High-Speed Rail Research: Activities of MIT's Regional Transportation Planning and High-Speed Rail Research Group

March 26, 2013

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Massachusetts Institute of Technology
Engineering Systems Division

MIT Regional Strategies/ High-Speed Rail Group I

- Measuring productivity of HSR under various institutional structures
  - Public vs. Private Ownership
  - Vertical Separation vs. Vertical Integrattion
- HSR in Portugal
  - Regional development: The concept of mega-regions
  - The relationship of urban transportation/ planning to intercity HSR

MIT Regional Strategies/ High-Speed Rail Group II

- HSR in the Northeast Corridor of the U.S.
  - Incremental- vs. International-quality HSR
  - Various organizational options
  - Opportunities for further economic development in an already very developed region
  - Environmental and energy implications

Critical Contemporary Issues (CCI)

- Global Climate Change
- Energy/Environment
- Developing Country Megacities
- Global Economy
- National Security
- Productivity
- Mobility and so forth

Two Linked Concepts

CRITICAL CONTEMPORARY ISSUES

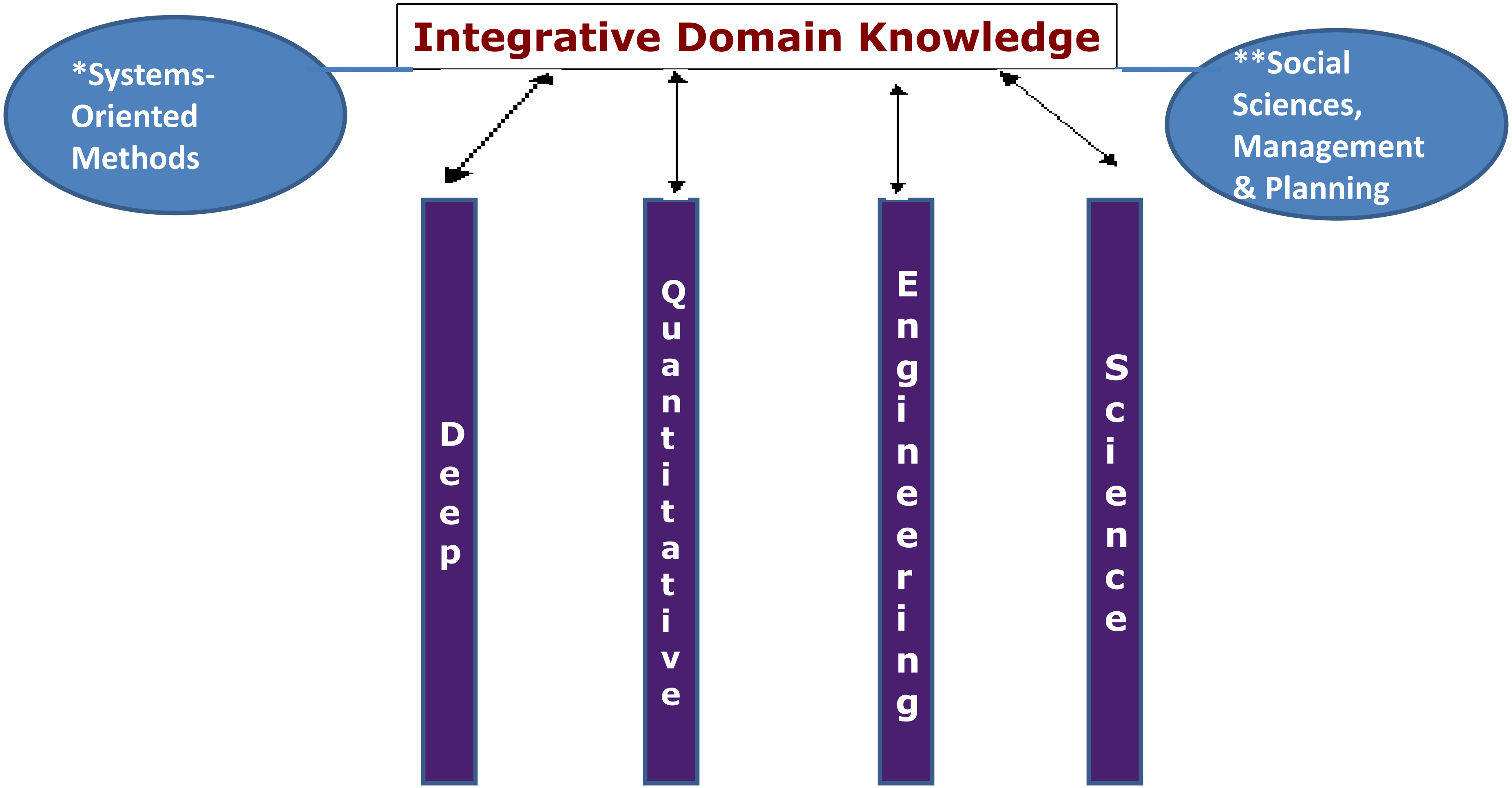
AND

COMPLEX SOCIOTECHNICAL SYSTEMS

Complex Sociotechnical Systems

- *Technologically enabled* networks which transform, transport, exchange and regulate Mass, Energy and Information
- *Large-scale*
  - large number of interconnections and components
- *Sociotechnical aspects*
  - social, political and economic aspects
- *Exhibit Nested complexity*
  - technical complexity nested within institutional complexity
- *Exhibit Evaluative complexity*
  - *Recognize different views of various stakeholders*
- *Dynamic*
  - involving multiple time scales, uncertainty & lifecycle issues
- They require deeply rigorous quantitative and qualitative approaches

