KEYNOTE ADDRESS:
A Regionally-Scaled Intermodal Transportation System for Portugal: Critical Design Considerations for Sustainability in a Changing World

Transportation for a Sustainable Development TDeS‘07

60th Anniversary of the Laboratório Nacional de Engenharia Civil (LNEC)

Lisbon, Portugal, June 21, 2007

Joseph M Sussman
JR East Professor of Civil & Environmental Engineering and Engineering Systems

MIT|Portugal

Overview of Activities in the Transportation Systems Focus Area



MIT|Portugal

$40 Million/5-Year Program of Education and Research

Focus Areas:
Transportation Systems
Energy
Manufacturing
Bioengineering
Engineering Systems



Objectives/Vision

An overarching focus of the MIT/Portugal Transportation Systems Program is the **design of complex large-scale systems that have major societal impact and provide opportunities for sustainable economic development.**

The vision for the transportation component of the MIT/Portugal program is the design of an **integrated, technology-intensive, intermodal transportation system** considering all of the above not as independent modally-oriented transport elements, but rather as an integrated whole.

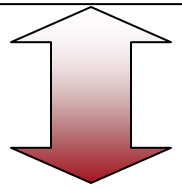
PROGRAM FRAMEWORK

MSc in Leaders for Transportation + Diploma
Complex Transportation Infrastructure Systems: Conceiving, Designing, Integrating, and Operating the Intermodal Transportation Enterprise

Short Courses and Executive Courses

PhD in Leaders for Transportation

Education



Research

Horizontal Subjects – Systems Integration; Strategic Planning for the Regionally-Scaled Integrated Transportation Intermodal Enterprise: Toward Sustainable Development

ITS

ITS: Understanding the Benefits and Costs

New Methods Related to Understanding, Valuing and Deploying ITS

Cross-Cutting Methods:

Real Options Analysis

Design Structure Matrices

Airports

Airports as Complex Systems: Dealing with Uncertainty

High-Speed Rail

Modal, Intermodal Connectivity and Competitive Issues in HSR

Generalized Global Risk Assessment:
Financial Risks
Market Risks
Technology Risks
Safety and Security

High-Speed Rail/Airport Relationship

MPP TRANSPORTATION SYSTEMS FOCUS AREA—ORGANIZATIONAL SCHEMA FOR RESEARCH I

- **RESEARCH PRINCIPLES/ GOALS**
  - Complex Systems Approach
  - Intermodal, Integrated Approach
  - Technology Intensive Systems
  - Sustainability as an overarching design principle
  - Advance Understanding in TR SYS field
  - Solid research content of value in Portugal
  - Contribute to Portugal's Economic Development Strategy

