# SHMII-3 Workshop on Transformation of Civil Engineering Education, Research and Practice

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Vancouver

Emin Aktan and Aftab Mufti
ISHMII

# *outline*

- introduction to civil engineering
- drivers for change
- challenges
- field laboratory
- products, success benchmarks

# *the more things change the more they remain the same (Charles Dickens)*


**Pont du Gard, Aqueduct of Nîmes**
South France
Over the Gard River


**Woodrow Wilson Bridge**
Maryland-Virginia
Over the Potomac, 2007

# *then and now…*

heuristics
codes

*"The trouble with modernity is how efficiently it obliterates the troves of age-old knowledge otherwise known as wisdom." NYT Editorial 4.21*

World … society … generations …

applied science …***think*** versus ***look***

emerging paradigms *performance-based design, structural health monitoring, asset management …*

# *critical driver: increasing societal importance of civil engineers (NAE Engineer 2020, ASCE Vision)*

traditional focus

- plan, design, construct and manage the built environment …

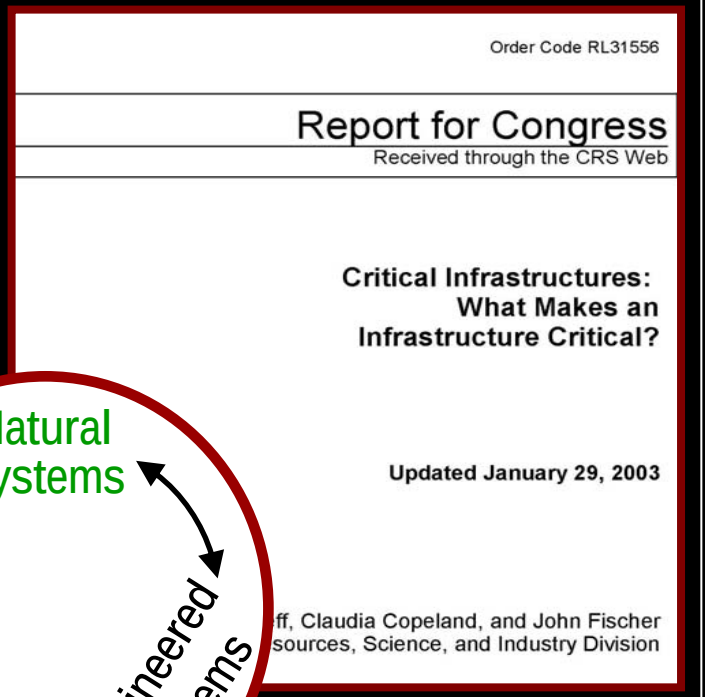
*…which is getting exceedingly complex as renewal takes over new*

more contemporary additions

- stewardship of the natural environment - sustainability
- management and mitigation of multi-hazards risk
- guiding public policy
- preserving historic landmarks

# *Critical Driver: Infrastructures Exceeding Their Performance and Lifecycle Cost Limits*

- food;
- ***water***
- agriculture;
- health systems and emergency services;
- ***energy*** (electrical, nuclear, gas and oil, refineries, plants, pipelines, dams);
- ***transportation*** (air, road, rail, port, waterways);
- information and telecommunications;
- banking and finance;
- chemical;
- defense industry;
- postal and shipping; and,
- national monuments and icons



Order Code RL31556

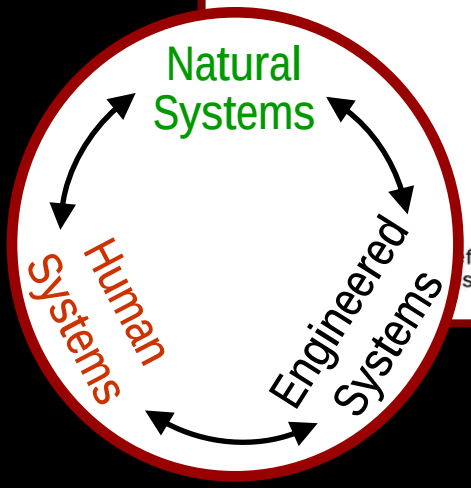
Report for Congress

Received through the CRS Web

**Critical Infrastructures: What Makes an Infrastructure Critical?**

**Updated January 29, 2003**

ff, Claudia Copeland, and John Fischer
sources, Science, and Industry Division



# *critical driver – urbanization, mega-cities*

*(Satterthwaite 2005 and Zwingle 2002)*

- soon more than half of the world's population will be living in urban centers
- cities worldwide are gaining over one million new inhabitants each week
- many US cities are gaining population, newer urban centers are growing