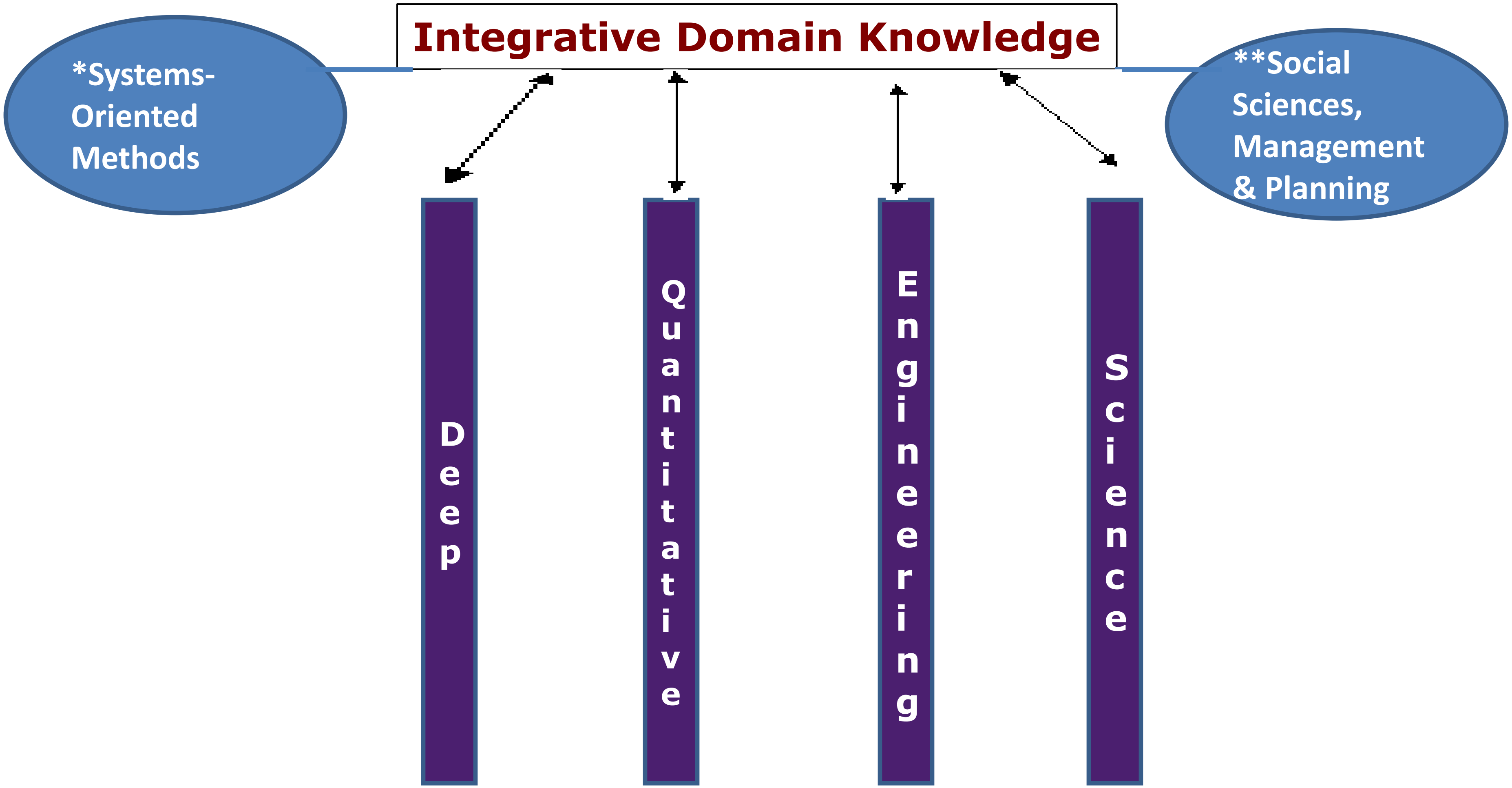
An Approach to the Study of Complex Sociotechnical Systems



Beyond “Study” to “Design”

- We are not simply observers
- Our Complex Sociotechnical Systems are purposeful
- We have a normative view – what does good performance mean?
- We have a prescriptive view – how do we make our system perform better?

An Approach to the *Design* of Complex Sociotechnical Systems



"Work, however, cannot be defined in terms of the disciplines. End results are interdisciplinary of necessity." Drucker

TRANSPORTATION IN THE NORTHEAST CORRIDOR OF THE U.S.: A MULTIMODAL AND INTERMODAL CONCEPTUAL FRAMEWORK

Research Performed for the Institution for Transportation Policy Studies, Japan International Transport Institute (JITI)

Northeast Corridor of the U.S. – What more can possibly be learned?

- MIT's approach– treat the NEC as a complex sociotechnical system (CSS)

Methodology

1. CLIOS Process: Conceptual Framework -- Physical Domain embedded in an Institutional Sphere
2. Scenario Planning: Scenarios are "stories about the way the world might turn out", but not predictions of the future nor extrapolations of the past
3. Flexibility – 'Real Options': Flexibility allows decision-makers to respond dynamically to different realizations of the future

Motivation and Objective

Motivation
- The Obama administration is the first U.S. administration that has made HSR a national priority
- The nascent field of engineering systems as studied in the ESD of MIT presents the possibility of looking at the NEC with new methods that could possibly lead to further insights about how one might go about improving mobility.

Objective
-Apply new and innovative methods in the engineering systems field to seek new insights.
-Platform for further study.

Source: Sussman

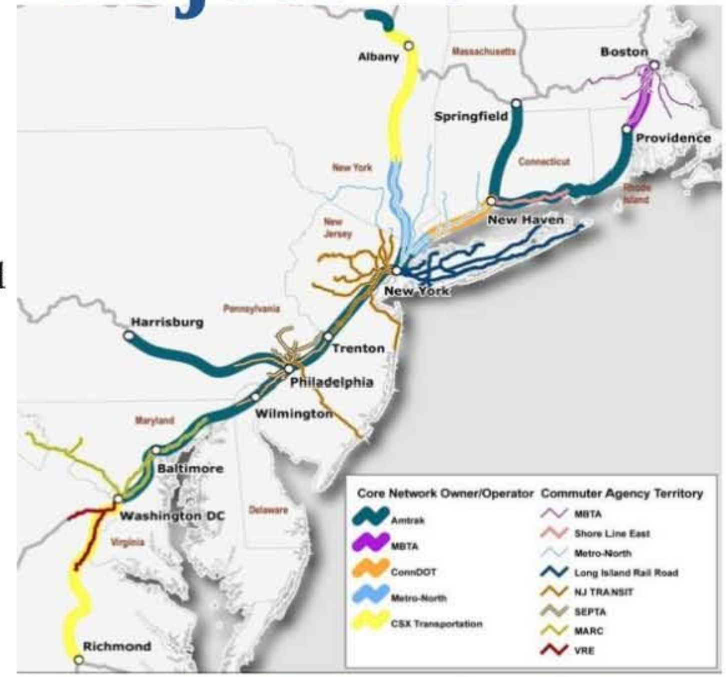


Figure 1: Map of Northeast Corridor rail infrastructure owners and passenger rail operators (Source: NEC Infrastructure Master Plan Working Group 2010)

Source: FRA website, Designated High Speed Rail corridors

Context I

- The Northeast Corridor (NEC) is the most densely settled and richest region in the US – congested transportation system
- Challenges in upgrading to high-speed rail a multi-state, multi-use and multi-operator corridor

