Societal Institutions, Organizational Systems and Individuals in PBIAM

Louise K. Comfort
University of Pittsburgh, Pittsburgh, PA 15260
comfort@gspia.pitt.edu

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Performance-Based Infrastructure Assets Management as a Complex System

- PBIAM involves a diverse set of actors interacting at different scales of performance over time and space
  - Societal institutions: Legislative bodies, executive administrations, judicial authorities
  - Organizational systems: DOTs, engineering firms, civic associations
  - Individuals: Construction managers, transportation analysts, media reporters, business owners, citizens

Challenge to PBIAM

- Maximize performance of this complex system of actors under changing conditions
  - Technical systems are designed and built to serve social needs
  - Yet, management of technical systems is rarely congruent with social needs, capacities and limits that are in continual flux
  - Discrepancies occur between performance of technical system and information used to support decisions that affect social needs
- PBIAM offers a framework for designing and maintaining a resilient, sociotechnical infrastructure system

PBIAM in Theory

- Design and construction of technical infrastructure assets represent a major investment in every nation
- Maintaining and managing these assets require the design and development of organizational infrastructure
- Critical to both is a sociotechnical knowledge base to support decision making among multiple actors
- PBIAM depends upon effective cognition, communication, coordination, and control processes that support information search, exchange, and learning

PBIAM in Practice

- Key tasks in design and implementation of PBIAM
  - Identify existing constraints and possible collaborations:
    - What laws, policies, and procedures govern infrastructure design and construction?
    - Who are the actors – public, private, and nonprofit – engaged in infrastructure construction and management?
    - What are the assumptions and needs of each actor for infrastructure performance?
    - Where are the existing conflicts and potential collaborations among actors?

PBIAM in Practice, continued

- What innovative approaches build sociotechnical capacity in practice?
  - Structural health monitoring:
    - Use data to identify discrepancies between infrastructure goals and actual performance in both technical & organizational systems
  - Network analysis:
    - Identify and track interdependencies among actors in system-wide performance
  - Distributed cognition:
    - Identify types of knowledge, measurement, and inference that are critical for informed, adaptive performance of technical infrastructure in complex, dynamic social and physical environment

PBIAM as a Learning System

- Primary goal for PBIAM:
  - To integrate information and action for a complex set of actors operating at different scales of action over time and space
- Examine organizational cognition, communication, coordination, and control processes
  - Identify systematic processes, instruments for monitoring performance and providing timely feedback to agents
  - Institute timely means of information search and exchange to support interorganizational performance among actors
  - Develop system-wide culture for rapid identification, correction of error in system
  - Track and report status of system to multiple users in real-time to sustain resonance between system and society of users

PBIAM in Research

- Implement testbeds for PBIAM in practice
  - Select key regions of the world that demonstrate critical interdependence in sociotechnical infrastructure systems
  - Design alternative methods of monitoring performance, communication of data, feedback among participants, mobilization of response to threats
  - Simulate performance of actual systems using computational models to estimate effects of conditions, climates under stress
  - Evaluate results to inform management of infrastructure assets for different regions, cultures, societies in global network of transportation