Increasing

*reliance*

*density*

*inter-dependency*

*vulnerability*

of infrastructures

# *other drivers*

- Climate change
- Environmental degradation, depletion of natural resources, hunger for energy
- Population and Demographic Trends:
  - Aging of the industrial world
  - Youth bulge, poverty
  - Increasing multi-hazard risks
- Globalization

# *principal challenge – Proliferation of CEE education programs (ASEE, 2004)*

- 220 Abet Accredited Bachelors Degree Programs
- 125 offering PhD's
- 8142 Bachelors, 3745 Masters, 644 PhD's awarded

BSCE Degrees Awarded:

**1. Purdue University 176**

**2. Texas A&M University 157**

4. Polytechnic Univ. of Puerto Rico 131

5. Univ. of Illinois 128

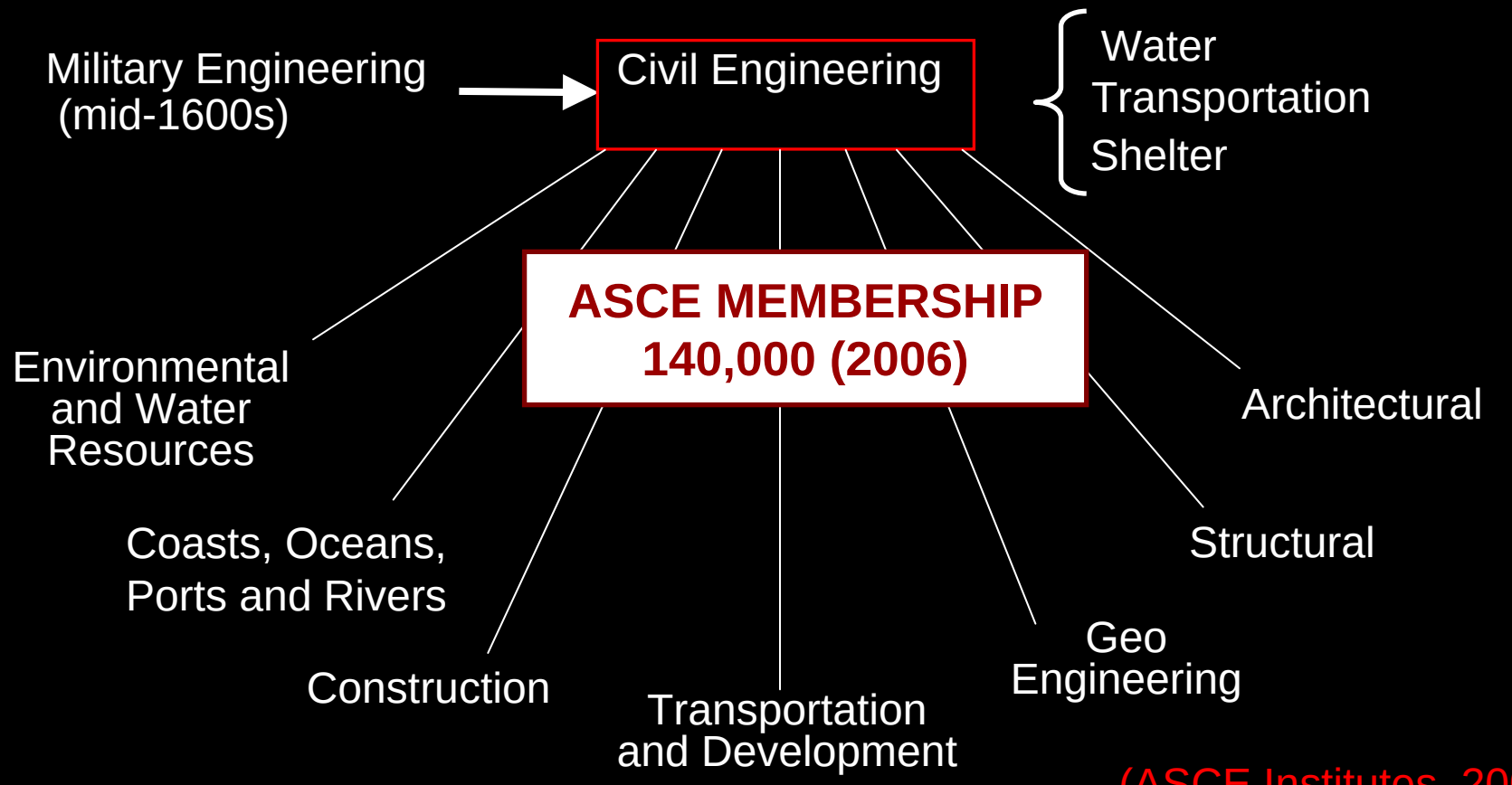
