



# Introduction to Transportation Systems

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**PART I:**

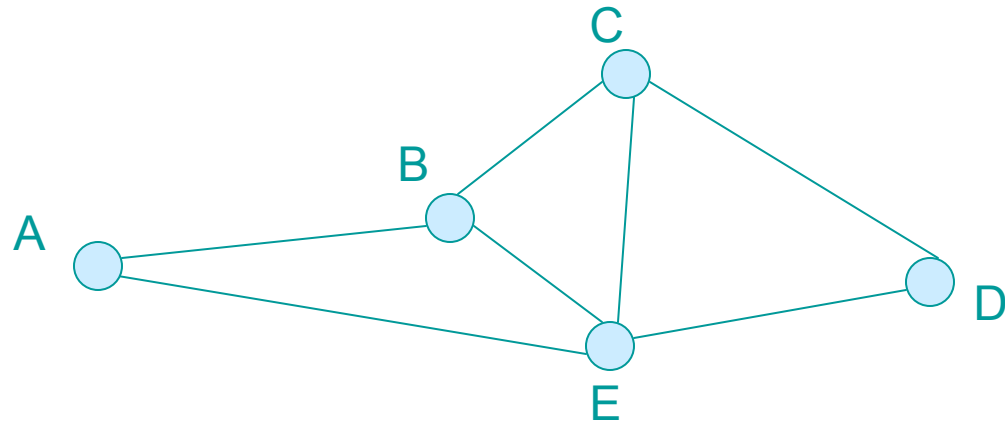
**CONTEXT,  
CONCEPTS AND  
CHARACTERIZATION**



## **Chapter 9:**

# **Transportation Systems: Key Points 25-30**

# A New Concept: Network Behavior



Redundancy in Routes -- to go from A to C, we can travel

- A-B-C
- A-B-E-C
- A-B-E-D-C
- A-E-B-C
- A-E-C
- A-E-D-C

# Congestion

- ◆ Congestion at a “choke-point” can propagate throughout the network
- ◆ Highway  
Examples in your city?
- ◆ Air Transportation  
Examples in your country?

# Key Point 25: Network Behavior and Capacity

Network behavior and network capacity, derived from link and node capacities and readjustment of flows on redundant paths, are important elements in transportation systems analysis.

# Stochasticity

- ◆ The concept of *stochasticity* in transportation system performance. Here we refer to random effects in the way transportation systems operate and respond to external stimuli.

Examples:

Weather

People's Behavior

CLASS DISCUSSION

Recurring vs. Non-Recurring Congestion

# Key Point 26: Stochasticity

Stochasticity -- in supply and demand -- is characteristic of transportation systems.



# Stochasticity

Stochasticity in traffic volume is *different* than peaking.

