Frameworks and Models in Engineering Systems
Engineering Systems Design (ESD.04J/1.041J)
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# Models and Frameworks

## DISPLAYS

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# Introduction to Transportation Systems

Sussman, Joseph M., Artech House Publishers, Boston and London, 2000.

# Chapter 10:

# Models and Frameworks

# Models and Frameworks: An Introduction

- Models are mathematical representations of a system.
- Frameworks are qualitative organizing principles for analyzing a system.
- We can use both models and frameworks to do *analysis.*

# What is our function as transportation professionals?

- Designing better transportation systems
- Using resources, financial and otherwise, effectively in a transportation context
- Operating transportation systems optimally
- Maintaining transportation systems efficiently

Value-laden words:

- better
- effectively
- optimally
- efficiently

These depend on your point of view.

# A Structure for Transportation System Analysis

# A Systems Analysis Framework: A First Look

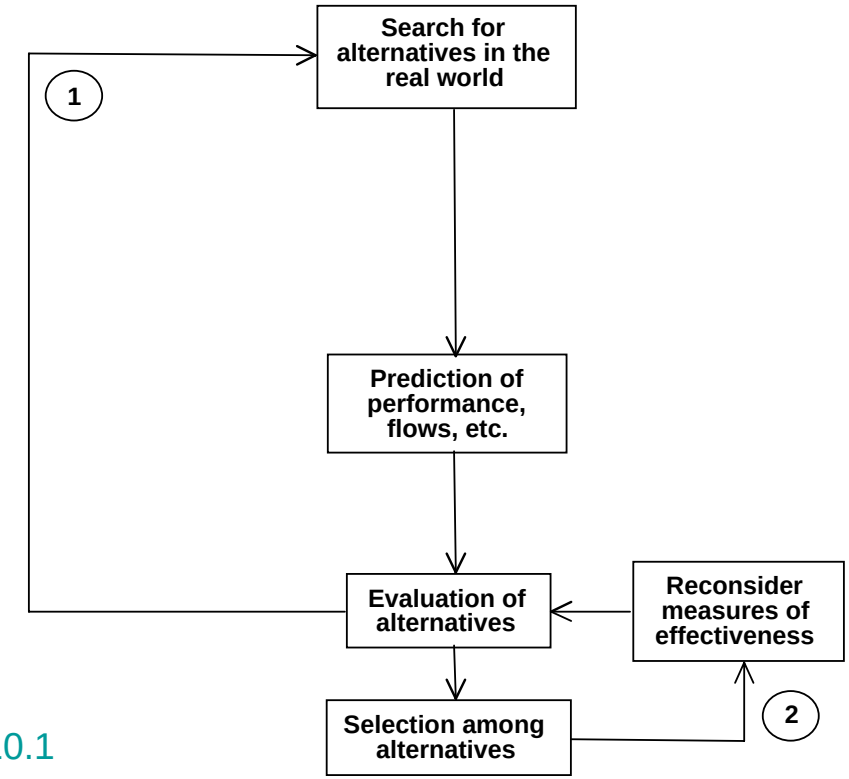


Figure 10.1

LOOP 1: Does the evaluation suggest other alternatives?

LOOP 2: Are the measures of effectiveness appropriate?

