73	11.8	24,409,428
Home-based social/recreation	1,910,361	7.39	13.7	14,117,568
Home-based school				
Home-based grade school	842,871	3.2	8.1	2,697,187
Home-based high school	345,542	4.41	10.0	1,523,840
Home-based college	438,063	8.81	17.9	3,859,335
Total home-based school	1,626,476	4.97	11.2	8,083,586
Nonhome based	4,716,990	6.11	12.8	28,820,809
Total trips, all purposes	17,078,173	7.69	15.1	131,368,034

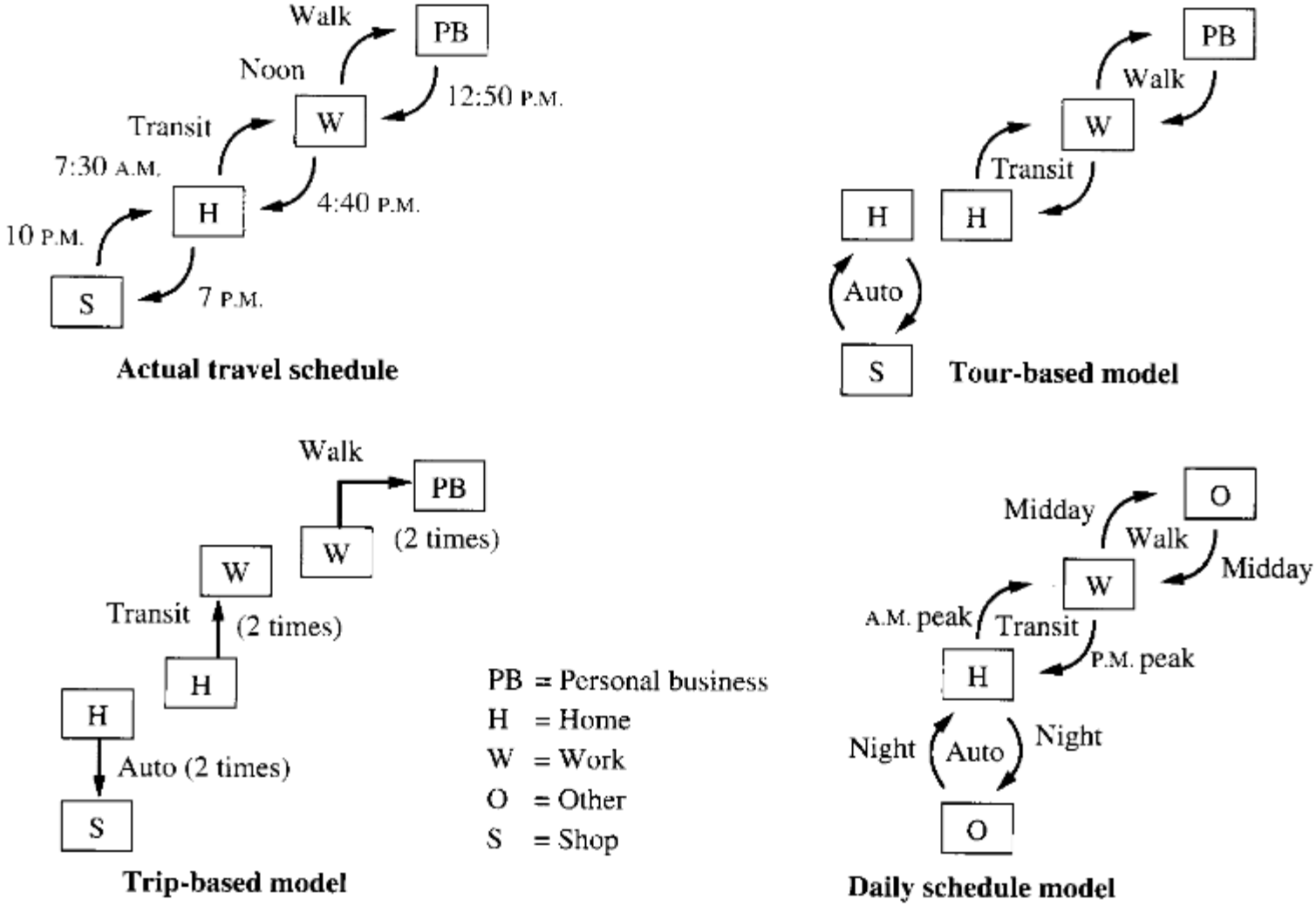

Figure 3.11 Three approaches for modeling trips