Source: NEC Infrastructure Master Plan Working Group 2010

Context II

- 457 mile-long corridor

- 4 owners
- 9 states

- 13 million intercity rail passengers per year

- Amtrak

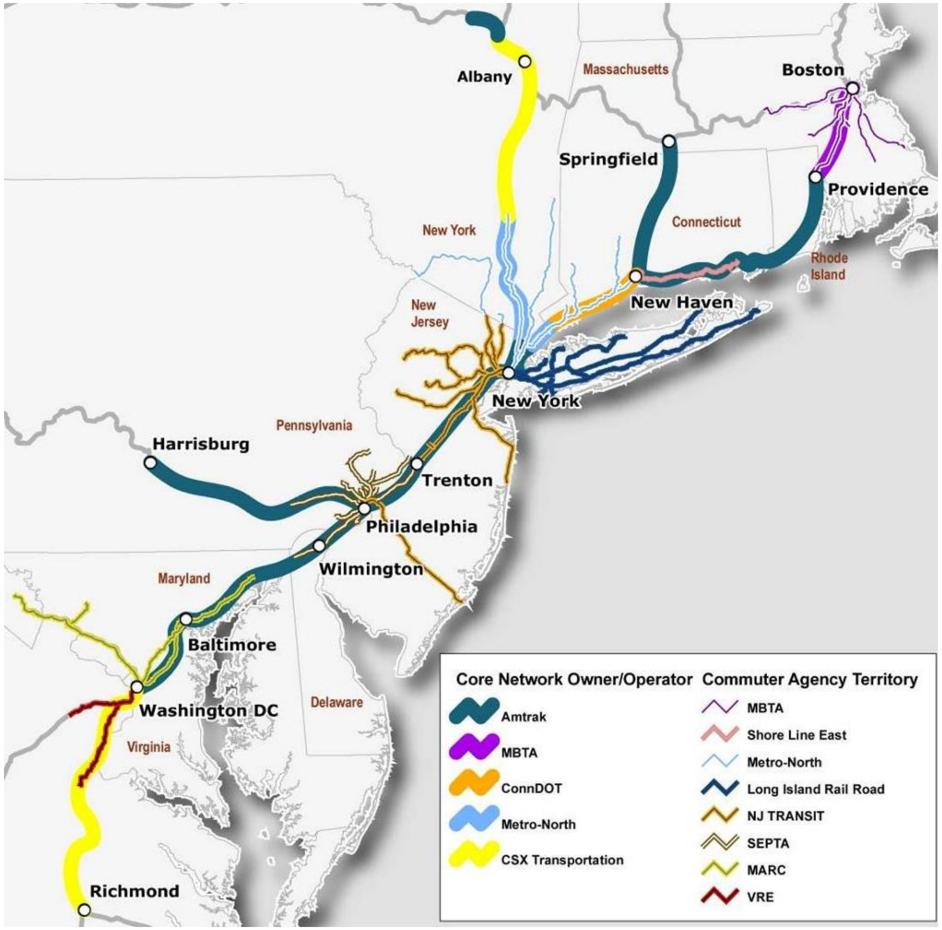
- 250 million commuter rail passengers per year

- 8 agencies

- Freight rail traffic

- 7 companies

Source: NEC Infra. MP 2010



Approach

- New and innovative methods in the engineering systems field to seek new insights about how one might go about improving mobility
- Planning and implementation under uncertainty related to inputs, requirements, and outcomes of the system