# The Subtlety in Choosing Measures of Effectiveness

Be sure your measures of effectiveness are good

**An Urban Area**

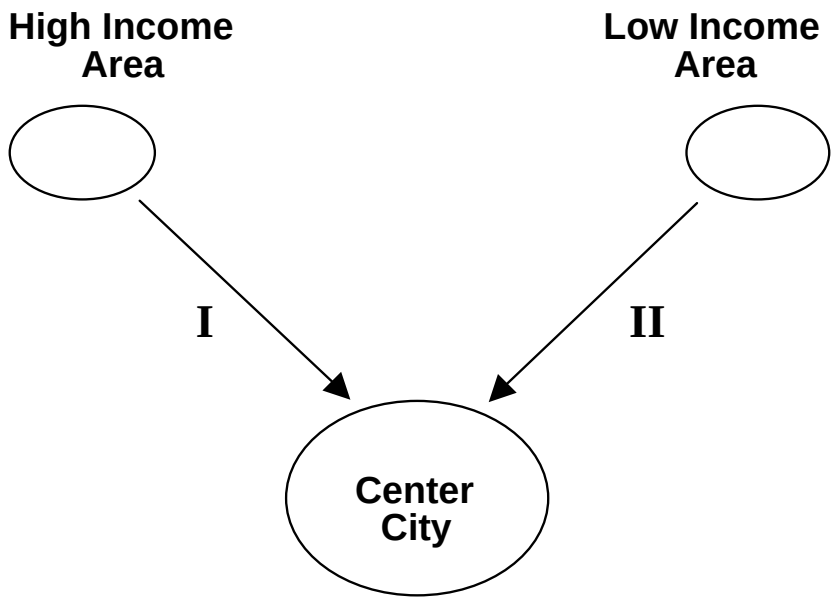


Figure 10.2

# A Systems Analysis Framework: A Second Look

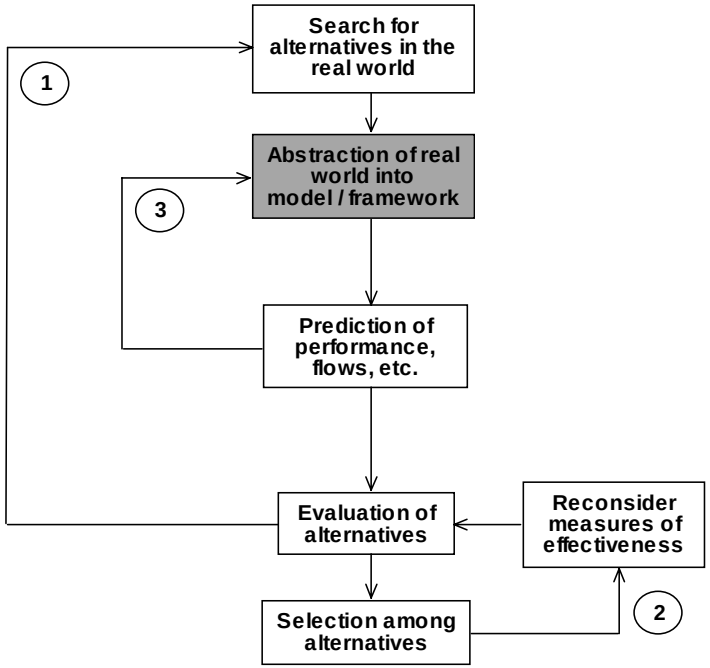


Figure 10.3

LOOP 1: Does the evaluation suggest other alternatives?

LOOP 2: Are the measures of effectiveness appropriate?

LOOP 3: Is the "abstraction" good at predicting?

We need to ask, "Is the abstraction any good?"