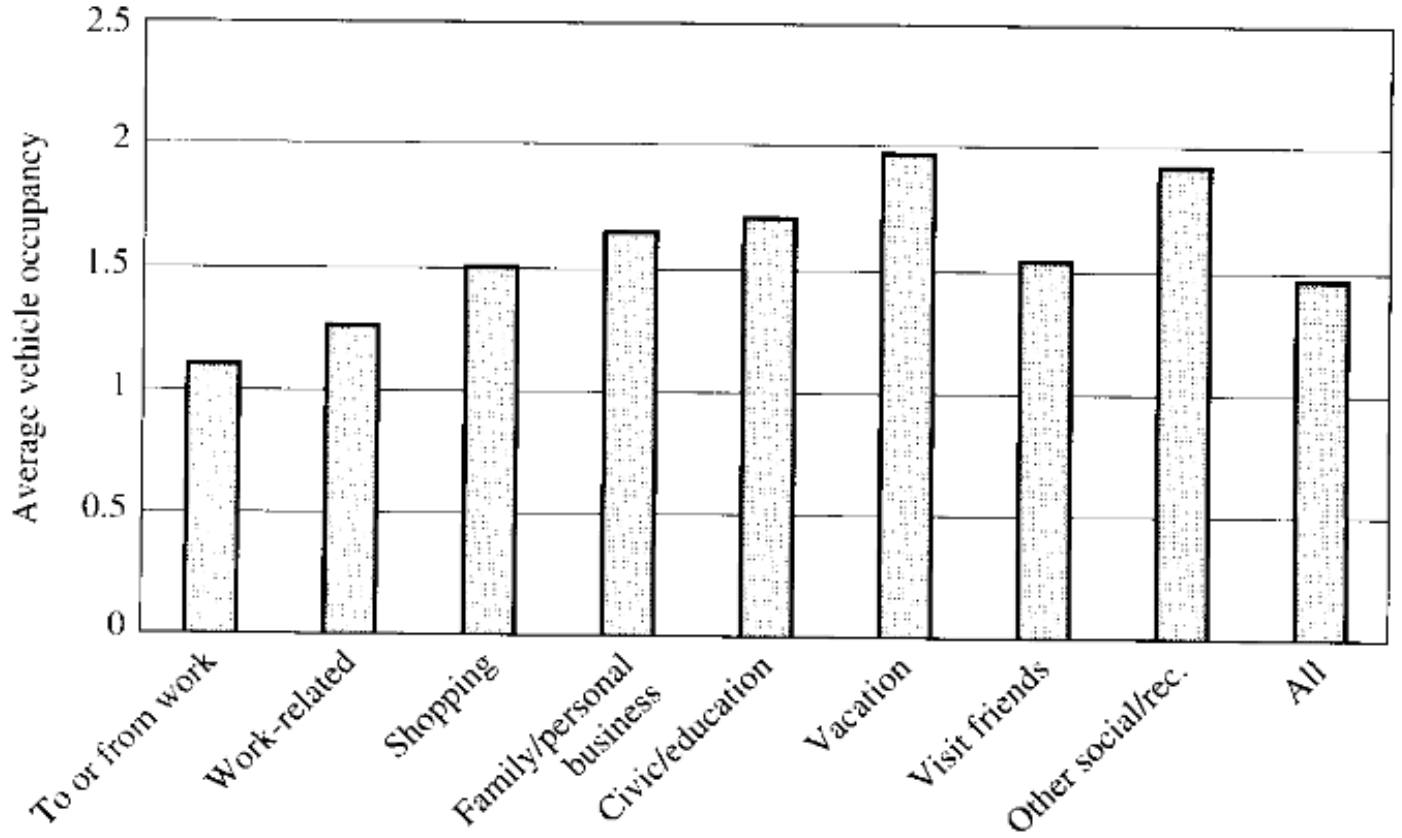

Figure 3.15 Average vehicle occupancy by trip purpose, 1990

Characteristics of Urban Travel

- **Temporal Distribution of Trips**
  - Peaking charct.
  - AM vs. PM
  - Urban goods movement trips temporal dist.
  - Congestion related issues
- **Spatial Distribution of Trips**
  - Trips origins-destinations (O-D matrix)
  - Traffic analysis zones
  - Trips are directly related to land-use pattern
  - Trans Networks: Road vs. transit networks