11. Univ. of Puerto Rico, Mayaguez 104

12. North Dakota State University 103

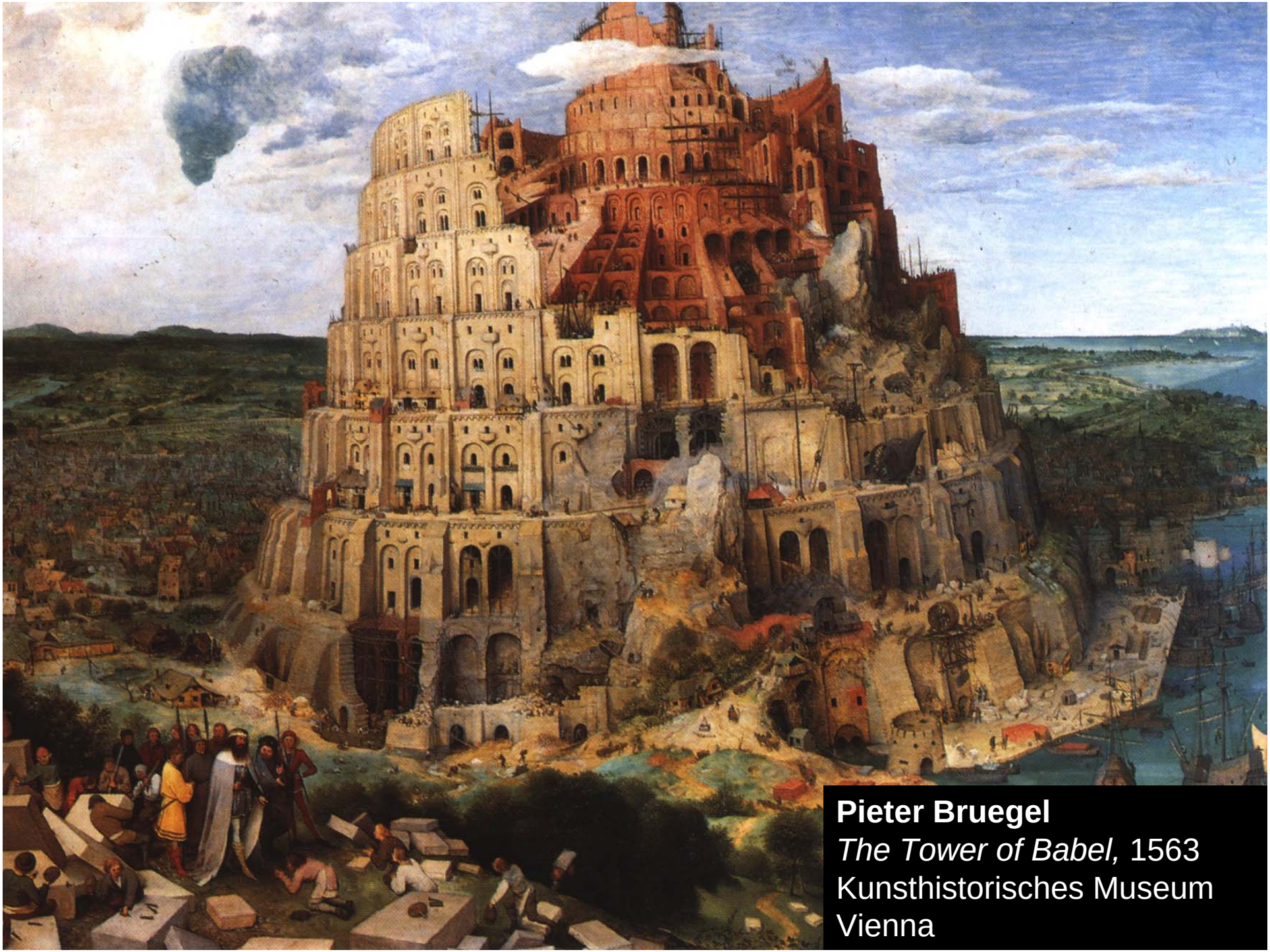
**42. Northeastern University 53**

**53. Drexel University 48**

# *principal challenge – proliferation, fragmentation*




(ASCE Institutes, 2006)



**Pieter Bruegel**
*The Tower of Babel,* 1563
Kunsthistorisches Museum
Vienna

# *principal challenge – proliferation, fragmentation*



ENR.com
Engineering News-Record

comparisons:

- Japan has half of the U.S. civil engineers per capita and the worlds best infrastructure
- globally there are 15 automakers 7 civil airplane makers

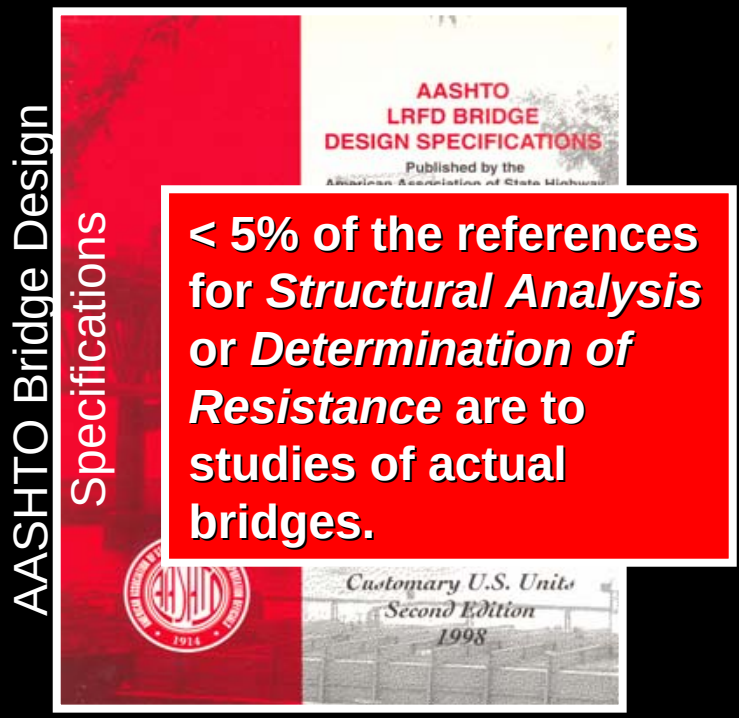
# *principal challenge – fragmented, disconnected lifecycle:*

*Politics - Policy - Planning - Financing - Preliminary / Conceptual Design – Feasibility - Social and Environmental Impacts - Detail Design - Bidding - Contracting - Redesign - Refinance for Construction - Procure Materials - Fabricate - Construct - Commission - Operate - Inspect - Manage – Maintain - Repair - Rehabilitate - Change/modify - Reuse - Hazard - Retrofit - Renew - Decommission - Recycle …..*

# *principal challenge – disconnect with reality*

- actual live load capacity of infrastructure is often 10 to 20 times code predicted values…
- actual failures of bridges are often unrelated to design limit states (overloads, earthquake, soil, fatigue)…

hydraulic events, collision, deterioration, fire, ice, construction, design errors, storm/tsunami



