



Introduction to Transportation Systems



PART I:

**CONTEXT,
CONCEPTS AND
CHARACTERIZATION**



Chapter 8:

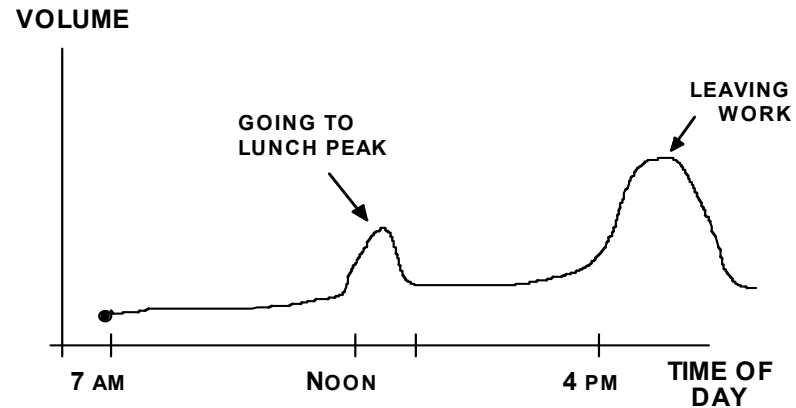
Transportation Systems: Key Points 18-24

Our Next Concept -- Peaking

Volume vs. Time of Day



UP DIRECTION

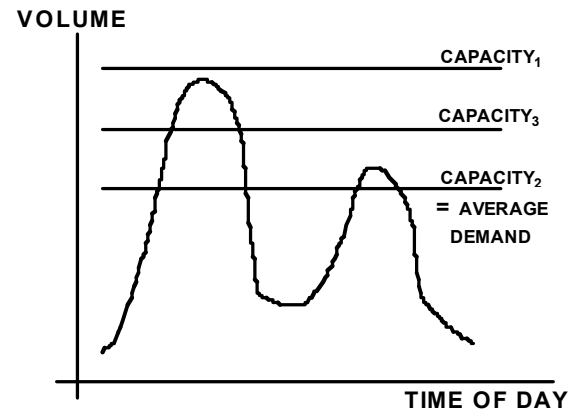


DOWN DIRECTION

Figure 8.1

How much capacity should we provide?

Different Capacity Decisions



So what do we do? We cannot choose such a low capacity that customer levels-of-service during peak periods are unacceptable. At the same time, however, we cannot provide a level-of-service such that nobody ever has to wait -- it's not economical. So, capacity₃ may be a good compromise. The question of design capacity and how we accommodate temporal peaks in demand is Key Point 18.

Figure 8.2

Key Point 18: Peaking

Temporal peaking in demand:
a fundamental issue is design
capacity -- how often do we not
satisfy demand?

Our Next Concept

- ◆ The volume that a transportation service attracts is a function of the level-of-service provided to customers. If the level-of-service deteriorates, less people will want to use the service.
- ◆ This is simply a micro-economic concept. For example, if a movie theater doubles its price, therefore making its service less attractive -- in this case, more expensive -- fewer people will go to that movie theater. If a movie theater halves its price, more people will go.

