1.201J/11.545J/ESD.210JJ

Introduction to Transportation Systems

Fall 2006

LECTURE 1

DISPLAYS

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CRITICAL CONTEMPORARY ISSUES (CCI)

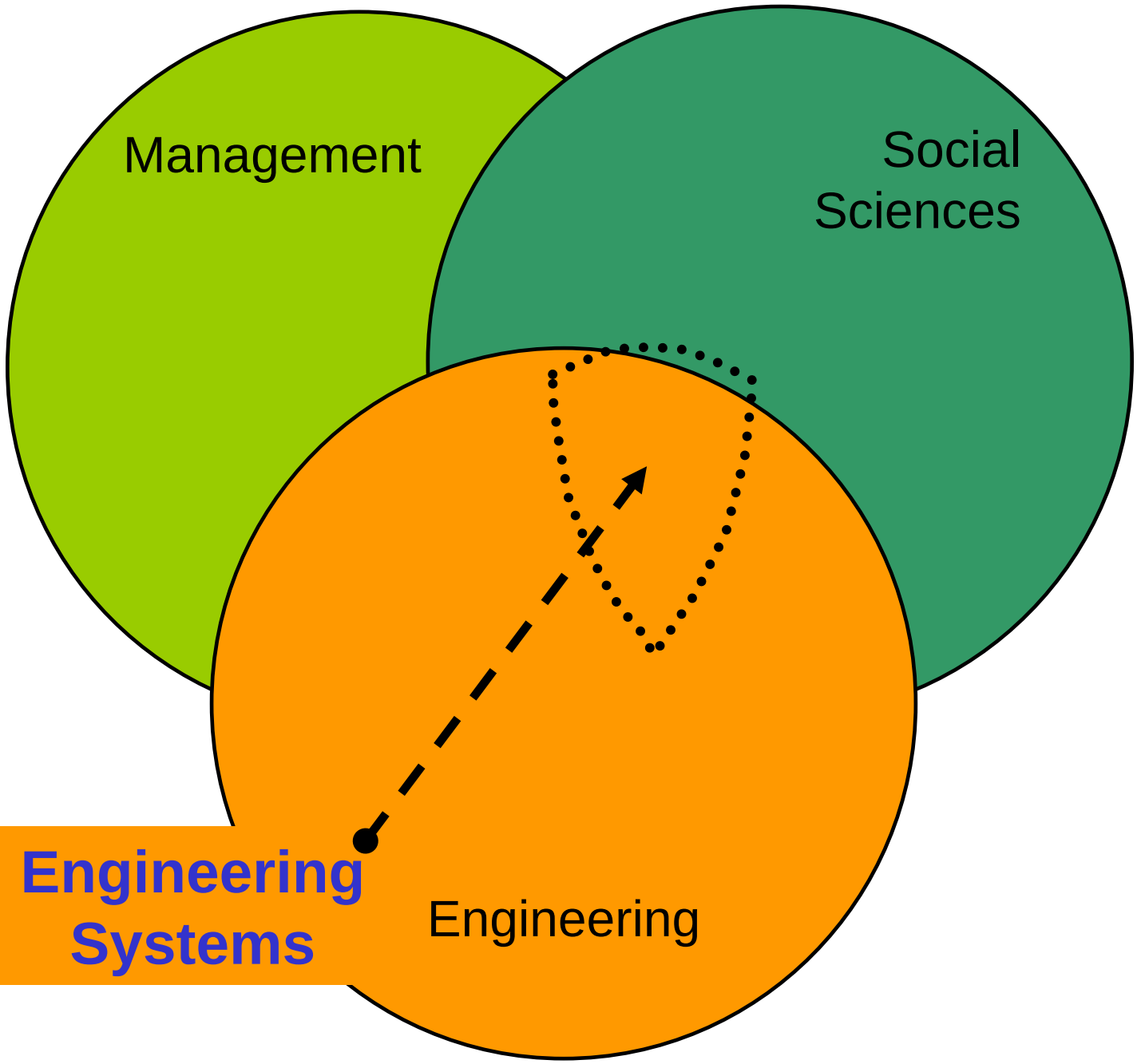
- Mobility
- Energy
- Global Climate Change
- Urban Form
  - Developing world
  - Developed world
- Population
  - Growth in developing world
  - Shrinkage in parts of developed world
- Economic development/growth
- Environmental issues
- Social equity
- Productivity
  - Manufacturing
- Security