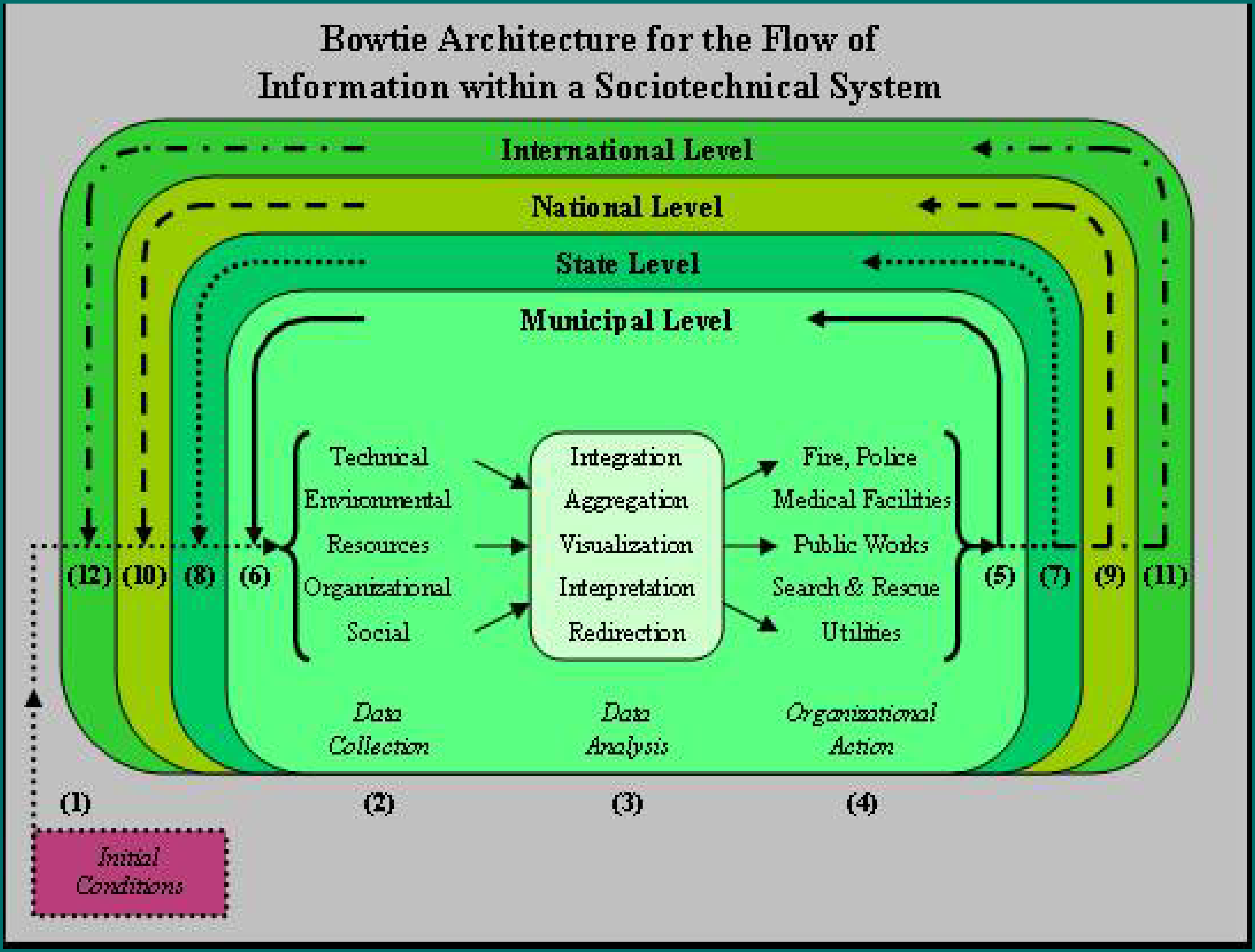
Testbed for PBIAM in Southwestern Pennsylvania

- Challenge: To build a 'common operating picture' for managing transportation in SW PA
- Complex physical, engineered, and social region
  - Six counties, 130 municipalities in Allegheny County alone; PA: 'home rule' state where basic authority rests with localities
  - 3 rivers, 446 bridges in City of Pittsburgh, 1700 in Allegheny County, 35% of which are unsafe
  - Transportation nexus for tri-state region of SW PA, eastern Ohio, northern West Virginia
  - Population: ~3 million in metro region; economy tied to global exchange

Three hypotheses for building regional capacity in transportation system:

- As key actors increase their understanding of responsibilities and constraints on other actors in the transportation system, they improve their capacity to recognize risk to the whole system.
- As timely, valid information is exchanged among key actors in the public transportation system, the system's capacity to mobilize action rapidly in response to specific threats increases.
- As information flow among actors in the public transportation system is disrupted, distorted, or missing, the performance of the system degrades.