# A Systems Analysis Framework: A Third Look

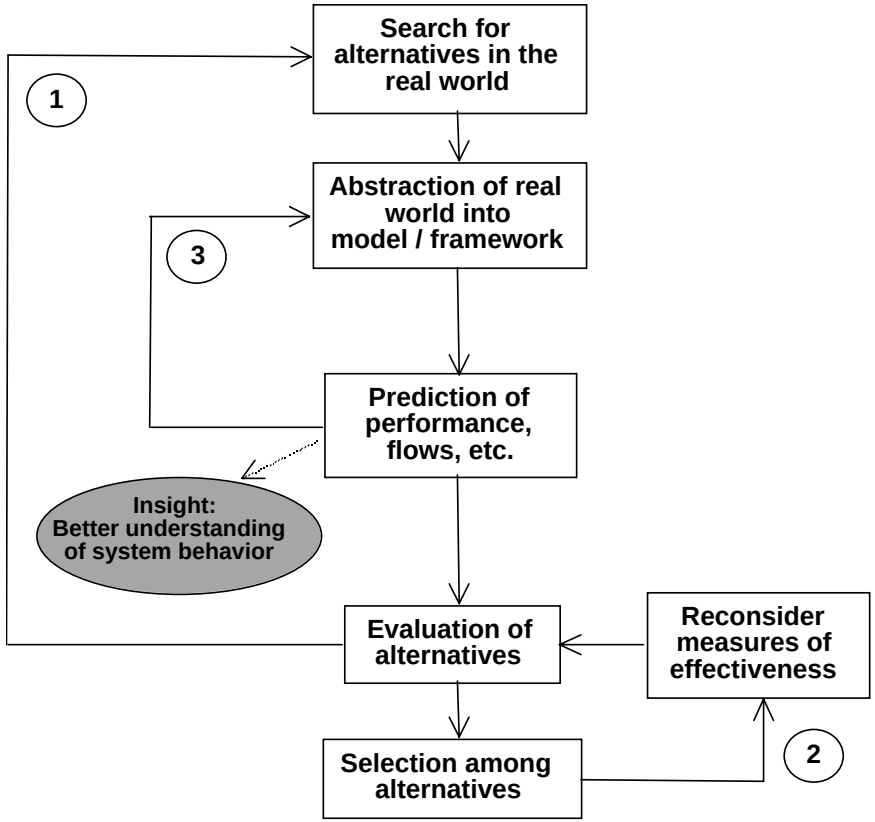


Figure 10.4

LOOP 1: Does the evaluation suggest other alternatives?

LOOP 2: Are the measures of effectiveness appropriate?

LOOP 3: Is the "abstraction" good at predicting?

# Why Are We Modeling?

- Choosing the Best Alternative -- Optimization
- System Operation
- Learn from Model Building Processes
- Insight

  “We may gain insight into complex situations by first understanding simpler situations resembling them.”

# Modeling for Negotiation

- Prodyut Dutt, in “A Standards-Based Methodology for Urban Transportation Planning in Developing Countries”, focused on how planners work in developing countries versus the way urban planners work in the developed world. The essence of his research looked at the differences in planning methodologies necessary in the two environments.
- Dutt developed “models for negotiation” -- the idea of *transparent* models, where rather than shielding the outside world from what was going on within that “black box” model, planners could look into the model and clearly see the assumptions driving the trade-off about location of corridors in urban areas.

# The Model Is a Shaper of Your World View

- A hammer is a fine tool, but it is not very good for washing windows.

# Modeling Approaches

- Network Analysis
- Linear Programming
- Non-linear Programming
- Simulation
- Deterministic Queuing
- Probabilistic Queuing
- Regression
- Neural Networks
- Genetic Algorithms
- Cost/Benefit Analysis
- Life-cycle Costing

# Modeling Approaches (continued)

- System Dynamics
- Control Theory
- Difference Equations
- Differential Equations
- Probabilistic Risk Assessment
- Supply/Demand/Equilibrium
- Game Theory
- Statistical Decision Theory
- Markov Models

# Getting Answers from Models

Developing a model -- an abstraction -- and getting results from it are two different things.

