Comparing and Contrasting Health and Transportation as Complex Sociotechnical Systems

Sociotechnical Systems Research Center (SSRC) Series
Conversations on Sociotechnical Systems
September 4, 2013

Joseph M. Sussman
JR East Professor of Engineering Systems and Civil and Environmental Engineering
Ideas about Complex Sociotechnical Systems

• April 2012- *Miller Lecture*— Complex Sociotechnical Systems: The Case for a New Field of Study

• February 2013 – *Inaugural SSRC Distinguished Lecture*: Developing Processes for Understanding Complex Sociotechnical Systems: Are We There Yet?

• September 2013 – *SSRC Series – Conversations about Sociotechnical System*: Comparing and Contrasting Health and Transportation as Complex Sociotechnical Systems
Two Linked Concepts

CRITICAL CONTEMPORARY ISSUES

and

COMPLEX SOCIOTECHNICAL SYSTEMS
Systems

- Composed of interconnected components and subsystems
- Often structured in a hierarchical manner
- Usually Interacts with the environment external to it
Sociotechnical

• Containing technology subsystems and components central to its performance and

• Having societal/political/economic relevance and impact
An Approach to the Design of Complex Sociotechnical Systems

*Systems-Oriented Methods

Integrative Domain Knowledge

**Social Sciences, Management & Planning

- Deep
- Quantitative
- Engineering
- Science
Integrative View of the Field

• Transportation
  • Economic Development, Energy, Environment, Land Use, Urban and Regional Structure, Public Health

• Health
  • Economic Development, Social Equity, Geopolitics, Transportation (Accessibility)
Where the Fields Connect

• Transportation impacts the environment (e.g., air quality) which in turn causes health issues, especially for the elderly and infants.

• Transportation is the means for accessing health services, conventionally and in emergencies.

• Highway safety is a major public health issue in both the “rich” world (death toll in U.S. of 35,000 annually) and the developing world (e.g., see statistics on pedestrian fatalities).
Uncertainty

In Transportation:

• Economy
• Energy Constraints
• Environmental Constraints
• Political Environment

In Health:

• Technology
• Political Environment
• Public Attitudes
• Epidemics
Networks

In Transportation:
• The physical network is central to transportation–infrastructure: highways, railroads, airports...
• Vehicles – cars, buses, trucks, locomotives, aircraft move on the network carrying people, freight.

In Health:
• The network is often virtual
• “Patients”, information flow
• A redefinition: care coming to the patient
In Transportation:

- Intelligent Transportation Systems (ITS) – changed the focus from low-tech infrastructure to high-tech infrastructure, smart vehicles and operations
- The “death” of the Highway Trust Fund and the need for new funding mechanisms like road pricing
- The public/private partnership

In Health:

- The Affordable Care Act (ACA)
- The recognition that you don’t need a doctor for everything!
- A variety of forms of care delivery
Nested Complexity

- Physical system
  - 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
System of Systems (SoS)

In Transportation:

• An example is the PhD dissertation of Nirav Shah, September 2012.

• The component systems are railroads and truckers competing and yet cooperating to move intermodal containers.

In Health:

• Work by Fradinho, Nightingale and Fradinho – studying a hospital as an SoS – comparing a hospital in the U.S. with one in the U.K.

• Another idea: consider multiple hospitals in the same city as a SoS.
Mitigation vs. Avoidance

In Transportation:

Mitigation

• Crashworthy cars.

• Good emergency response – get people to the hospital fast to an ED that is ready for them – Horan’s work on CrashHelp

Avoidance

• V2V communication– avoid crashes in the first place

In Health:

Mitigation

• Get people better

Avoidance

• Wellness – keep people healthy

• Vaccinations
People Making “Rational” Choices → System → Performance

Predicting Demand

In Transportation:
Demand is a function of multi-dimensional service quality; it is driven by economic factors – no job, less travel; multiple trip purposes; multiple mode choices; driven by land use, which changes slowly; relates to supply chain management (for freight).