TRANSPORTATION SYSTEM PHASES

- Conceptualization
- Planning
- Construction
- Operations/Maintenance
- Decommissioning

ENGINEERING SYSTEMS

(at the interface of Engineering, Management, & Social Sciences)



C L I O S System

- Complex
- Large-scale
- Interconnected
- Open
- Socio-technical

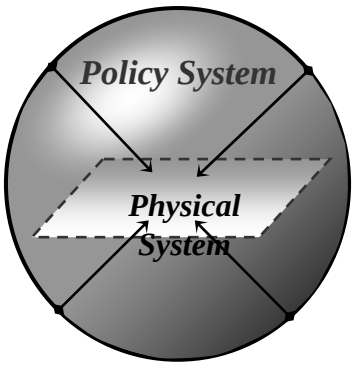
C L I O S System

Complex

- *Structural complexity*
  - The number of components in the system and the network of interconnections between them
- *Behavioral complexity*
  - The type of behavior that emerges due to the manner in which sets of components interact
- *Evaluative complexity*
  - The competing actions of decision makers in the system who have alternate views of “good” system performance
- *Nested Complexity*

  - The interaction between a complex “physical” domain and a complex “institutional” sphere

Nested Complexity



- Physical system “layer”
  - More quantitative principles
  - Engineering & economic models
- Policy system “sphere”
  - More qualitative in nature and often more participatory
  - Stakeholder evaluation and organizational analysis
- Different methodologies are required
  - within the physical system
  - between the policy system and the physical system
  - within the policy system

C L I O S System

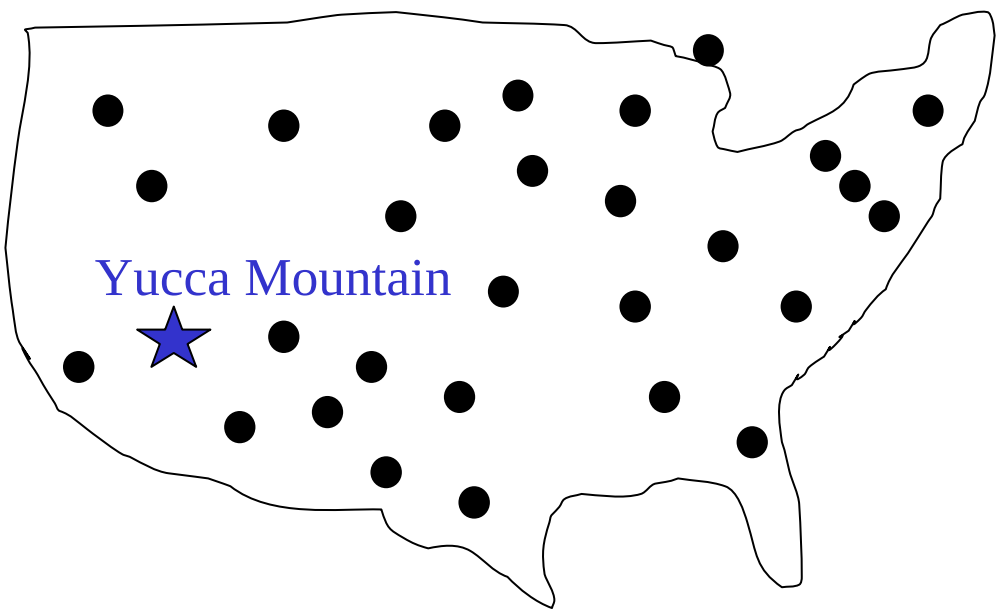
Complex

Large-scale

TRANSPORTING SPENT NUCLEAR FUEL

Large-scale in

- Geographic extent, and
- Impact



C L I O S System

Complex
Large-scale
Interconnected

TRANSPORTING SPENT NUCLEAR FUEL

Transportation interconnected with:

- **Energy**
- **Global Climate Change**

C L I O S System

TRANSPORTING SPENT NUCLEAR FUEL

Complex
Large-scale
Interconnected
Open

- Social Factors
  - Risk
- Political Factors
  - Geopolitics
- Economic Factors
  - Development