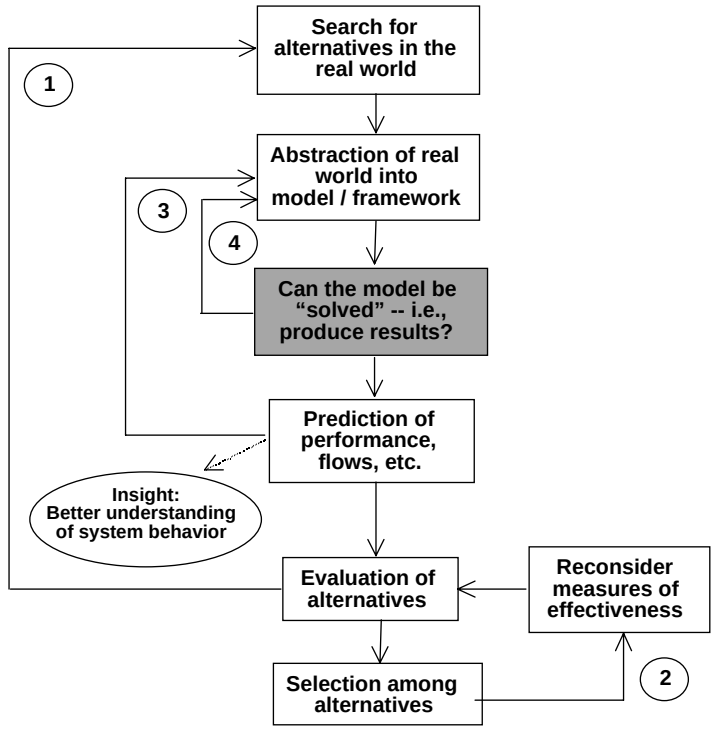


Figure 10.5

LOOP 1: Does the evaluation suggest other alternatives?
LOOP 2: Are the measures of effectiveness appropriate?
LOOP 3: Is the "abstraction" good at predicting?
LOOP 4: Develop new abstraction.

# Models vs. Frameworks

- Models
  - Models are a mathematical representation of reality -- quantitative in nature.
- Frameworks
  - When we talk about a *framework*, we are generally talking about a qualitative view of a complex system. It is “a way of thinking” -- a way of *organizing* our thinking about a complex system.