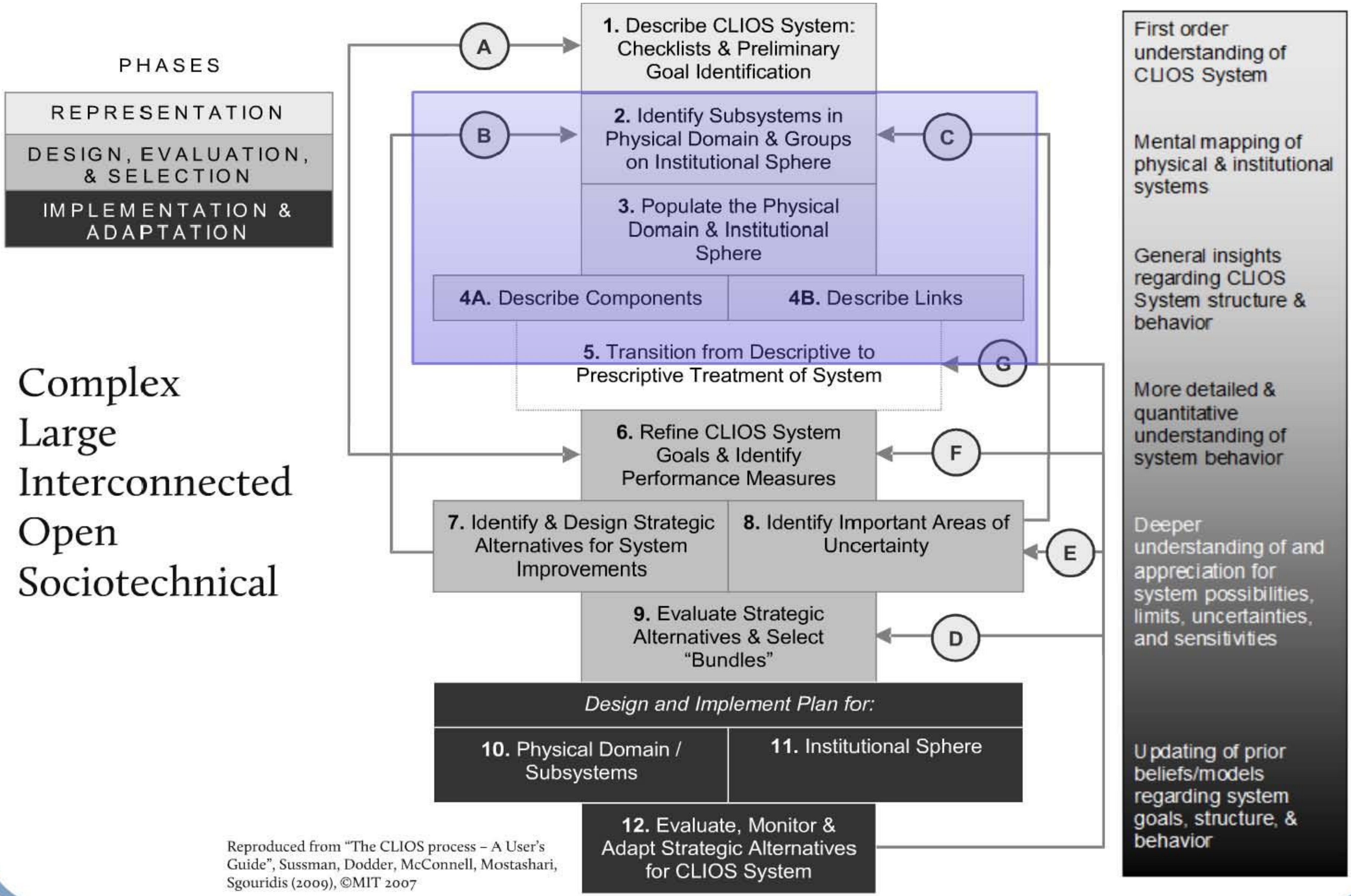
Source: www.theatlantic.com

Complex, Large-Scale, Interconnected, Open, Sociotechnical (CLIOS) Systems

A CLIOS (Complex, Large-Scale, Interconnected, Open, Socio-Technical) System is characterized as follows:

A CLIOS system has **technology** as an important element – but, by definition, is **socio-technical** in nature, and therefore will almost always exhibit **nested and evaluative complexity**.

The CLIOS Process



Complex
Large
Interconnected
Open
Sociotechnical

Reproduced from "The CLIOS process – A User's Guide", Sussman, Dodder, McConnell, Mostashari, Sgouridis (2009), ©MIT 2007

Stages of the C L I O S Process

- Representation
- Design, Evaluation and Selection: Create ***bundles of strategic alternatives***
- Implementation

Distinction between CLIOS Process and specific methods (models and frameworks)

1. Representation

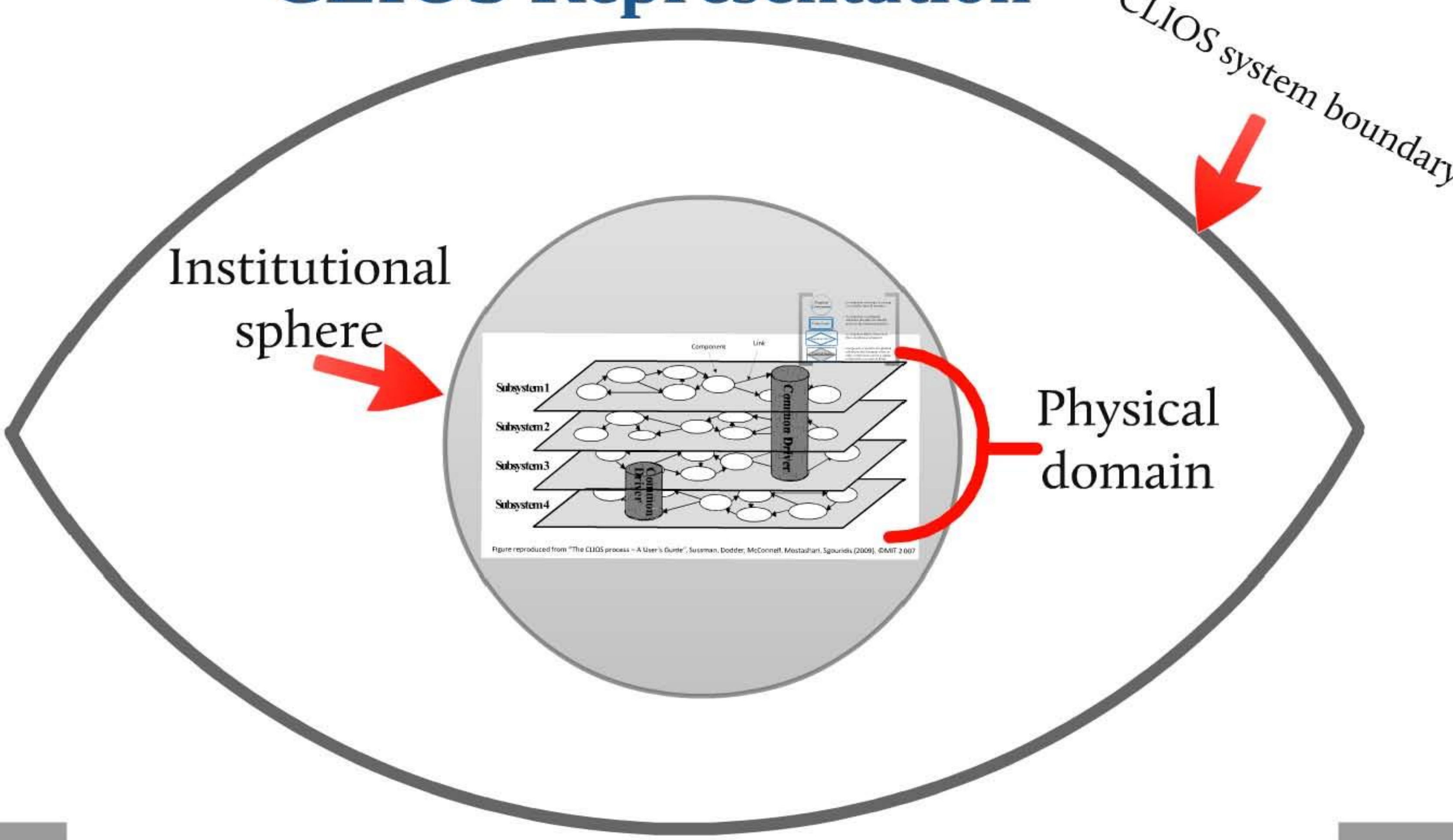
"Defining the problem may be the most important element in making effective decisions ... The right answer to the wrong problem is very difficult to fix … once the problem has been correctly defined, the decision itself is usually pretty easy." Drucker.