MPP TRANSPORTATION SYSTEMS FOCUS AREA—ORGANIZATIONAL SCHEMA FOR RESEARCH II

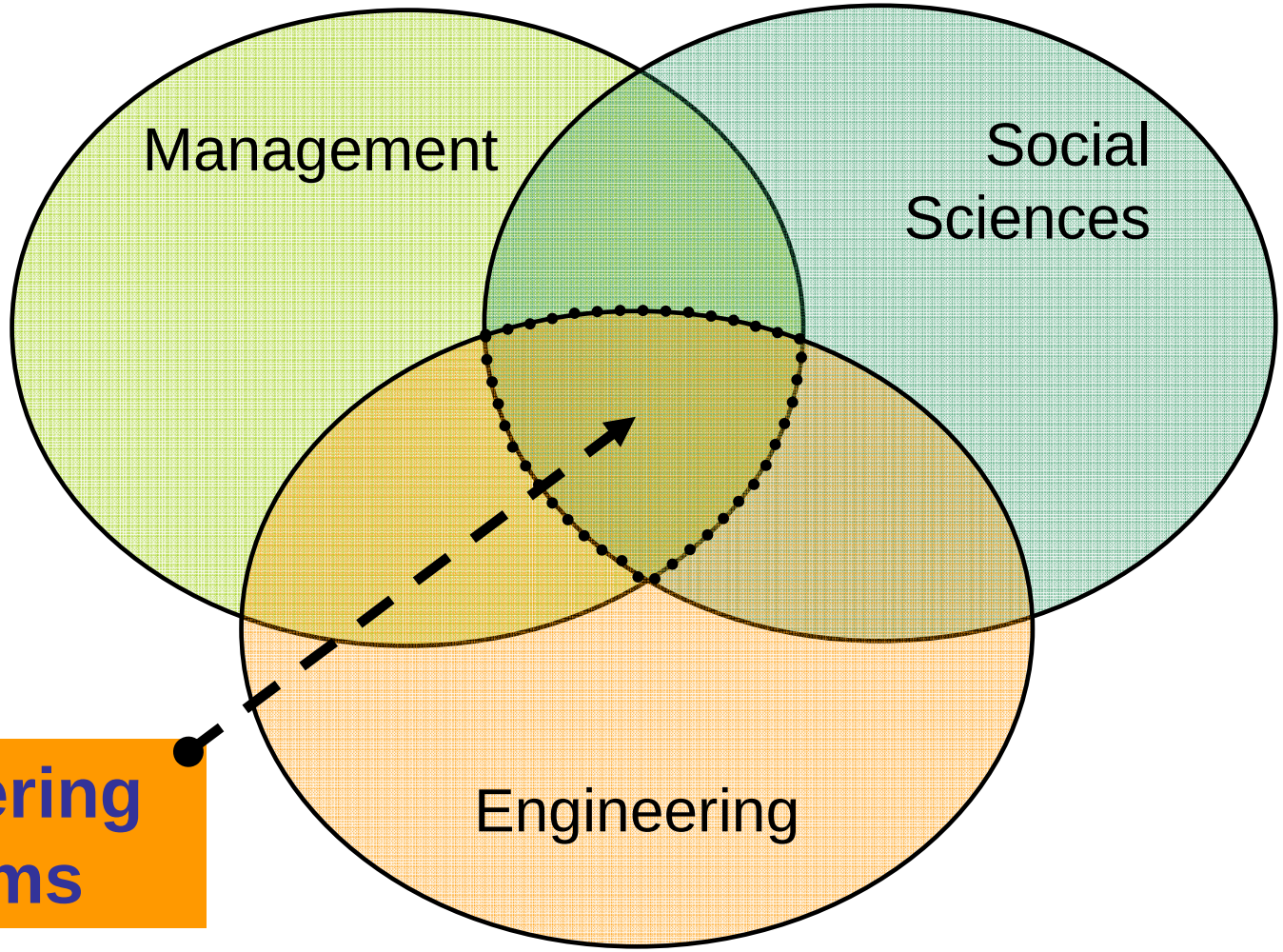
- **RESEARCH PRINCIPLES/ GOALS (Cont.)**
  - Connection to Other Focus Areas
    - -Energy
    - -EDAM
  - Advance TR SYS-related Methods
    - Real Options Analysis
    - Design Structure Matrices
    - Enterprise Architecting
    - Agent-based modeling
    - System Dynamics
    - CLIOS Process

WHERE TRANSPORTATION IS GOING:
Transportation in the CLIOS System Era

- What is the context within which the MPP Transportation Systems Research and Education program is taking place?

ENGINEERING SYSTEMS

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



C L I O S System

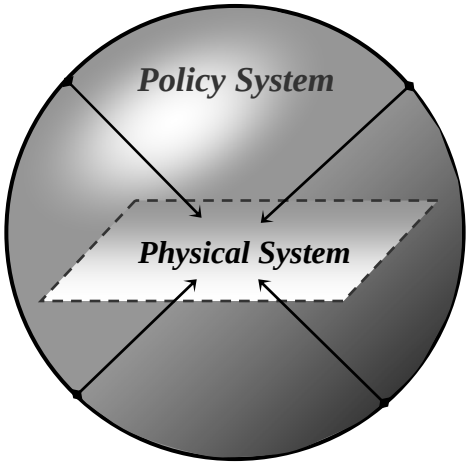
- Complex
- Large-scale
- Interconnected
- Open
- Socio-technical