# Here is a framework we discussed earlier:

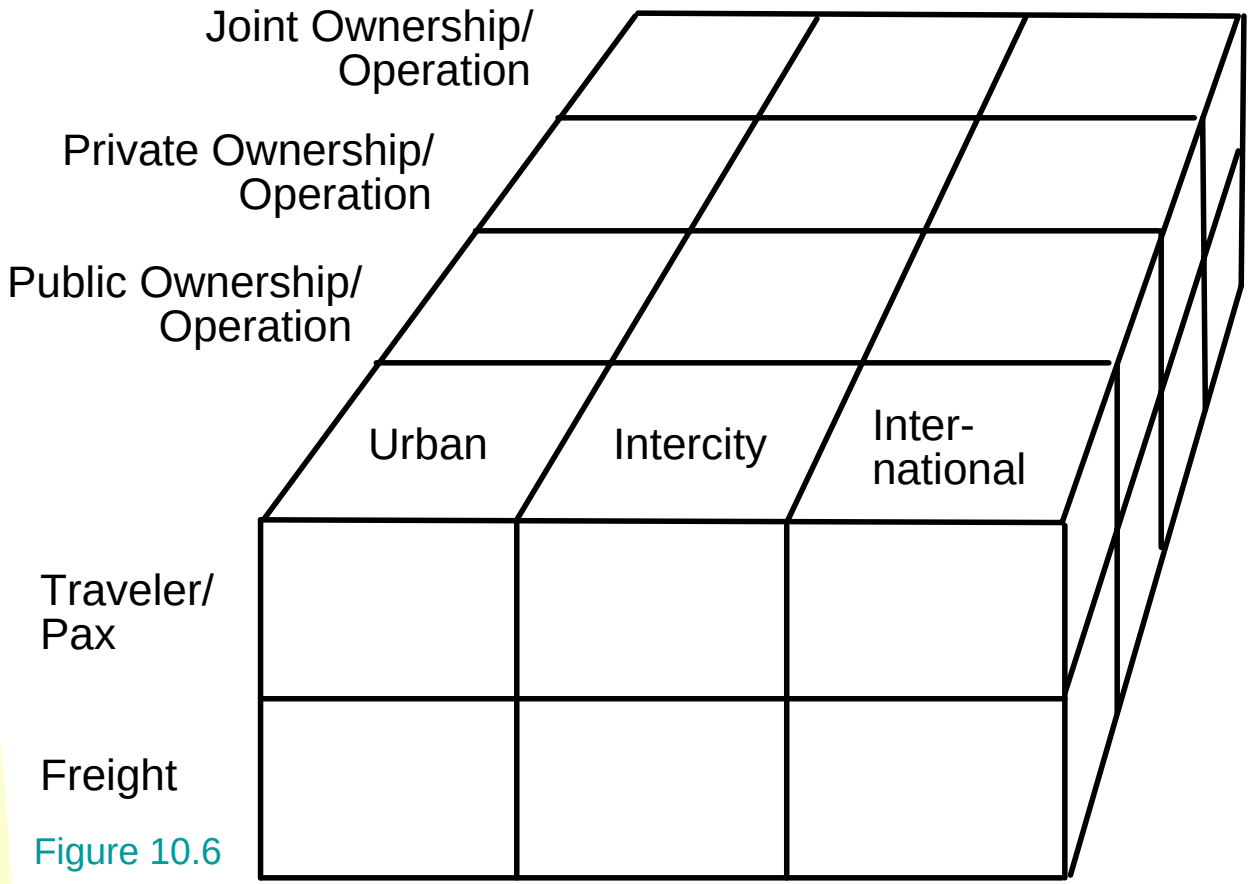


Figure 10.6

# Simple vs. Complex Models and Frameworks

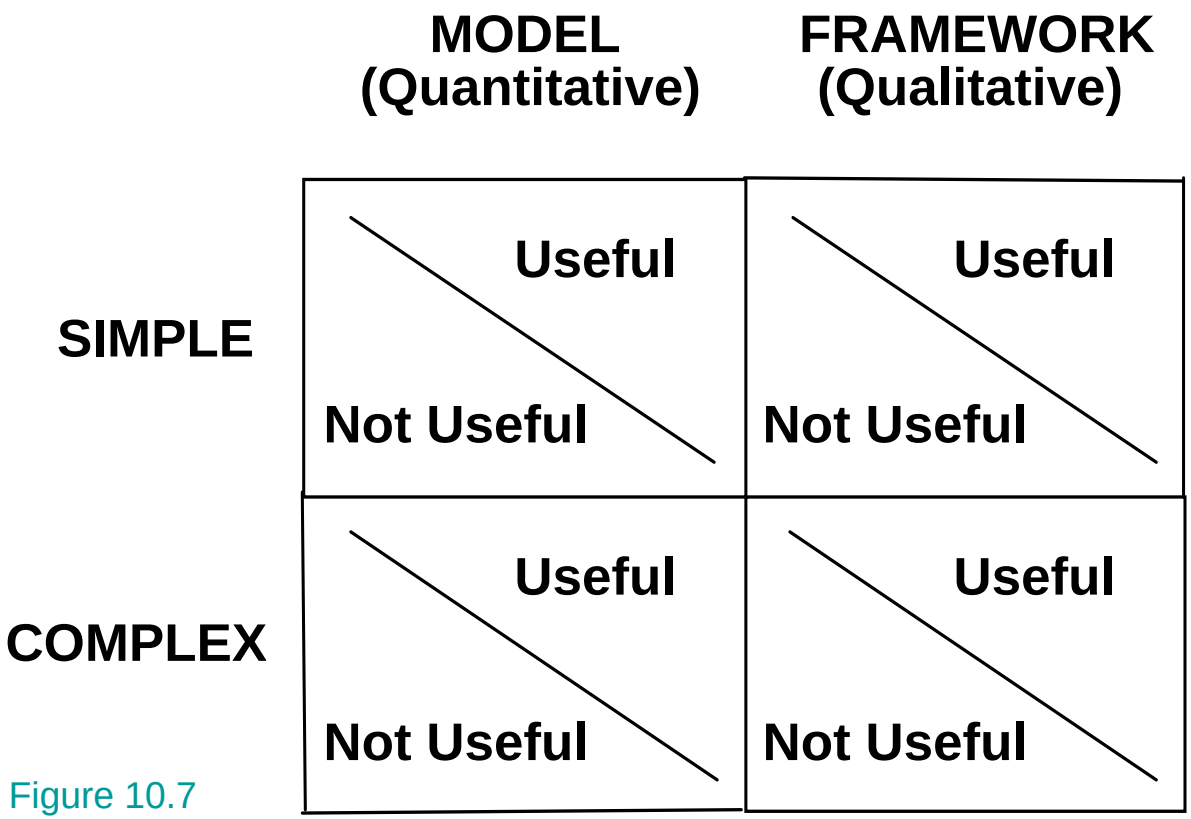


Figure 10.7