C L I O S System

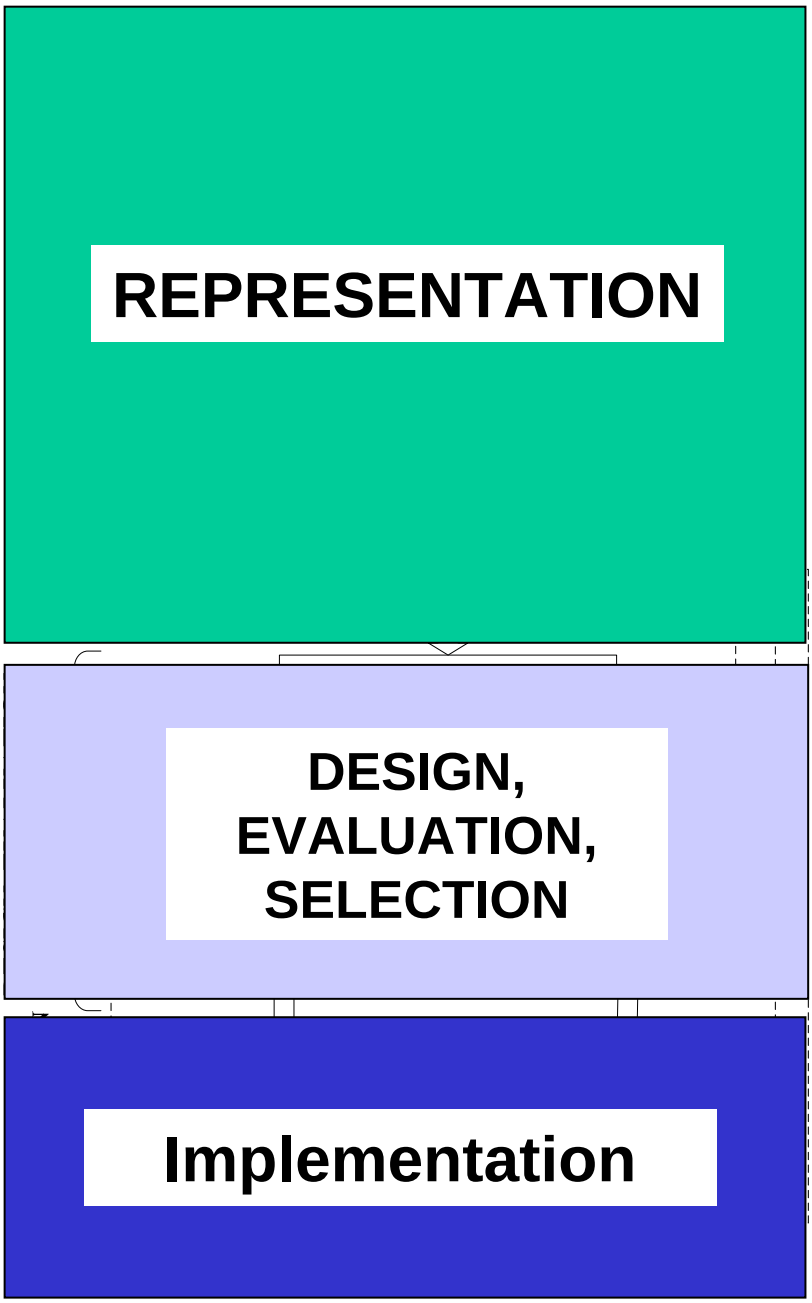
An Example of a Socio-technical System:

Complex
Large-scale
Interconnected
Open
Socio-technical

TRANSPORTING SPENT NUCLEAR FUEL

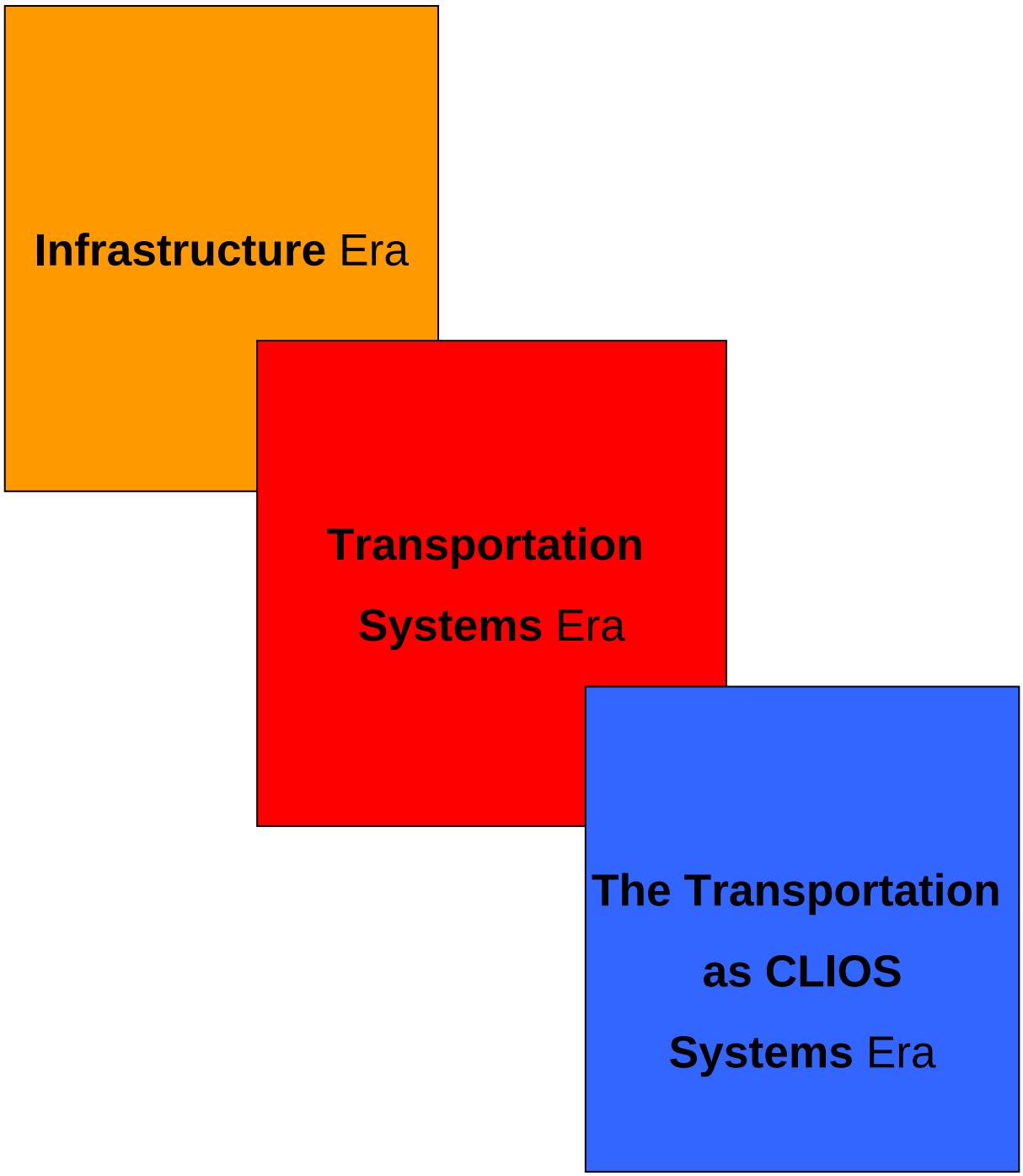
- **Complex Technology**
- **Important Social Impacts**

The C L I O S Process



A 3-Stage, 12-step, iterative process used to study CLIOS Systems

Transportation Eras



- Build what “they” want
- Focus on physical facilities
- Focus on mobility
- Focus on economic growth
- Largely a modal perspective

- Economics-based framework
  - Supply
  - Demand
  - Equilibrium
  - Networks
- Focus on economic development and environmental concerns
- Focus on both mobility and accessibility
- Recognition of unpriced externalities as causing problems – congestion, air quality, sprawl
- Intermodal Perspective (largely limited to freight)

Focused on transportation as a **C**omplex, **L**arge-scale, **I**nterconnected, **O**pen, **S**ocio-technical (**CLIOS**) System

Characterized by:

- Advanced Technology and Mathematics
- Institutional Change – the New Concept of Enterprise Architecture
- Transportation Connected to other Sociotechnical Systems
- Expanded Role for Stakeholders *and* a Broader Definition of Interested Stakeholders
- "Macro-design" Performance Considerations for the Transportation Enterprise – the "ilities"

The Transportation as CLIOS System Era is Characterized by:

Advanced Technology and Mathematics Enabling…

- Operations Focus
- Tailored Customer Service
- A Rich Information Environment
- A Higher and More Effective Level of Intermodalism Extending into Supply Chain Management
- Large-scale Optimization

The Transportation as CLIOS System Era is Characterized by:

Advanced Technology and Mathematics Enabling… (cont.)