# *principal challenge – disconnect with reality*

inspection procedures routinely miss structures in imminent danger of collapse

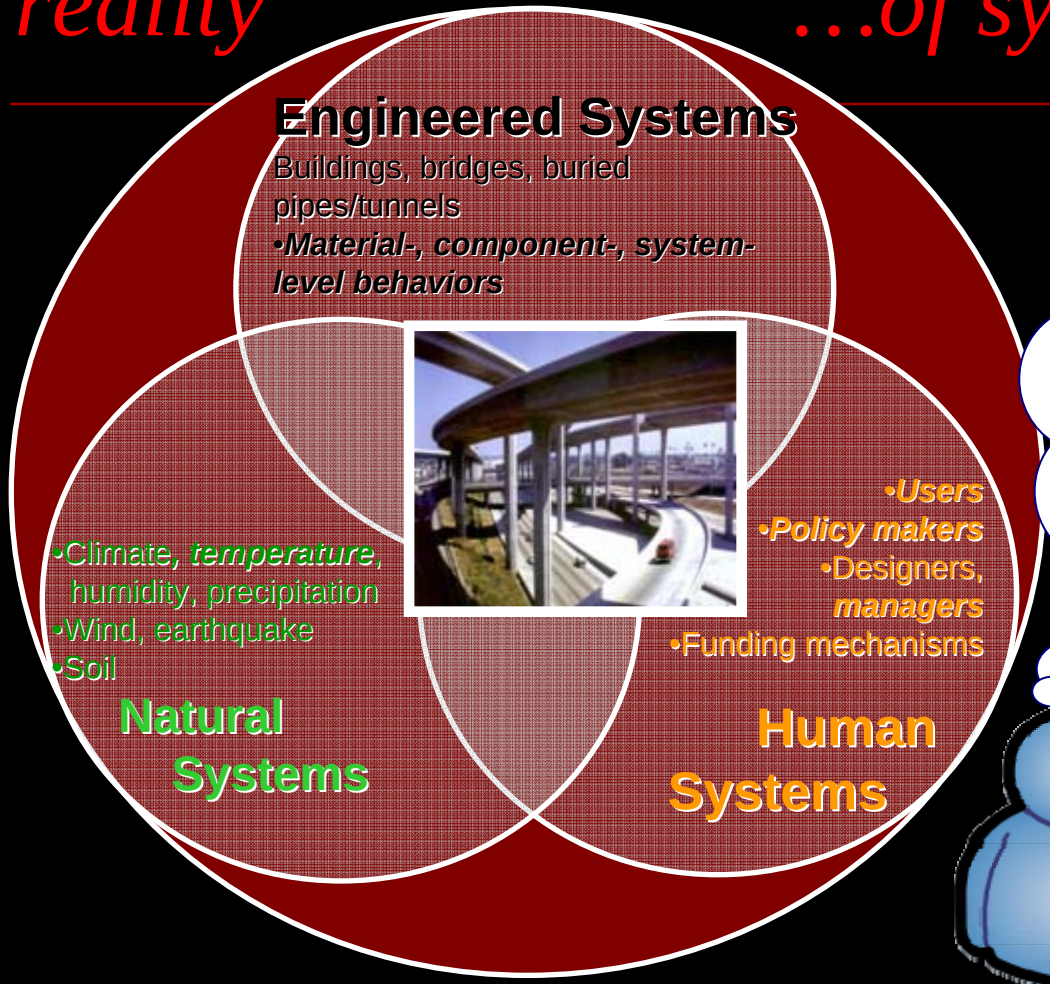
Pittsburgh, PA - Collapse of I-70 overpass under its own weight, 27 December 2005