C L I O S System

Complex

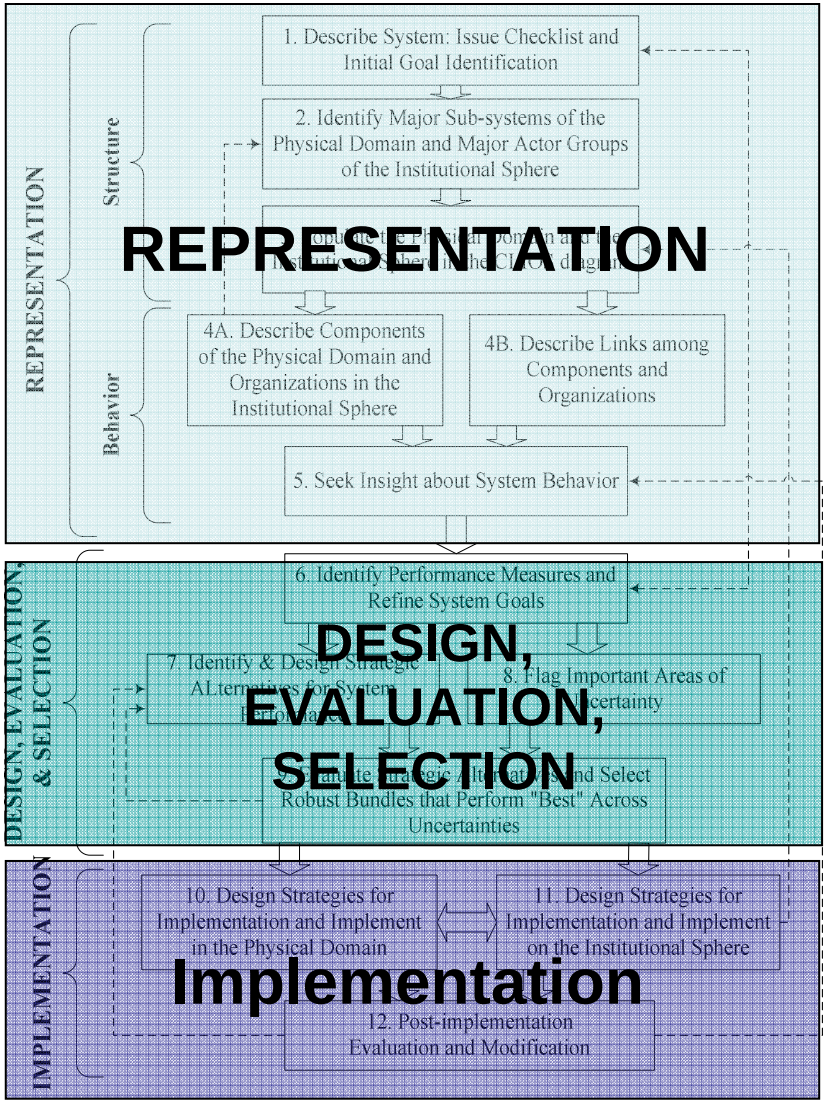
- *Structural complexity*
  - The number of components in the system and the network of interconnections between them
- *Behavioral complexity*
  - The type of behavior that emerges due to the manner in which sets of components interact
- *Evaluative complexity*
  - The competing perspectives of stakeholders who have different views of "good" system performance
- *Nested Complexity*
  - The interaction between a complex "physical" domain and a complex "institutional" sphere