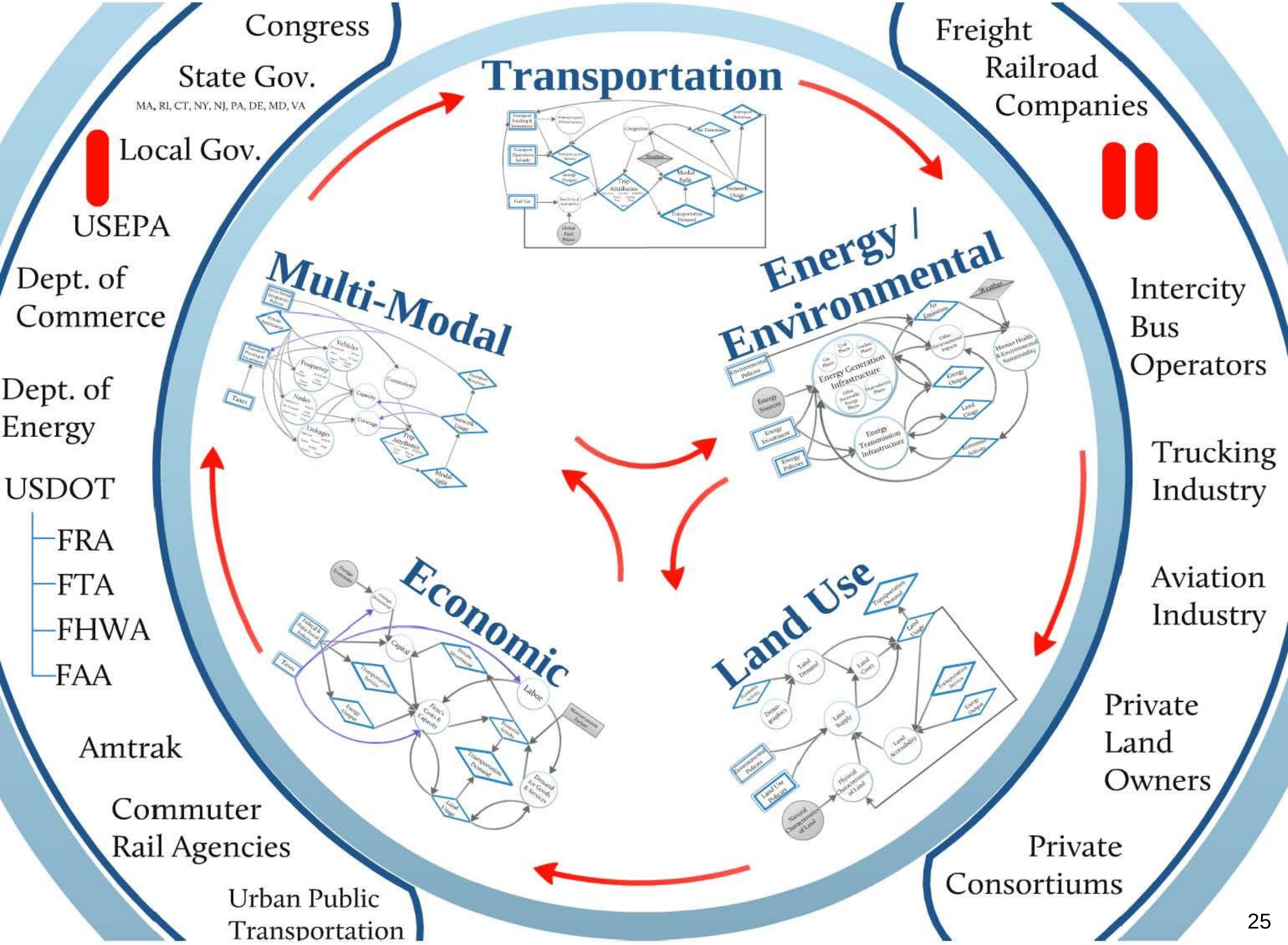
2. Design, Evaluation and Selection: develop bundles of strategic alternatives and select among them