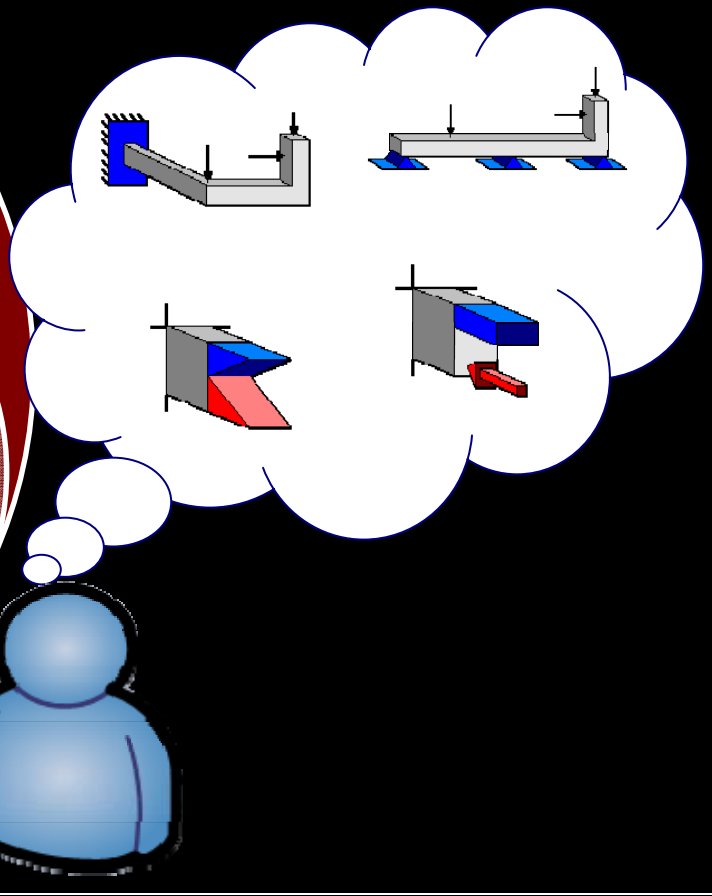
Associated Press 29 April 2007

***Bridges are not designed for accidents or fire …***

*A tanker carrying gasoline exploded before dawn on Sunday, and the resulting blaze caused the collapse of a section of freeway that funnels traffic onto the Bay Bridge. The damaged sections of the interchange are likely to take months to repair, causing numerous problems for commuters. (www.nytimes.com)*