Key Point 19: Volume = f (level-of-service); *Transportation Demand*

Transportation Demand: LOS vs. Volume

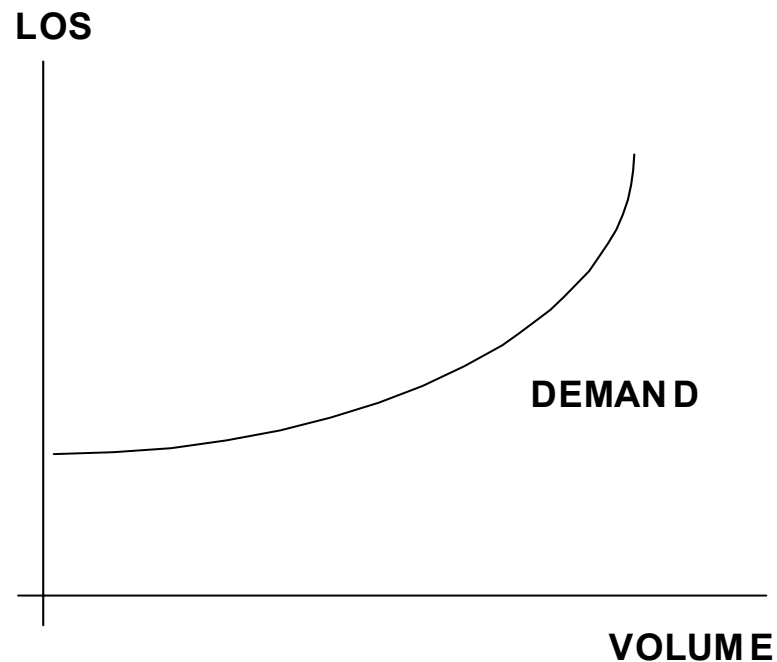


Figure 8.3

Level-of-Service Is Multi-Dimensional

- ◆ We simply cannot measure LOS by a single variable -- like travel time. Rather, we measure it with a number of level-of-service variables.
- ◆ Often, we have to collapse several level-of-service variables into a single variable -- utility.
- ◆ For example, “utility” V might be the linear sum of various LOS variables, such as travel time, access time, waiting time, fare and comfort, as described earlier.

Key Point 20: Multi-Dimensional Level-of-Service

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 Point 21: Different Time Scales

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.

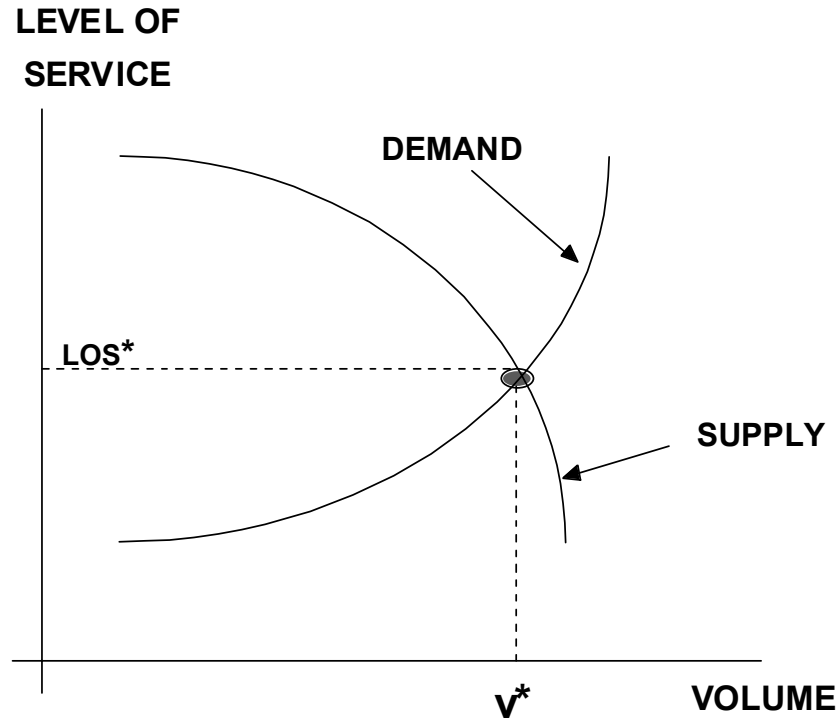
Equilibrium between Supply and Demand

- ◆ Level-of-service is a function of volume. As a facility gets congested, the level-of-service for customers deteriorates, as discussed in Key Point 9.

But,

- ◆ as level-of-service changes, demand changes as well. Demand increases as level-of-service improves and decreases as level-of-service deteriorates.

Key Point 22: Equilibrium



Equilibration of transportation supply and demand for transportation service to predict volume is a fundamental network analysis methodology.