3. Implentation: develop bundles of strategic alternatives and select among them

Implicitly, there is iterative behavior throughout

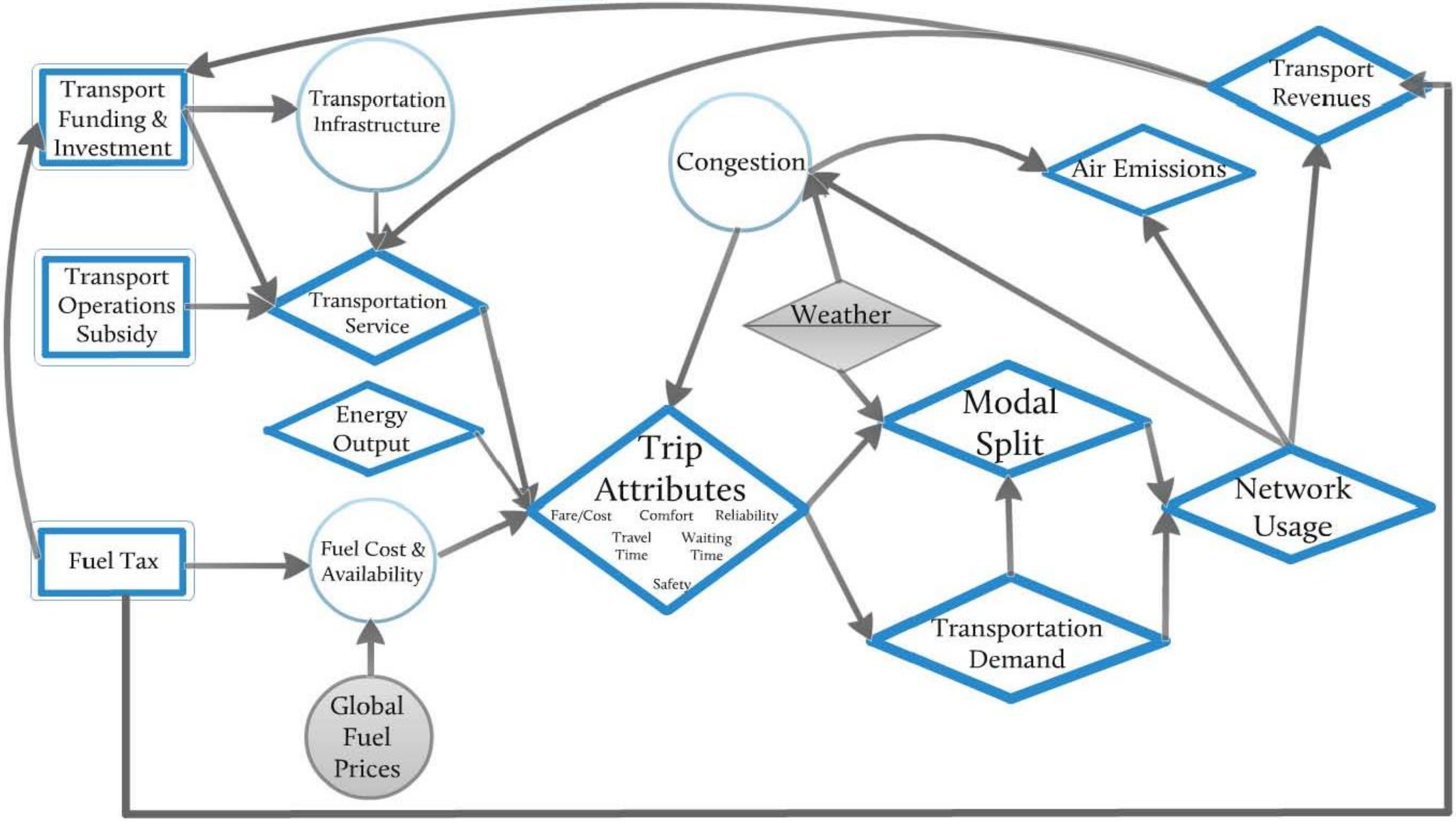
CLIOS Representation



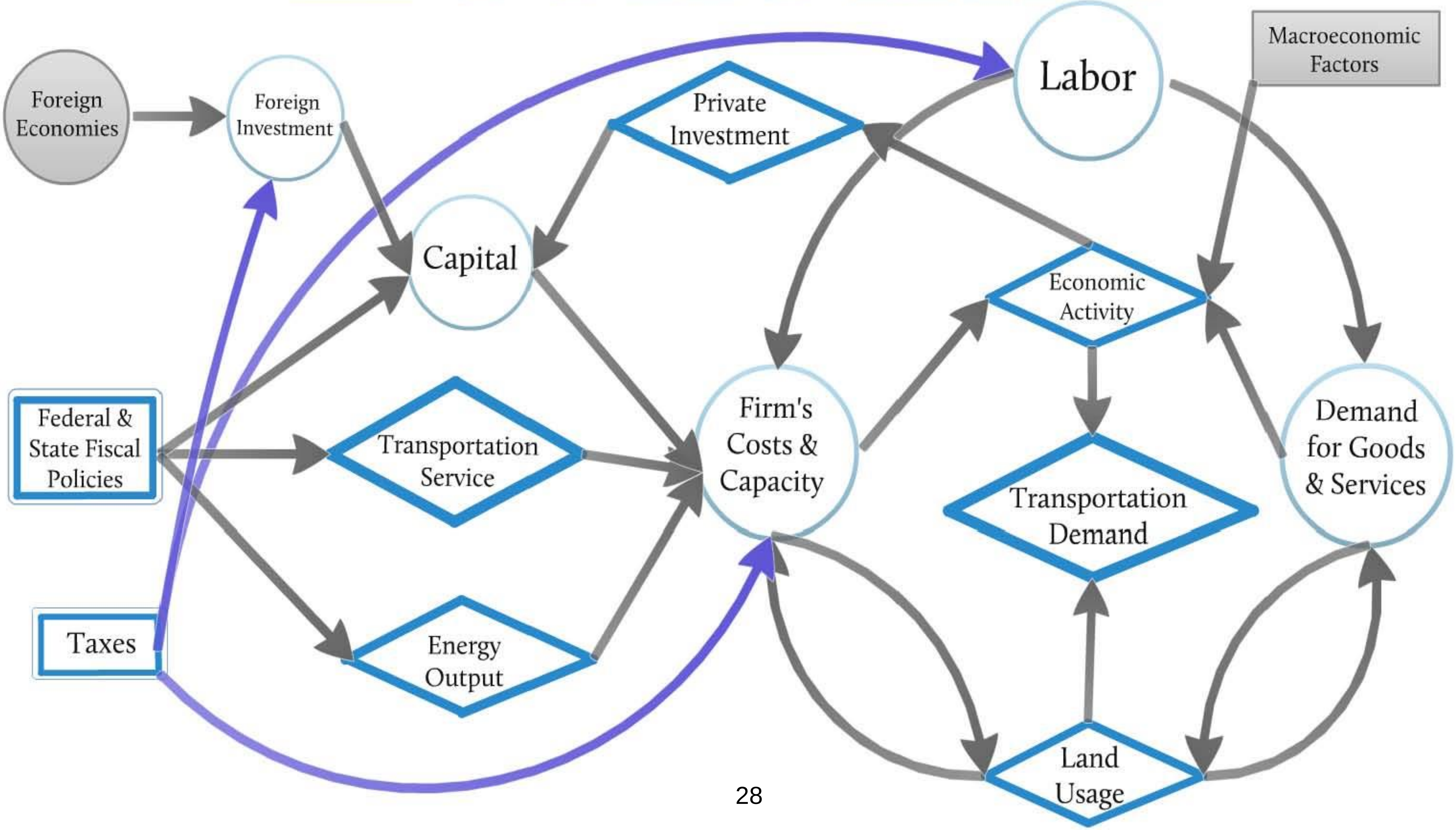

Congress
State Gov.
MA, RI, CT, NY, NJ, PA, DE, MD, VA
Local Gov.
USEPA
Dept. of Commerce
Dept. of Energy
USDOT
FRA
FTA
FHWA
FAA
Amtrak
Commuter Rail Agencies
Urban Public Transportation
Freight Railroad Companies
Intercity Bus Operators
Trucking Industry
Aviation Industry
Private Land Owners
Private Consortiums
Transportation
Energy / Environmental
Land Use
Economic
Multi-Modal

"The characteristic of the innovator is the ability to envisage as a system what to others are unrelated, separate elements." Drucker