In Health:
• Demand is a function of demographics, community health, access to care.
• Social Attitudes
• Public Health Initiatives
  • Smoking
  • Obesity
Congestion

- In transportation we know that the quality of service on a link is a function of the volume/capacity ratio – the well-known hockey stick – as volume approaches capacity, travel time increases in a non-linear fashion.

In health, the same occurs – e.g., *Stress on the Ward: Evidence of Safety Tipping Points in Hospitals*, Kuntz, et al.– “Do hospitals experience safety tipping points as utilization increases? What are the implications for hospital operations?”
Cost vs. Service Quality: The Imperative to Lower Costs Without Service Degradation
Costs vs. Service Quality

In Transportation:
The BMW is “the ultimate driving machine” – that doesn’t mean we think it is inequitable if everyone doesn’t have access to one.

In Health:
Everyone deserves access to the best available and deployed technology. That is what social equity means.
In Transportation:

If a high-technology, high-performance and expensive alternative is available – say, high-speed rail – we may choose not to deploy it – say, in the U.S.

In Health:

If a high-technology, high-performance and expensive alternative is available – say, a better chemotherapy treatment for cancer – there is a moral imperative to deploy it...... *let me get this straight. We are not going to give our patients this life-saving new treatment because it is too expensive?!*
System Safety as an Emergent Property

In Transportation:

• It is not always “pilot error”
• Prince William Sound

In Health:

• Gawande—The Checklist Manifesto
• Hierarchy
Economic Development

In Transportation:
Mobility as a plus but congestion as a minus; enabling the global economy through efficient freight movements; creating an economic drag because of environmental impacts.

In Health:
Costs of care; lost productivity because of illness but creating a longer, more productive “life-cycle” for many individuals; a recession-proof source of jobs – the “Louisville” story.
THE “T-SHAPED” NEW TRANSPORTATION PROFESSIONAL

Breadth in:
- Transportation
  - Fundamentals
  - Technology
  - Systems
  - Institutions

In-depth knowledge within a transportation specialty
THE “T-SHAPED” NEW HEALTHCARE PROFESSIONAL

Breadth in:

- Health

Fundamentals
- Technology
- Systems
- Institutions

In-depth knowledge within a health specialty
What does the “T-shaped” professional have?

• Breadth for an integrative “systems” view
• Depth for professional confidence
• An open and curious mind
• Ability to communicate
  – In writing
  – In oral presentations
• Ability to work as a member of a team
• Ability to lead a team (or perhaps an enterprise)
• An ethical sense
Transportation Eras

- Infrastructure Era
- Transportation Systems Era
“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)
“Infrastructure” Era – What’s the Equivalent in Health

• ?
“Transportation Systems” Era – What is the Equivalent in Health

• ?
PRINCIPLES FOR PROCESS FORMATION FOR COMPLEX SOCIOTECHNICAL SYSTEMS
Principles for Process Formation for Complex Sociotechnical Systems

• Keep institutional changes on the agenda (recognizing the difficulties).
• Optimization is a will-o’-the-wisp
  – Too hard to find an optimum
  – Oft-times, not even sure what we are optimizing
• Uncertainty dominates
  – Known unknowns
  – Unknown unknowns
Principles for Process Formation for Complex Sociotechnical Systems

• Understanding structure is vital
  – Don’t rush to quantify
  – There is no silver bullet
  – Bundles of strategies alternatives

• Retain flexibility:
  – “The essence of project leadership is to selectively commit as needed to move projects forward, but to delay costly and irreversible commitments until dominant uncertainties are resolved”. (Lessard and Miller)
Questions and Comments
References

• Sussman, Introduction to Transportation Systems
• Sussman, T-Shaped Professional
• de Weck et al.
• Donofrio, et al. T-Shaped Professional
• Fradinho, Nightingale and Fradinho
• Lessard, et al.