# *principal challenge – disconnect with reality …of system-of-systems*

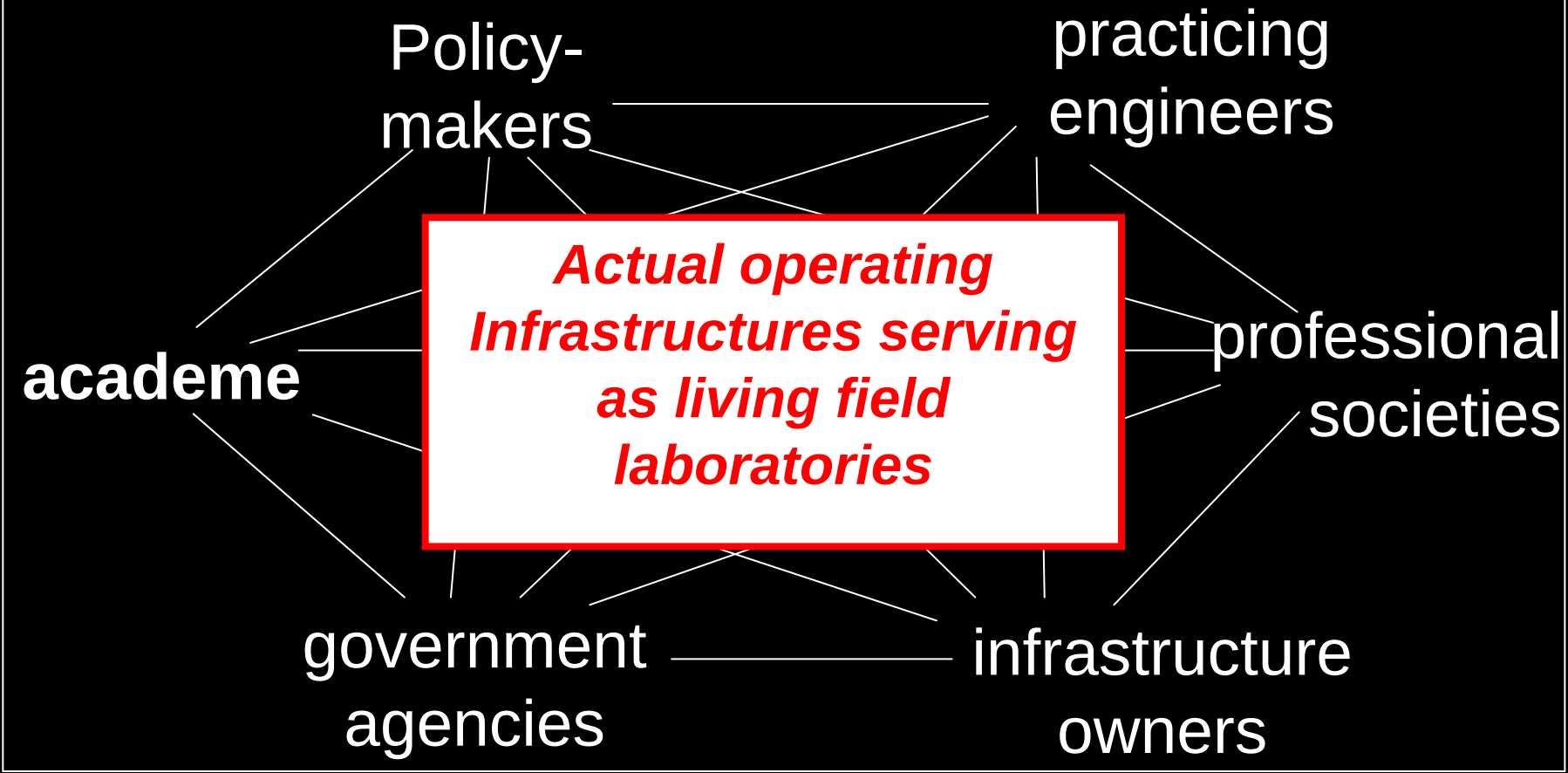


## *need for reality observation platforms i.e. field laboratories*

to overcome fragmentation and to provide a ‘concrete’ link between civil engineering education, constructed and infrastructure systems

# *Vision*


Policy-
makers
practicing
engineers
Actual operating
Infrastructures serving
as living field
laboratories
academe
professional
societies
government
agencies
infrastructure
owners

# *learning factory framework: think, look, measure, identify, analyze*

**Input to Policy, Revenue Generation, Allocation**

***Look Measure Model***

***Applied Systems Analysis***

**Human**

**Engineering**

**Natural**

*GIS-based mapping, modelmg*

**Identify interactions interconnections**

e.g. congestion tax:
- implementation?
- value?
- trade-offs
  - economy vs. revenue ?
  - economy vs. environment ?

# *Core Concepts for a 21st Century CE Curriculum:*

BASIC SCIENCES

Math, Physics, Chem-Bio | Statistics, Probability *Risk, Uncertainty* | Mechanics of Solids and Fluids | *Discrete Math* *IT for Engineers* | Material Science Energy Science

ENGINEERING ARTS

Multidisciplinary Team Skills and Problem Solving | *Physical/Numerical Experiments* | Construction Materials, Processes and Logistics | Multidisciplinary Engineering Design For Sustainability

Constructed Systems | Natural Systems Soil, Water, Air | Lifecycle Management | ***Applied Systems Analysis and Design in Specialization Area***

SOCIAL SCIENCES

Humanities | Ethics | Communication | Psychology | Economics | Decision-Making

MANAGEMENT ARTS

Attitudes/Leadership | Public Policy and Law | Organization Theory | Management | Globalization