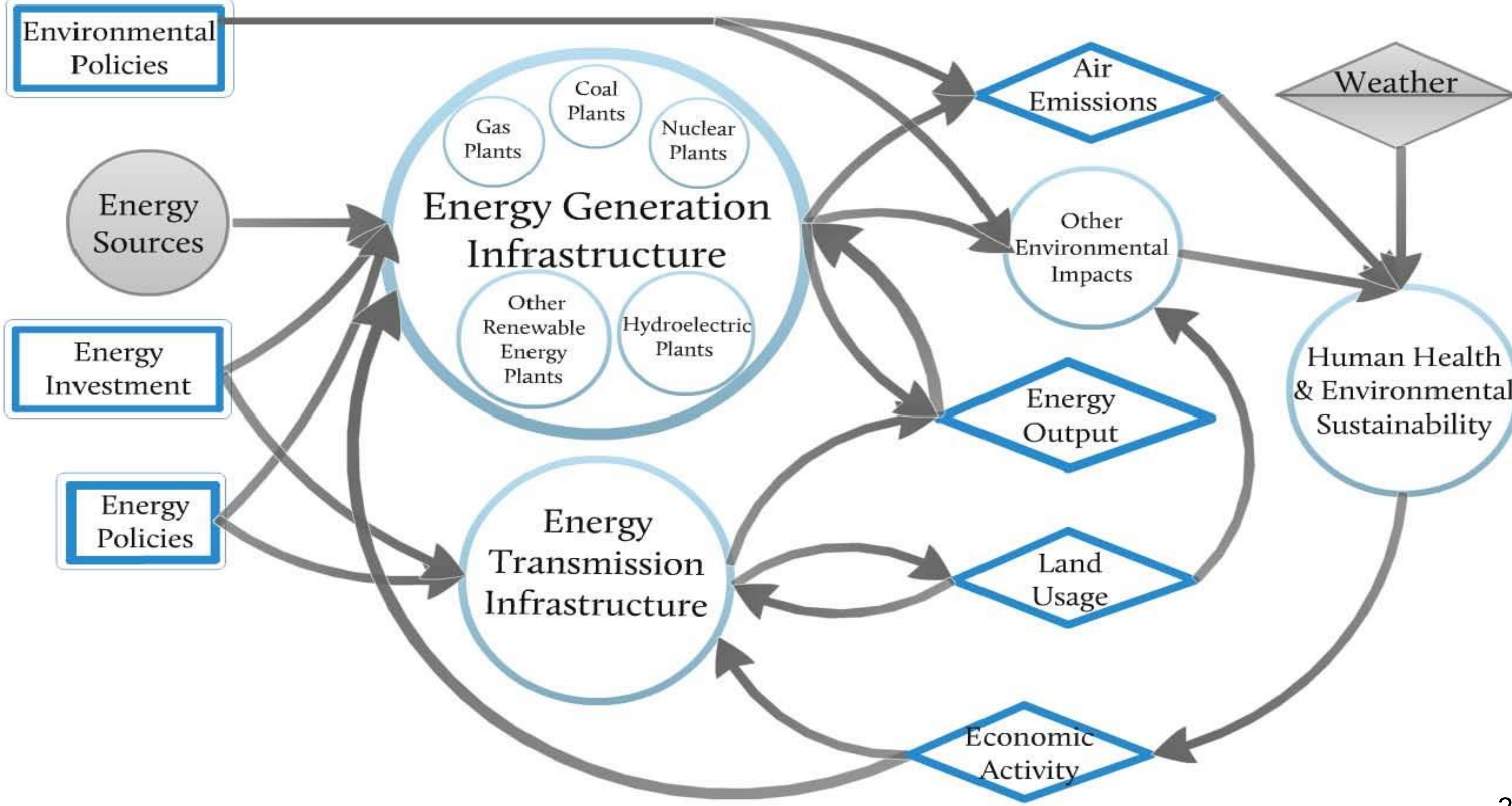
Transportation



Economic


Foreign Economies
Foreign Investment
Private Investment
Labor
Macroeconomic Factors
Capital
Economic Activity
Federal & State Fiscal Policies
Transportation Service
Firm's Costs & Capacity
Demand for Goods & Services
Transportation Demand
Taxes
Energy Output
Land Usage

Energy / Environmental



Complexity

Complexity

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

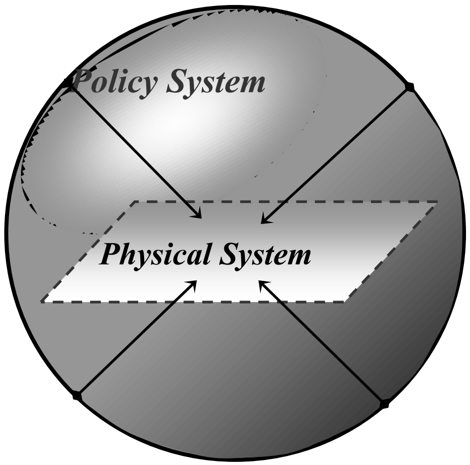
Evaluative complexity

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
- Institutional "sphere"
  - More qualitative in nature and often more participatory
  - Stakeholder evaluation and organizational analysis
- Different methodologies are required
  - within the physical system
  - between the institutional sphere and the physical system
  - within the institutional sphere

CLIOS System/Process Ideas I

- Sustainability as an overarching design principle for CLIOS Systems
- Separate “organizations” from other components -- CLIOS System world view
- Distinguish between representation and modeling

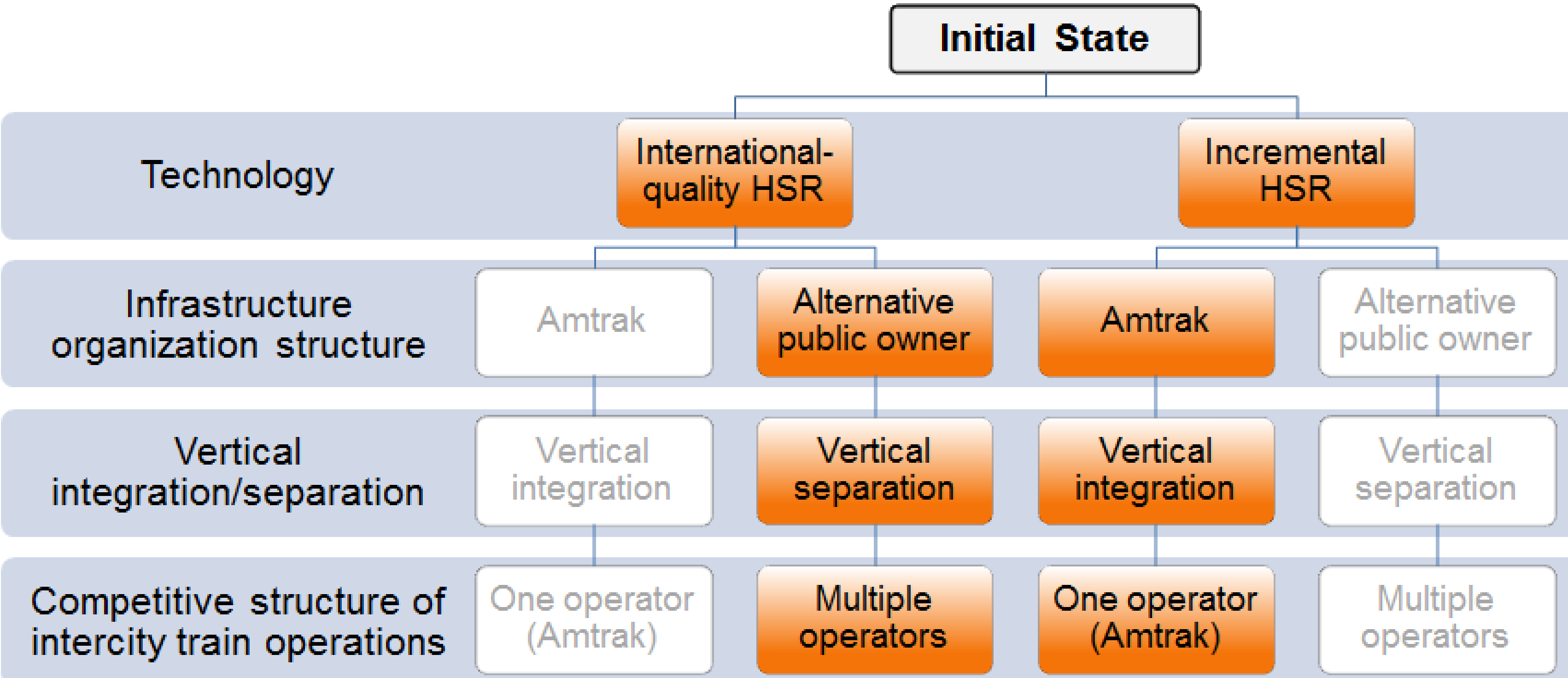
  Representation related to visualization