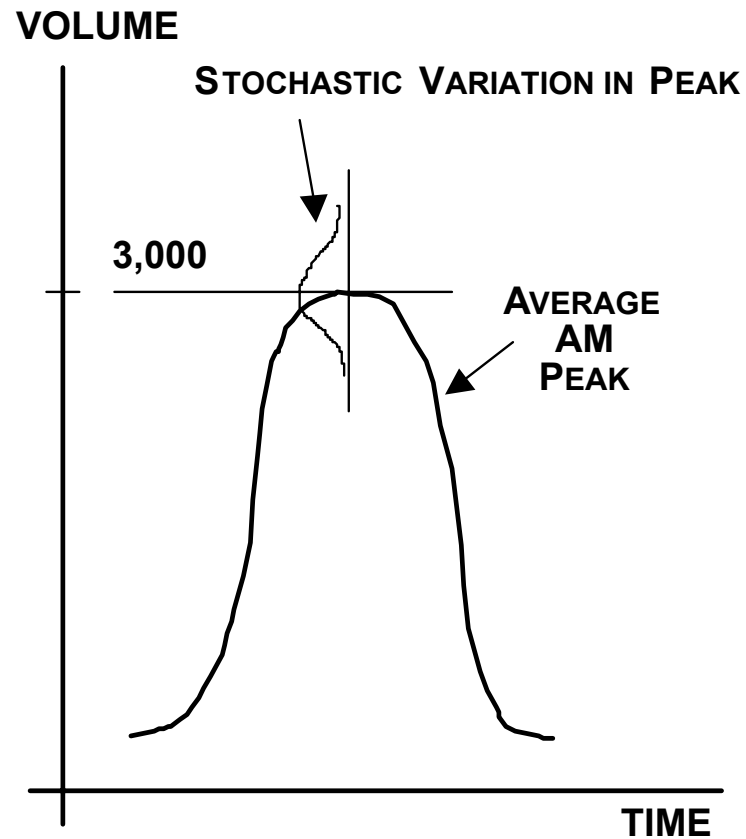


Figure 9.1

# Key Point 27: Transportation, Economic Development and Land Use

The relationship among transportation, economic development, and location of activities -- the transportation/land-use connection -- is fundamental.

# Two Cities and Their Economies

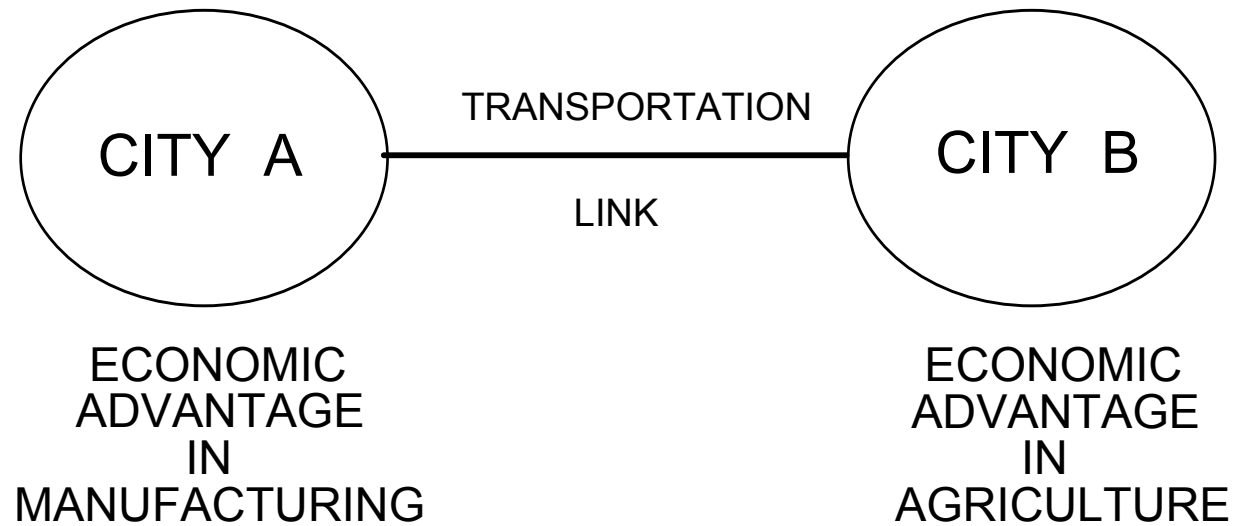


Figure 9.2

# Shifts in Activity Base Related to Transportation

- ◆ The importance of transportation investment and the shift of activities to areas of “cheap” transportation. Certainly, transportation investment, if intelligently made, is something that can have a positive impact on economic activity and on quality of life.

But,

- ◆ If we make a poor investment in infrastructure, we may be worse-off because those same resources could have been used in some better way.

# The “Rule” of 45 Minutes

- ◆ Urban planners talk about the “rule of 45 minutes” as something they argue has been relatively constant over human history.
- ◆ People are “willing” to travel 45 minutes to work. As technology enables faster travel, the size of cities grows, with the “rule” of 45 minutes (approximately) holding.

# Measuring Transportation System Performance

What do your customers perceive?

- ◆ *Our ways of measuring performance have to relate to the ways in which our customers make decisions about whether to use us or our competitors.*

# Performance Measures and Cost

- ◆ A second concept is that performance measures have to relate to costs of operations and revenues derived from operations of those systems.
- ◆ The customer cares about system performance (e.g., overall travel time), but
- ◆ A third concept: System vs. Component Performance. The operation is often managed on a component basis.
- ◆ The hope is, if we do a good job of operating the components, the system as a whole will operate well. Usually, it is a *necessary* condition that component operation be effective for system operation to be effective, but it is very often not a *sufficient* condition. We can have a poorly meshed system in which the components are operating well, but the system performance is still poor.