- Disaggregate Demand Analysis
- Real-time Network Control and Provision of Traveler Information
- Vehicle Automation and a Crash-Avoidance Safety Perspective
- Sophisticated Pricing
  - Yield Management
  - Pricing of Externalities
- Regionally-scaled Transportation Operations and Management

The Transportation as CLIOS System Era is Characterized by:

Institutional Change—the New Concept of Enterprise Architecture

- Public Sector Change—among and within levels of government
- Private Sector Change – with new business models and players beyond the traditional ones
- Public/ Private Relationships/ Partnerships

The Transportation as CLIOS System Era is Characterized by:

Institutional Change—the New Concept of Enterprise Architecture (cont.)

- An International/Global Perspective

  and

  The Challenge of Operating Regionally and with Advanced Technology
- The Relationship of Logistics and Supply Chain Management to Regional Strategic Transportation Planning and the Idea of Transportation Investment and Operations as a Means to Enhance Regional Competitive Advantage

The Transportation as CLIOS System Era is Characterized by:

Transportation Connected to other Sociotechnical Systems

- Environment
- Energy
- Economic
- Global Climate Change
- National Defense/ Geopolitics
- Telecommunications

The Transportation as CLIOS System Era is Characterized by:

Expanded Role for Stakeholders *and* a Broader Definition of Interested Stakeholders

- In system definition and representation
- In developing performance metrics
- In developing strategic alternatives
- In considering implementation strategies
- In decision-making

The Transportation as CLIOS System Era is Characterized by:

“Macro-design” Performance Considerations for the Transportation Enterprise---the “ilities”

(in addition to traditional micro-design considerations such as cost, level-of service (LOS) variables such as price, travel time, service reliability, service frequency, safety….)

- Flexibility
- Adaptability
- Robustness

The Transportation as CLIOS System Era is Characterized by:

"Macro-design" Performance Considerations for the Transportation Enterprise---the "ilities"

- Resilience (the opposite of vulnerability)
- Scalability
- Modularity
- Stability …

The Transportation as CLIOS System Era is Characterized by:

"Macro-design" Performance Considerations for the Transportation Enterprise---the "ilities"

… and, perhaps the most important "ility"

- **SUSTAINABILITY**

  as an overarching design principle– The 3 Es---Economics, Environment and Social Equity

US DEPARTMENT OF TRANSPORTATION STRATEGIC PLAN 2003-2008

"Safer, Simpler, Smarter Transportation Solutions"

KEY ISSUES

- Safety
- Mobility
- Global Connectivity
- Environmental Stewardship
- Security

"Transportation is a strategic investment essential to strengthening the American economy. America needs a fully integrated domestic transportation system as well as safe and efficient connections to the rest of the world."