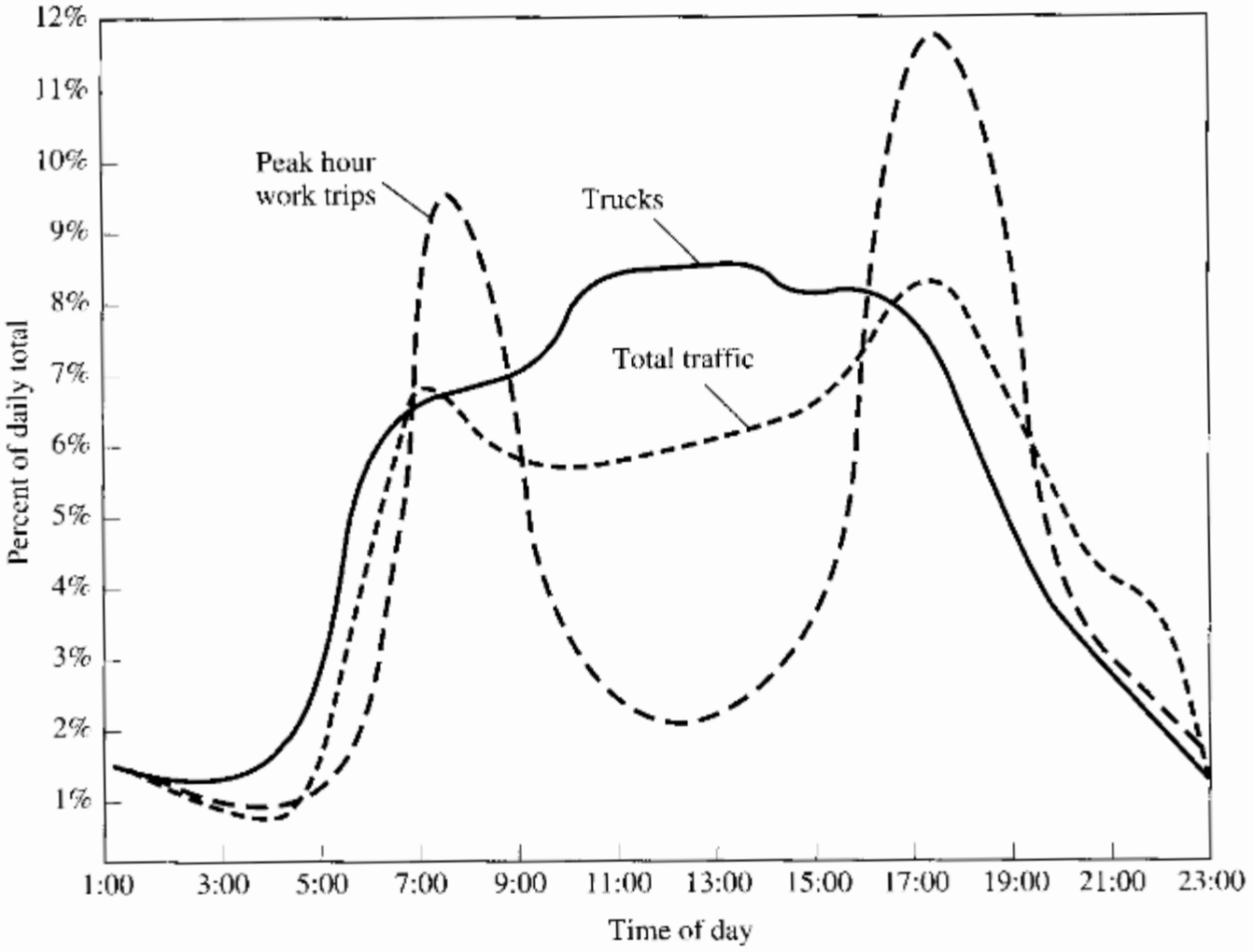

Figure 3.16 Typical distribution of trips during the weekday

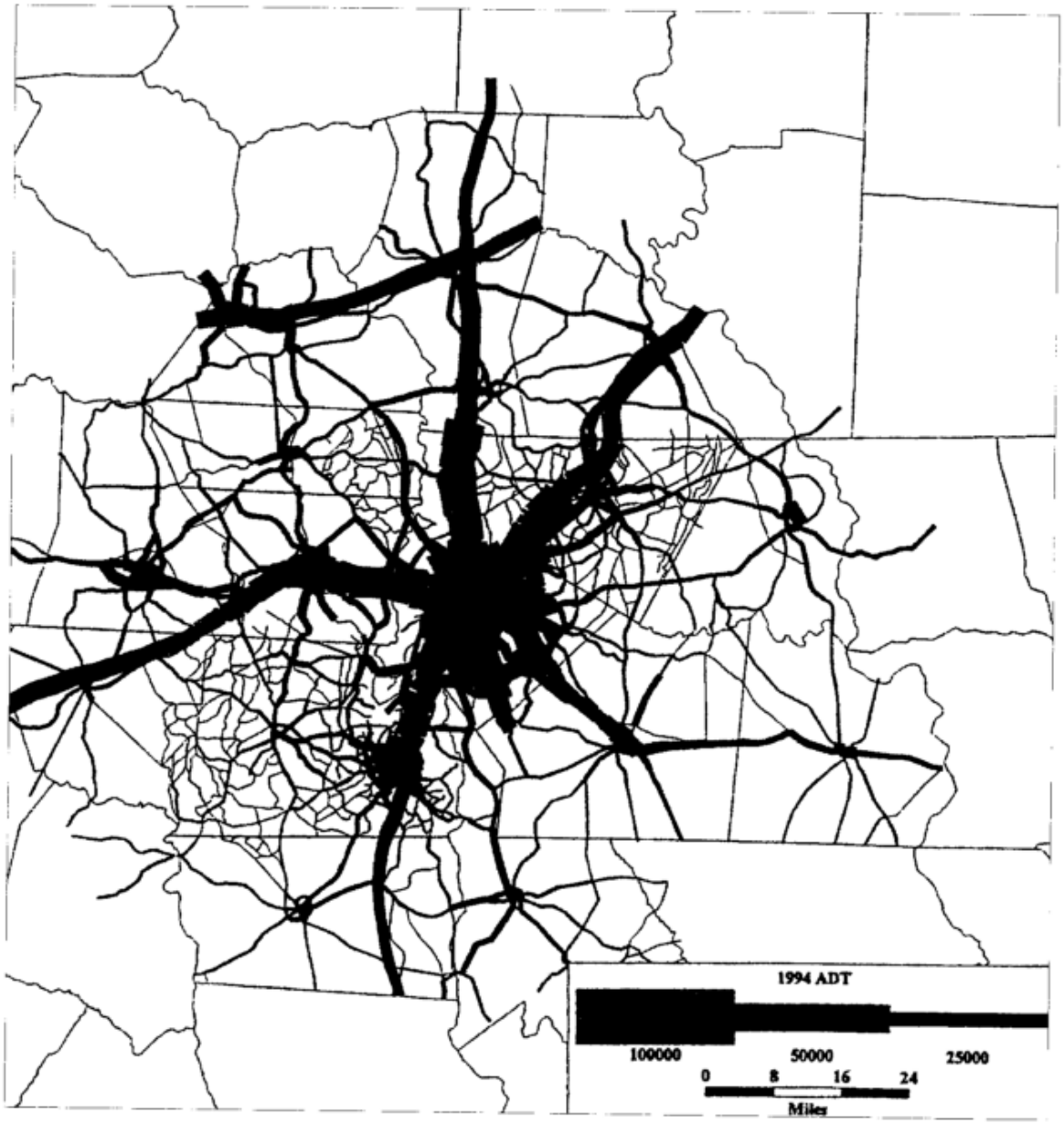

Figure 3.17 Vehicle flows in Charlotte, North Carolina, 1994

Characteristics of Urban Travel

- **Modal Distribution of Trips**
  - Trips are made by diff. modes: walking, bicycle, auto, shared taxi/taxi, bus, others