1 2 3 4 5

***Based on Case-studies From the Field Laboratory***

***Field Laboratory and Professional Practice***

***Lifelong Learning***

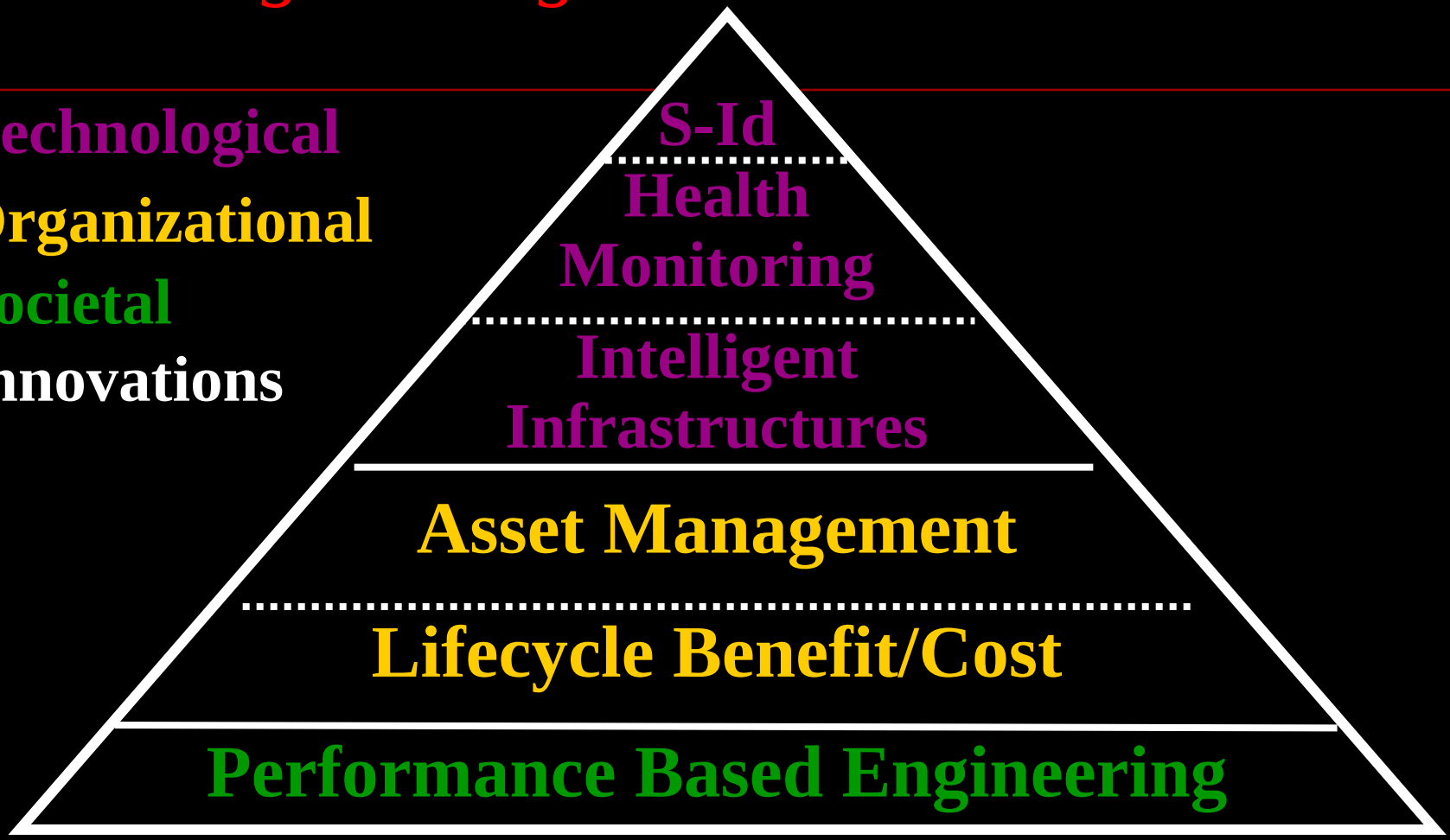
# *Leveraging Critical Paradigms for Civil Engineering Innovation*

**Technological**

**Organizational**

**Societal**

**Innovations**



# *a new civil engineer*

## Civil Engineering Domain Knowledge

Performance-based Engineering, Health Monitoring, Asset Management…

**identify challenges, need and role of associated disciplines**

### Associated Disciplines

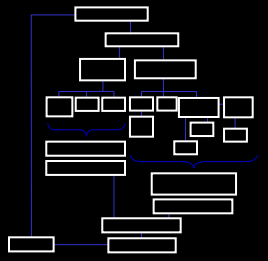
- public health
- environmental science
- social science
- urban planning
- Architecture
- finance, economics
- other engineering and science disciplines

**Coordinate and integrate multi-disciplinary teams**

**communicate technical information to public administrators and public**

### Policy-Makers

Decision Analysis



Public Policy