THE “T-SHAPED” NEW TRANSPORTATION PROFESSIONAL

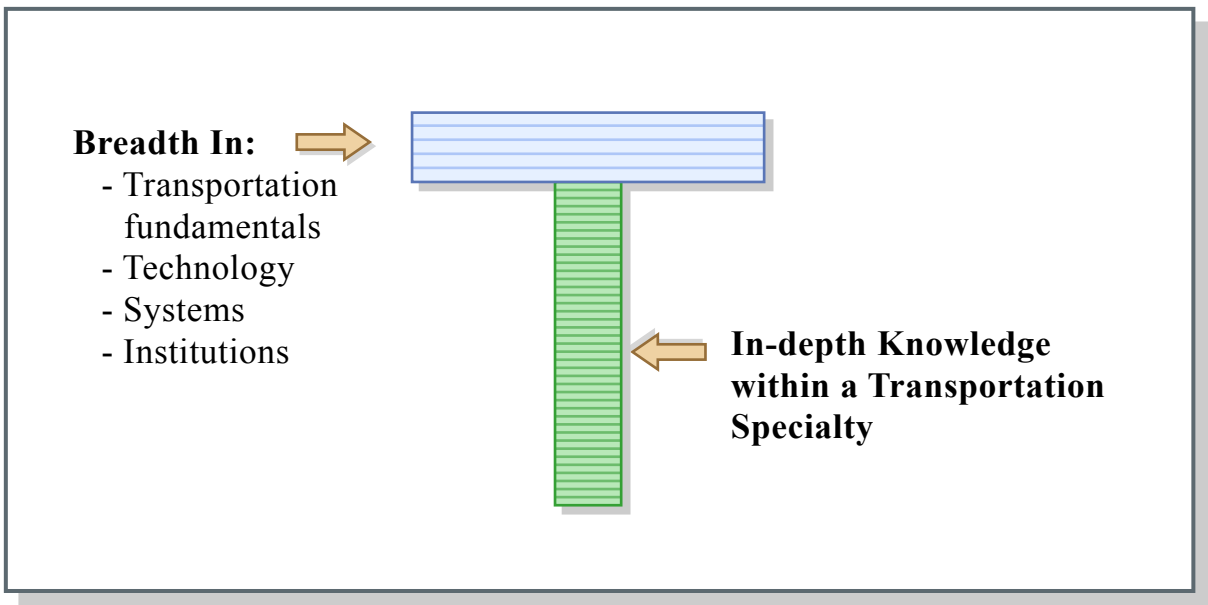


Figure by MIT OCW.

DRIVING FACTORS IN TRANSPORTATION

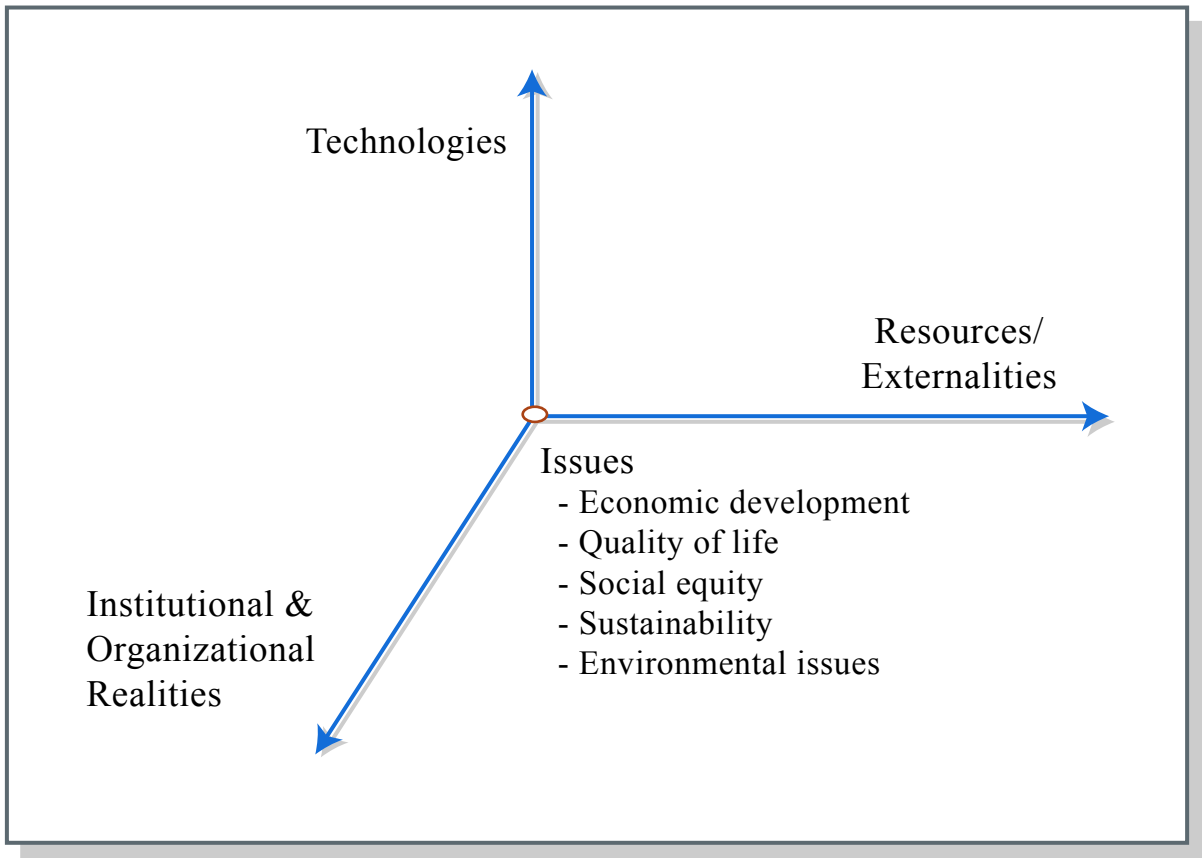


Figure by MIT OCW.