  - Mode split varies with trip purpose, trip time, trip fare, socio-economic chart., etc.
  - Public policies deal with modal changes
- **Trans. Safety**
  - Trip makers need to arrive safely
  - Decreasing trends in fatality rates ??
  - Mode related, time of day, facility, etc.

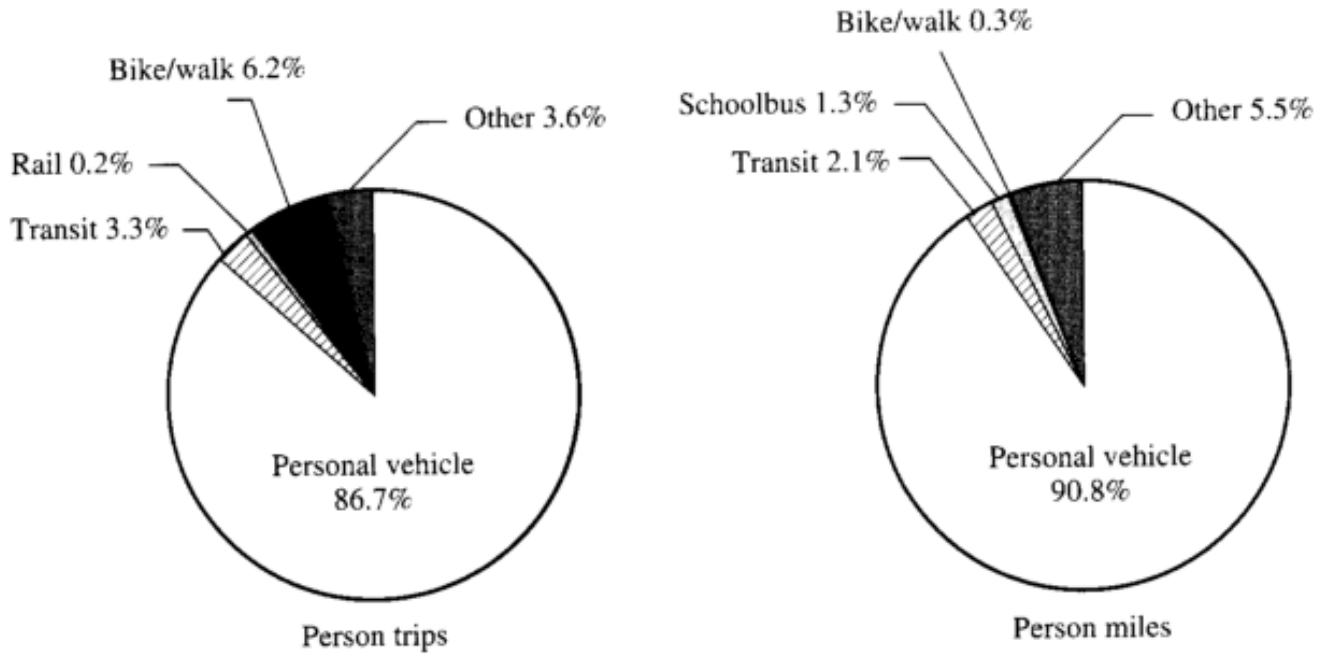

Figure 3.18 Person trips and person miles by mode

Characteristics of Urban Travel

- **Travel Cost**
  - Cost incurred when a trip is made
  - Defined by diff. users, stakeholders, system providers
  - Direct cost (out of pocket expend.)
  - Indirect cost (congestion, accident, pollution, etc.)