Figure 8.4

Different Time Scales for both Demand and Supply

	<u>Demand</u>	<u>Supply</u>
Short Run	Some people walk up and down	Elevator ops-- Change dwell times
Medium Run	Firms change work hours	Technological fix--New control system
Long Run	Firms move out	High-tech, high-speed elevator, more shafts

Table 8.1



**All models are wrong.
However, some are useful.**

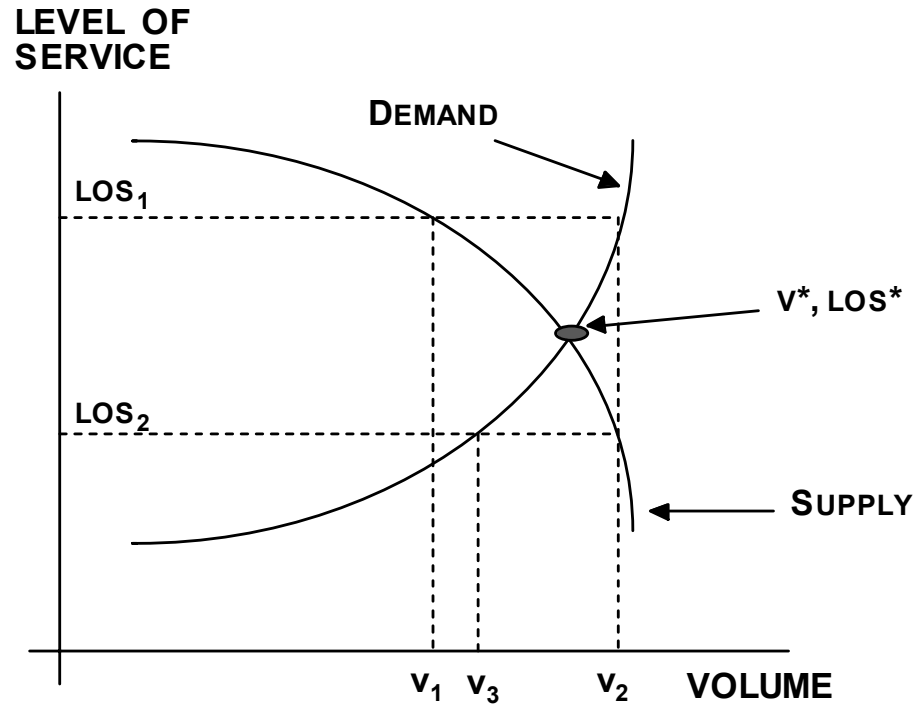
- ◆ Any model will, at some level of abstraction, fail to capture some aspect of the real-world system.
- ◆ Models can still be useful representations for the purposes of understanding the system, for the purposes of designing the system, for the purposes of changing operating plans, etc.
- ◆ So indeed, any modeling effort -- any reduction to an abstract form of a system is, in some sense, wrong. However, it may still be very useful.

Transportation Systems

- ◆ Transportation systems are complex, dynamic, and internally interconnected as well as interconnected with other complex dynamic systems (e.g., the environment, the economy).
- ◆ They vary in space and time (at different scales for different components). Service is provided on complex networks. The systems are stochastic in nature.
- ◆ Human decision-makers with complex decision calculi make choices that shape the transportation system.
- ◆ Modeling the entire system is almost unthinkable. Our challenge is to choose relevant subsystems and model them appropriately for the intended purpose, mindfully reflecting the boundary effects of the unmodeled components.