# Performance Measures and Behavior

- ◆ “People (and organizations) respond to incentives.”



# Key Point 28: Performance Measures

Performance measures shape transportation operations and investment.

## CLASS DISCUSSION

Some examples from transportation systems you are familiar with.

# Key Point 29: Balancing Centralized with Decentralized Decisions

Balancing centralized control with decisions made by managers of system components (e.g., terminals) is an important operating challenge.

# Key Point 30: Integrality of Vehicle/Infrastructure/Control Systems Decisions

The integrality of vehicle/infrastructure/control systems investment, design and operating decisions is basic to transportation systems design.

# Key Points -- Summary (1)

1. People and organizations alter behavior based on transportation service expectations.
2. Transportation service is part of a broader system -- economic, social and political in nature.
3. Competition (or its absence) for customers by operators is a critical determinant of the availability of quality transportation service.
4. Analyzing the flow of vehicles on transportation networks, and defining and measuring their cycle, is a basic element of transportation systems analysis.
5. Queuing for service and for customers and storage for vehicles/freight/travelers, etc., are fundamental elements of transportation systems.

# Key Points -- Summary (2)

6. Intermodal and intramodal transfers are key determinants of service quality and cost.
7. Operating policy affects level-of-service.
8. “Capacity” is a complex, multi-dimensional system characteristic affected by:
  - ◆ infrastructure
  - ◆ vehicles
  - ◆ technology
  - ◆ labor
  - ◆ institutional factors
  - ◆ operating policy
  - ◆ external factors (e.g., “clean air”, safety, regulation)
9. Level-of-service =  $f(\text{volume})$ ; *Transportation Supply*. As volume approaches capacity, level-of-service deteriorates dramatically -- the “hockey stick” phenomenon.
10. The availability of *information* (or the lack) drives system operations and investment and customer choices.

# Key Points -- Summary (3)

11. The “shape” of transportation infrastructure impacts the fabric of “geo-economic” structures.
12. The cost of providing a specific service, the price charged for that service, and the level-of-service provided may not be consistent.
13. The computation of cost for providing specific services is complex and often ambiguous.
14. Cost/level-of-service trade-offs are a fundamental tension for the transportation provider and for the transportation customer, as well as between them.
15. Consolidation of like-demands is often used as a cost-minimizing strategy.

# Key Points -- Summary (4)

16. Investments in capacity are often lumpy (e.g., infrastructure).
17. The linkages between capacity, cost and level-of-service -- the lumpiness of investment juxtaposed with the “hockey stick” level-of-service function as volume approaches capacity -- is the central challenge of transportation systems design.
18. Temporal peaking in demand: a fundamental issue is design capacity -- how often do we not satisfy demand?
19. Volume =  $f$  (level-of-service); *Transportation Demand*.
20. Level-of-service is usually multi-dimensional. For analysis purposes, we often need to reduce it to a single dimension, which we call utility.


# Key Points -- Summary (5)

21. Different transportation system components and relevant external systems operate and change at different time scales, e.g.,
  - ◆ Short run -- operating policy
  - ◆ Medium run -- auto ownership
  - ◆ Long run -- infrastructure, land use
22. Equilibration of transportation supply and demand for transportation service to predict volume is a fundamental network analysis methodology.
23. Pricing of transportation services to entice different behavior is a mechanism for lowering the negative externalities caused by transportation users on other users and society-at-large.
24. Geographical and temporal imbalances of flow are characteristic in transportation systems.
25. Network behavior and network capacity, derived from link and node capacities and readjustment of flows on redundant paths, are important elements in transportation systems analysis.



# Key Points -- Summary (6)

26. Stochasticity -- in supply and demand -- is characteristic of transportation systems.
27. The relationship among transportation, economic development, and location of activities -- the transportation/land-use connection -- is fundamental.
28. Performance measures shape transportation operations and investment.
29. Balancing centralized control with decisions made by managers of system components (e.g., terminals) is an important operating challenge.
30. The integrality of vehicle/infrastructure/ control systems investment, design and operating decisions is basic to transportation systems design.

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- ◆ Having completed our Key Points discussion as an introduction to transportation systems, we now proceed to discuss models and frameworks that are useful in the transportation context.