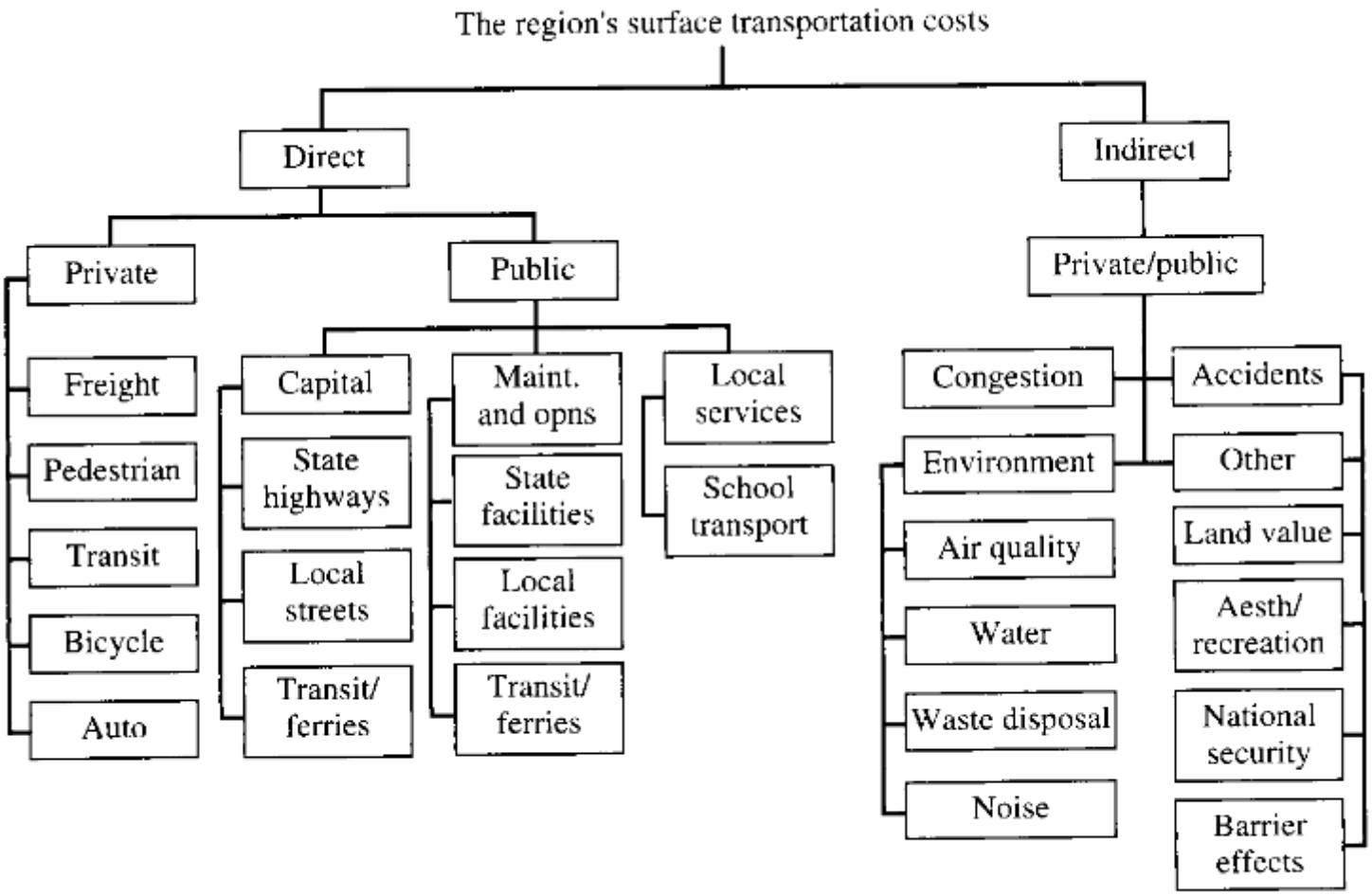

Figure 3.21 Transportation cost accounting in Seattle