The Mechanics of Supply/Demand Equilibrium

Iteration to Find Equilibrium



v_1 -- first guess at volume

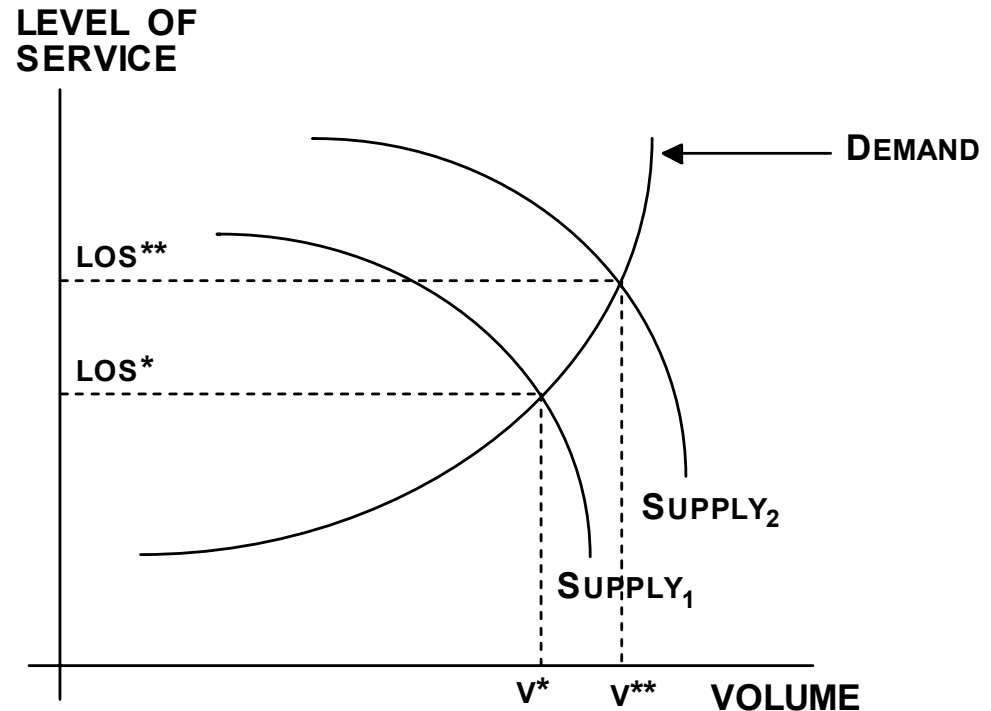
LOS_1 implies demand v_2

v_2 implies LOS_2

LOS_2 implies v_3 , etc., until v^*, LOS^* are found.

Figure 8.5

Changing Supply



People respond to incentives. If highway transportation becomes cheaper, people buy more.