Nested Complexity



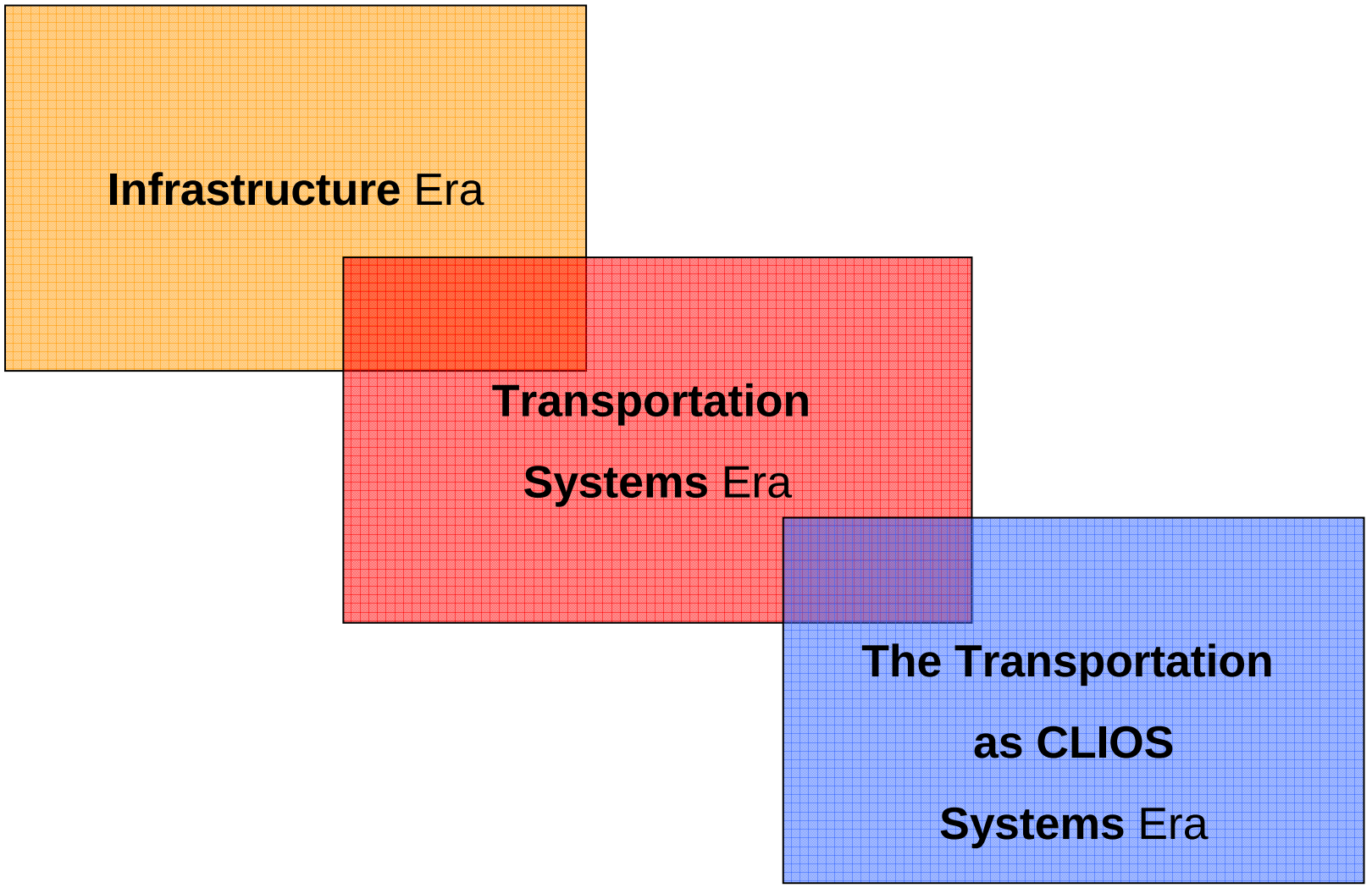
- Physical system “layer”
  - More quantitative principles
  - Engineering & economic models
- Policy system “sphere”
  - More qualitative in nature and often more participatory
  - Stakeholder evaluation and organizational analysis
- Different methodologies are required
  - within the physical system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

The CLIOS Process



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

Transportation Eras



Infrastructure Era

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

Transportation Systems Era

- 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)

The Transportation as CLIOS System Era

Focused on transportation as a

Complex, **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
- 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

Objectives/Vision

An overarching focus of the MIT/Portugal Transportation Systems Program is the **design of complex large-scale systems that have major societal impact and provide opportunities for sustainable economic development.**

The vision for the transportation component of the MIT/Portugal program is the design of an **integrated, technology-intensive, intermodal transportation system** considering all of the above not as independent modally-oriented transport elements, but rather as an integrated whole.

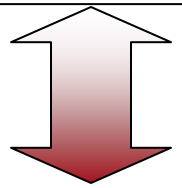
PROGRAM FRAMEWORK

MSc in Leaders for Transportation + Diploma
Complex Transportation Infrastructure Systems: Conceiving, Designing, Integrating, and Operating the Intermodal Transportation Enterprise

Short Courses and Executive Courses

PhD in Leaders for Transportation

Education



Research

Horizontal Subjects – Systems Integration; Strategic Planning for the Regionally-Scaled Integrated Transportation Intermodal Enterprise: Toward Sustainable Development

ITS

ITS: Understanding the Benefits and Costs

New Methods Related to Understanding, Valuing and Deploying ITS

Cross-Cutting Methods:

Real Options Analysis

Design Structure Matrices

Airports

Airports as Complex Systems: Dealing with Uncertainty

High-Speed Rail

Modal, Intermodal Connectivity and Competitive Issues in HSR

Generalized Global Risk Assessment:
Financial Risks
Market Risks
Technology Risks
Safety and Security

High-Speed Rail/Airport Relationship

Thanks for your attention!