  Think carefully about when to quantify – when to “model”
- Recognize different kinds of complexity
- Emphasis on dealing with uncertainty

CLIOS System/Process Ideas II

- Emphasis on stakeholder roles
- Strategic alternatives
- Robust bundles of strategic alternatives
- Strategic alternatives are needed for implementation as well
    - In the physical domain
    - On the institutional sphere -- change management
- Monitoring the outcomes is central to the CLIOS Process
- The CLIOS Process as iterative among all the stages

Bundles of Strategic Alternatives



Motivation for Flexibility

- One overarching conclusion: **Uncertainty dominates**
  - Demand for high-speed rail is uncertain
  - There may be changes in the fuel tax in structure and magnitude
  - What will be the pricing mechanism for high-speed rail? (does the gov't intend to recoup infrastructure costs?)
  - Is there sufficient patience in the political process?
  - Will there be intermodal cooperation between aviation industry and high-speed rail… etc. etc.

Achieving flexibility by the application of "Real Options"

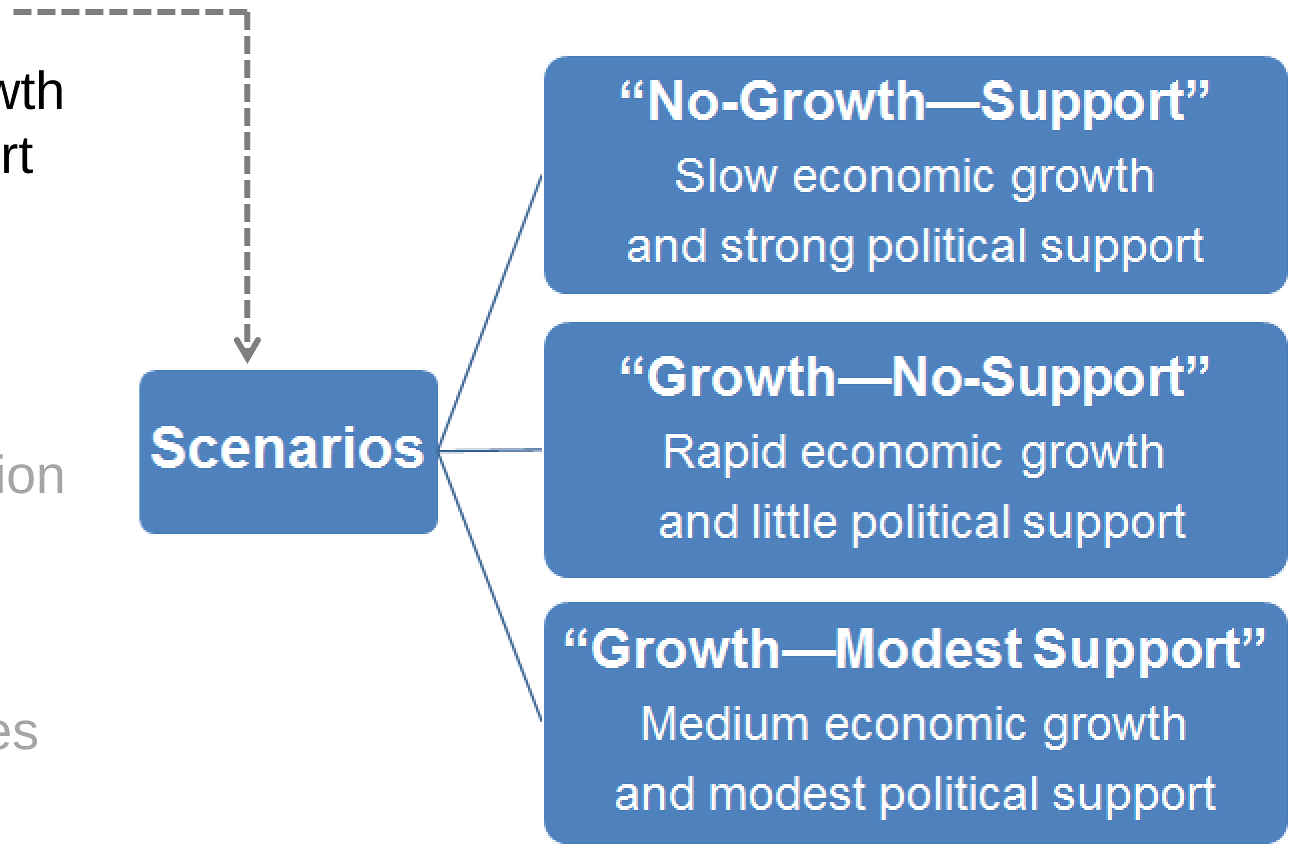
- We identified three categories of desired flexibility:
- Institutional flexibility
- Technological flexibility
- Intermodal-connectivity flexibility

Three Scenarios

Driving forces

- economic growth
- political support

- congestion
- technological change
- public perception
- environmental changes
- energy
- funding sources
- multimodal cooperation



Acknowledgements

- Japan International Transport Institute (JITI)
- US DOT University Centers Program
- Speedwell Foundation
- My graduate students current and past: Andrés Archila, Joel Carlson, Maite Peña-Alcaraz, Naomi Stein, Ryan Westrom, (Dr.) Regina Clewlow and Ryusuke Sakamoto
- Post-doctoral associate: Dr. Travis Dunn
- Visitors: Henning Colesman-Freyberger (DB), Taede Tillema (Gronengin)

Thanks for your attention!

Questions or Comments?