Prototype Decision Support System for Regional Transportation



Five specific tasks to achieve goal:

- Conduct a detailed assessment of vulnerabilities and capacities for key actors in a selected transportation region (SHM)
- Map existing patterns of information flow among the actors in the transportation system under three sets of conditions (SNA)
  - 1) normal operations; 2) moderate risk; 3) severe threat, using historical data
- Identify the interdependencies in performance of transportation functions among the actors for the field study region (DC)
  - assess performance of technical structures, organizational processes, and potential weaknesses and strengths of the transportation system
- Design a network of technical sensors, data transmission nodes, links, organizational communication, feedback processes to monitor changing status of vulnerability/capacity of region (All)
- Represent status of regional system in real-time to operational managers with different responsibilities at different locations using an electronic dashboard, www.iisis.pitt.edu

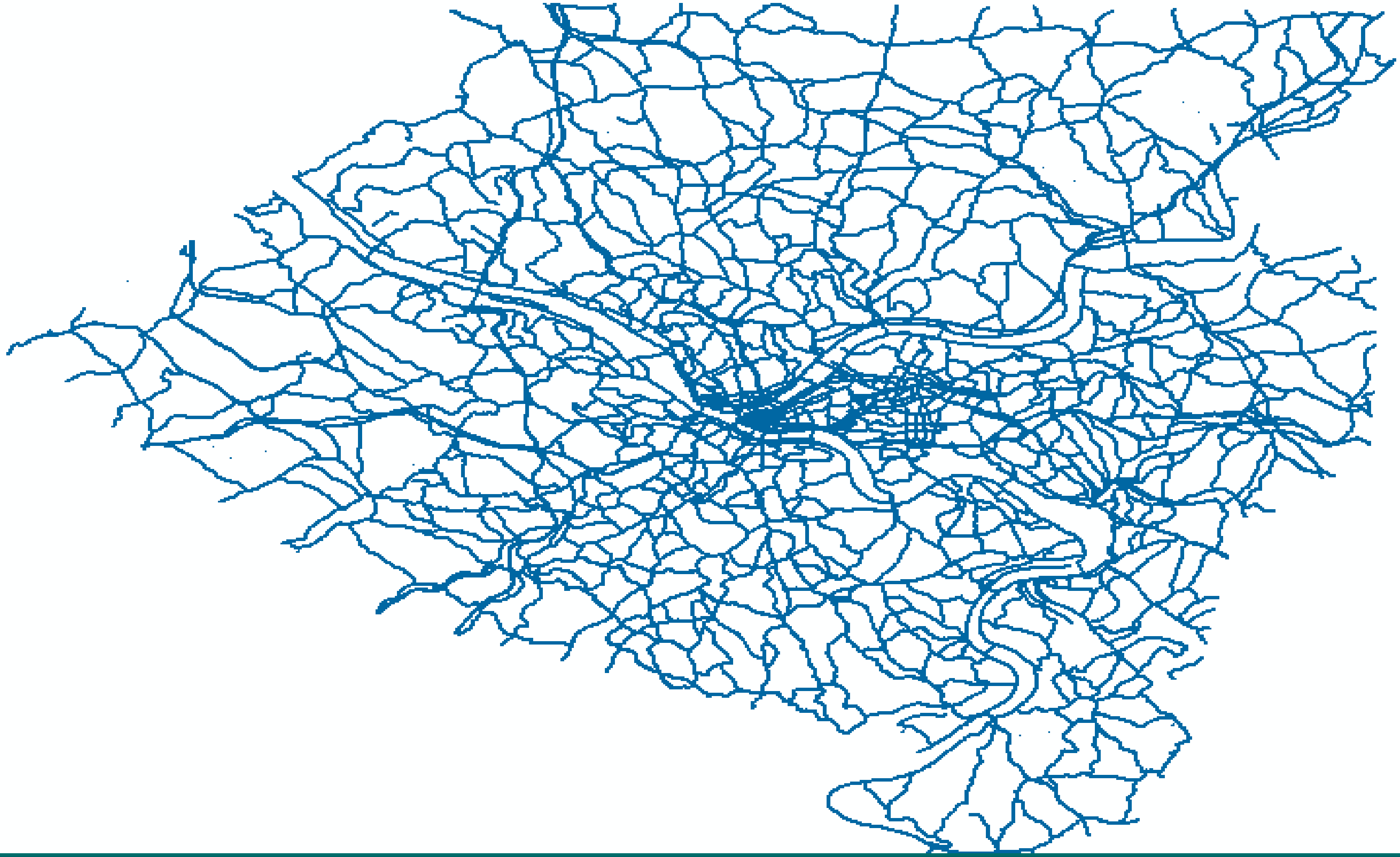


Fig. 2: Highway Network around Pittsburgh

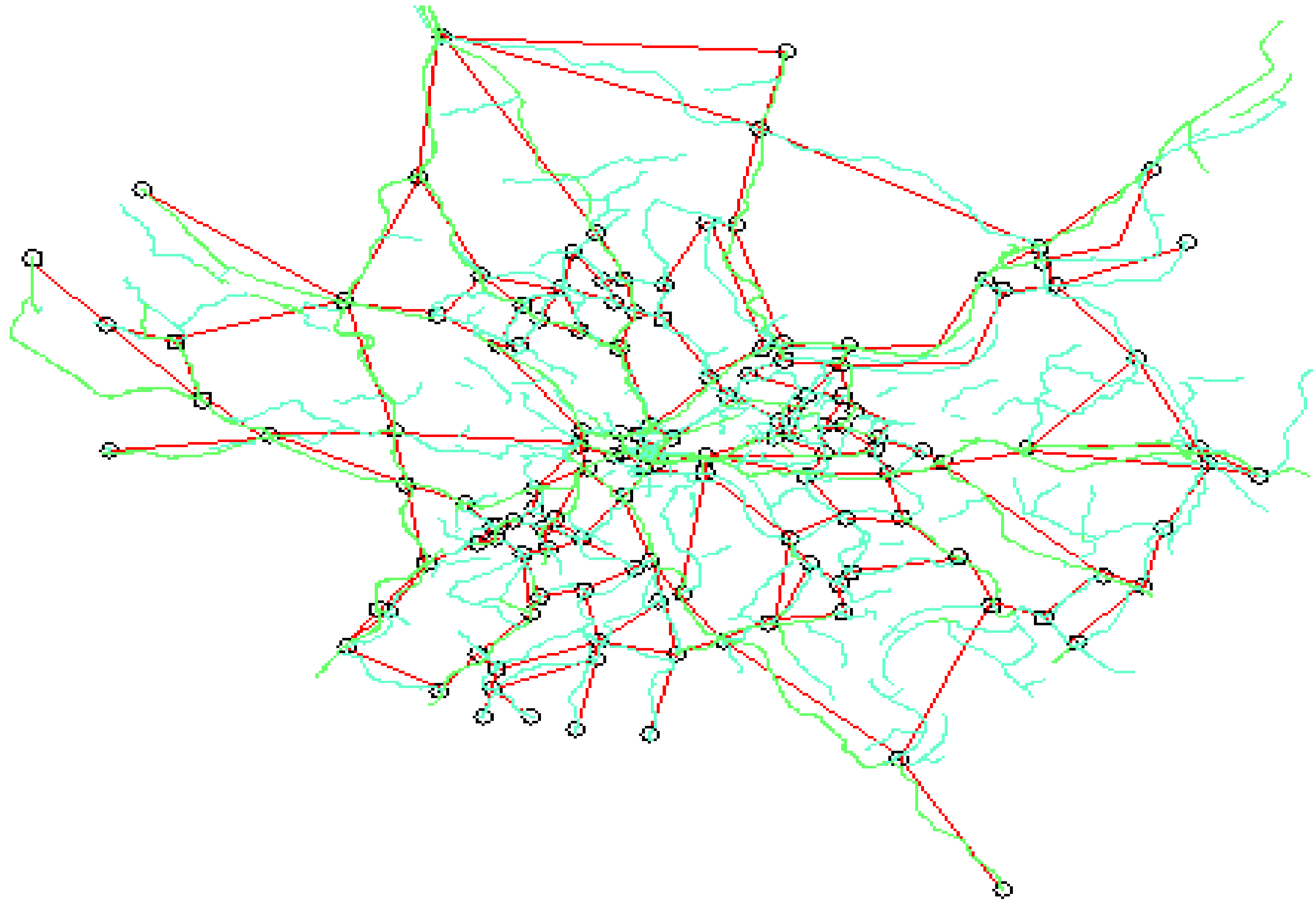


Fig. 3. Graph derived from Allegheny County Highway Network

Global Management of Infrastructure Assets

- Vision is achievable today, given:
  - Advanced technologies for performance-based management
  - Recognition of increasing importance for maintaining transportation infrastructure on a global scale
  - Rapid recognition of risk through improved cognition, communication, coordination and control processes
  - Creation of an 'epistemic community' of knowledgeable researchers, policy makers, analysts and entrepreneurs committed to designing and maintaining a global transportation system