Sussman, Joseph M., "The New Transportation Faculty: The Evolution to Engineering Systems", *Transportation Quarterly*, Eno Transportation Foundation, Washington, DC, Summer 1999.

TRANSPORTATION SYSTEMS CHARACTERIZATION

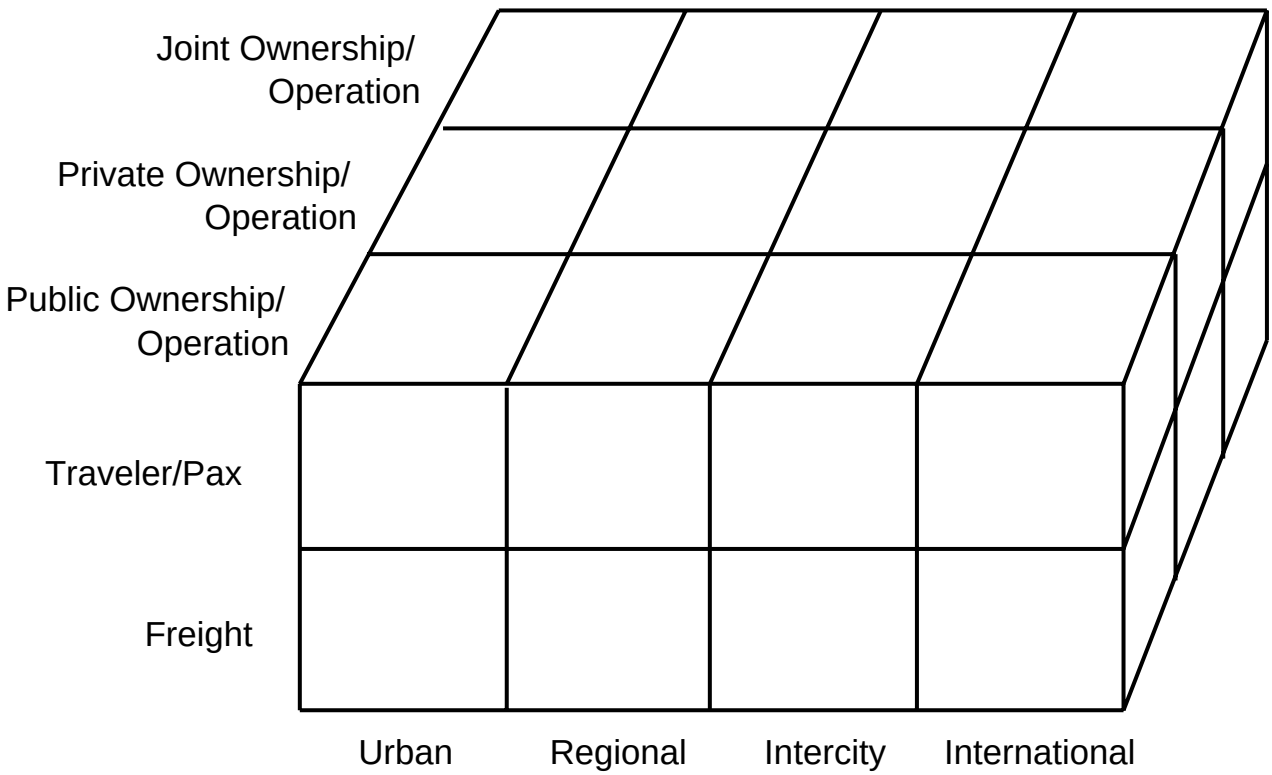


Figure 1.2

Sussman, Joseph M., *Introduction to Transportation Systems,* Artech House Publishers, Boston and London, 2000.