Figure 8.6

Boston and West

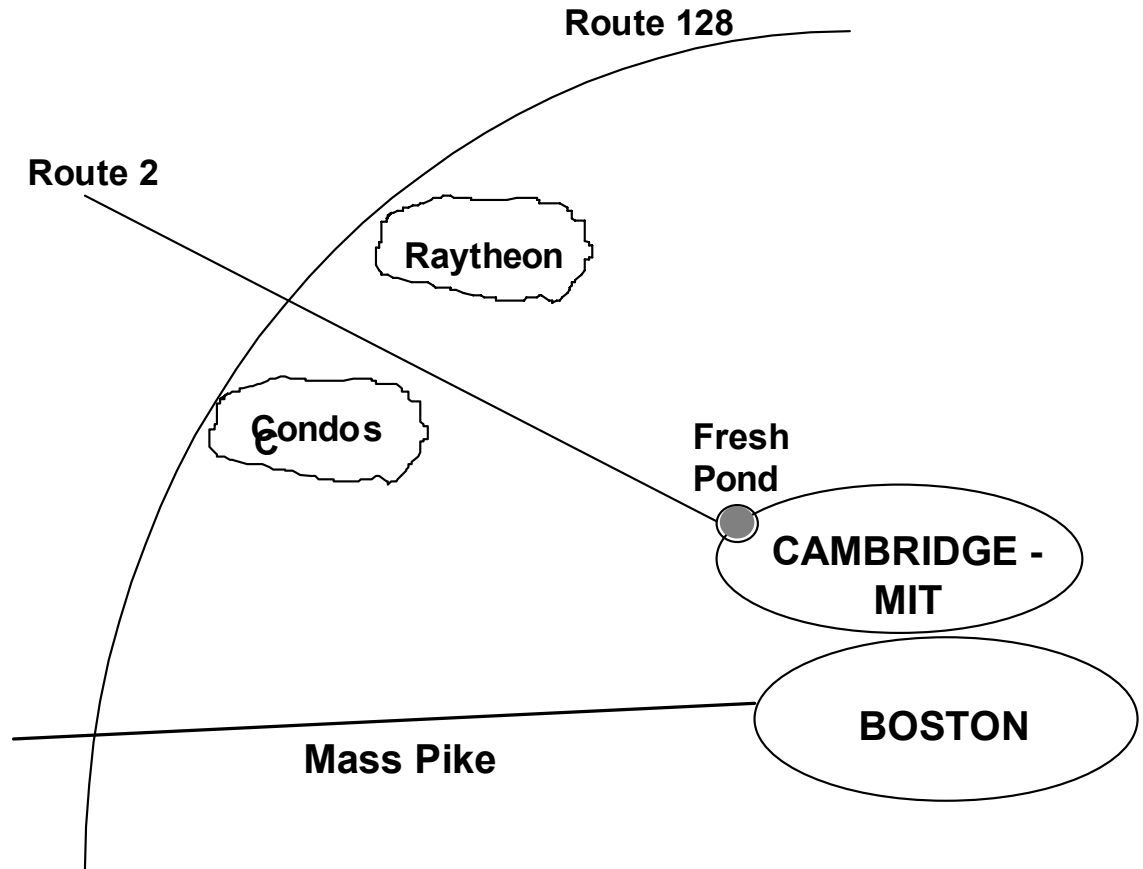


Figure 8.7

Changing Demand

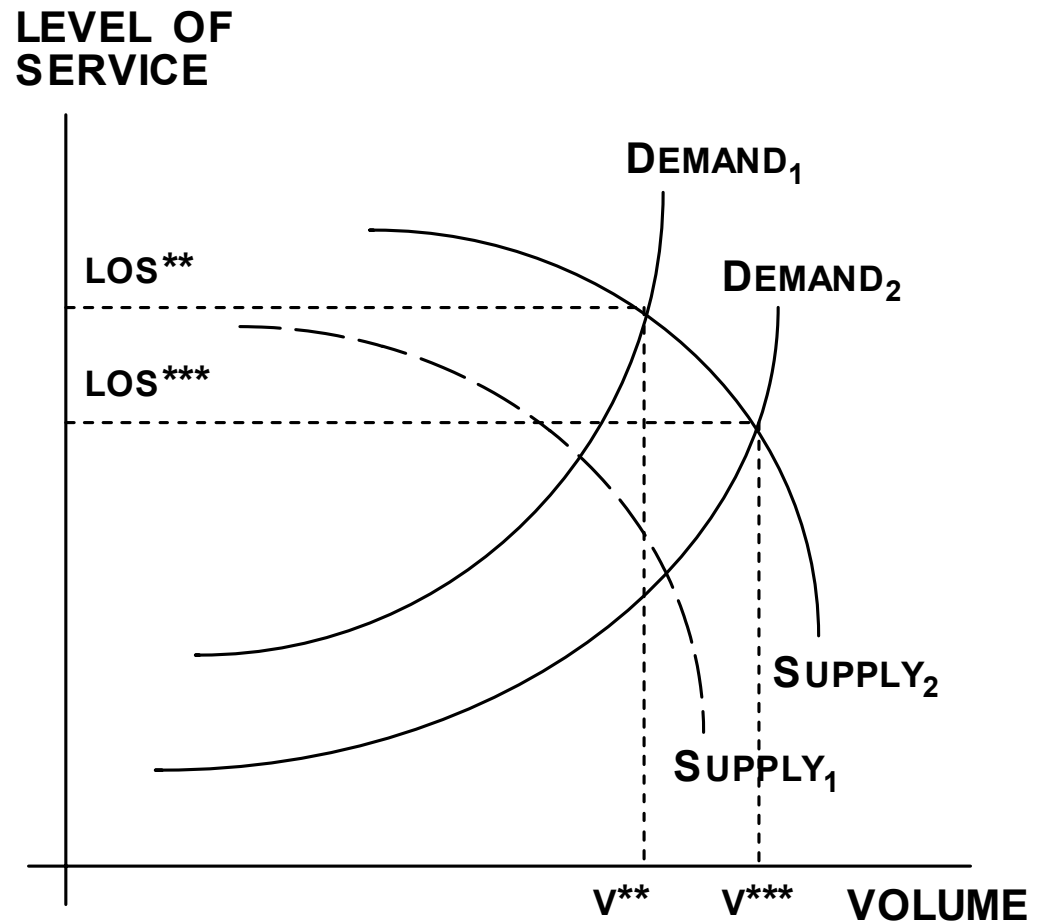


Figure 8.8

Equilibrium: A Second Look

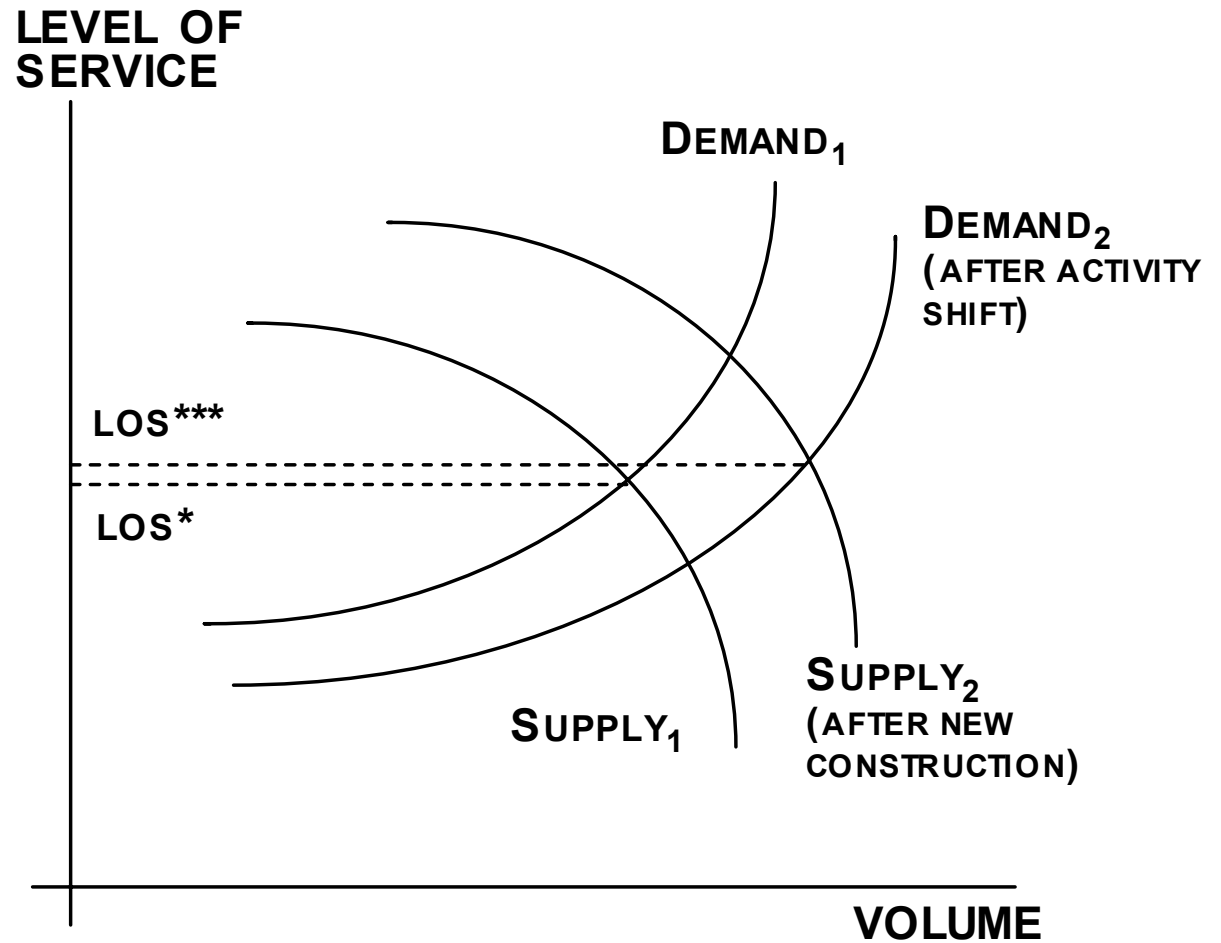


Figure 8.9

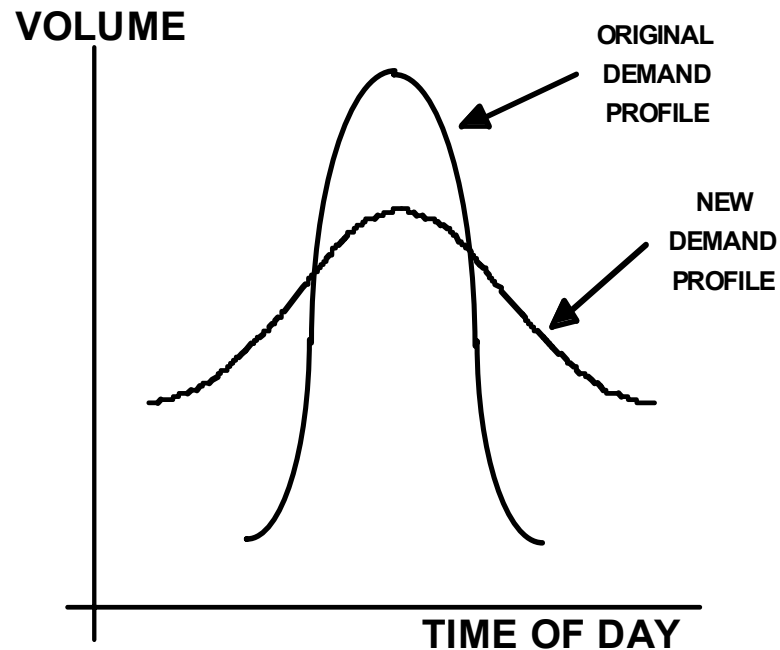
Increased Volume: Better or Worse?

- ◆ So, at a higher volume, the customers are seeing the same level-of-service. Are we worse or better off than we were before we started?

CLASS DISCUSSION

Peaking Using Price as an Incentive

Changing the Demand Profile



This is called “congestion pricing”.

Externalities

- ◆ The costs imposed by our use of the transportation service may be imposed not only on us, but on others as well. For example, when we choose to travel at peak-hour, we cause further delays for our fellow travelers.
- ◆ When we drive, we impose costs -- due to environmental degradation -- on society as a whole, for which we don't directly pay.
- ◆ Economists use the term “negative externality” for these effects. Our decision to use the system creates costs for others and may lead to sub-optimal use of resources from a societal perspective.

Key Point 23: Pricing

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

Flow Imbalance

- ◆ A characteristic of transportation systems is “imbalance in flows”. In our elevator system, we have an imbalance. In the morning, everybody wants to go up. In the evening, everybody wants to go down.
- ◆ In the U.S. rail industry, about 42% of freight car-miles are empty, reflecting imbalance in flow and the need to reposition empties.

CLASS DISCUSSION

Key Point 24: Imbalance in Flow

Geographical and temporal imbalances of flow are characteristic in transportation systems.