Systems Science and Systems Engineering Synergies

Systems Science Working Group

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Work in process (White Paper, version 1.0)...

Describe some commonalities and potential synergies between systems science and systems engineering

1. Systems Science and Systems Engineering Organizations
2. Historical Connections Between Systems Engineering and Systems Science
3. Challenges for SE
4. What Kind of Change is Needed?
5. The Interdependencies of Systems Engineering and Systems Science
6. Initial Conclusions

1. Systems Science and Systems Engineering Organizations

ISSS

International Society for the Systems Sciences

- Founded 1956, originally Society for General Systems Research, at American Association for Advancement of Science
- Often associated with Ludwig von Bertalanffy, but members and leaders span a wide range of professions

INCOSE

International Council on Systems Engineering

- Founded 1991
- Membership ~ 8000 systems engineers
- Aerospace, defense, other industries
- USA and other countries
- 2010 Systems Science Working Group "promote the advancement and understanding of Systems Science and its application to SE"

IFSR

International Federation for Systems Research

- Founded 1981
- Federation of systems organizations around the world, including the ISSS (and now INCOSE)

2. Historical Connections Between Systems Engineering and Systems Science

- In 1950s, Systems Engineering as "a more systematic approach than the ad hoc activities undertaken during WWII"

- Operations research → systems sciences
- Russell Ackoff "The Future of Operations Research is Past", 1979

- In 1950s, Macy Conferences → cybernetics

- Heinz von Foerster, second-order cybernetics
- C West Churchman, ethics in system design
- Peter Checkland, Soft Systems Methodology

- John Warfield, human factors in eng-ineering

Hard systems: software and complex technologies

Soft systems: human responses to complex situations

3. Challenges for SE

- Size and scope of projects
- Ability to meet requirements of time and budget

- Dynamic nature
- Human aspects, e.g. communication, healthcare, transportation

Complex systems that tend to include …
"people or other autonomous agents, cross organization boundaries, change continually, and be less predictable, less deterministic, more chaotic, less centrally controlled, and more self-organizing and adaptive"

Application domains that present pressing problems for systems engineering

- Service systems
- Infrastructure and transportation systems
- Environmental and energy systems
- Defence and space systems

4. What Kind of Change is Needed?

Service systems

- Service Dominant Logic, value cocreated rather than delivered (Vargo and Lusch)
- Coproduction in service, knowledge-based (Tien and Berg)
- Service Science Management, Engineering and Design (IBM)

Infrastructure and transportation systems

- 45% of cost of transportation is movement of goods (Hipel)
- In U.S. alone, 2.3 billion barrels of oil wasted each year on unnecessary street traffic; 25% of electricity generated each year is never consumed (IBM)

Environmental and energy systems

- $15 trillion in wasted or lost resources per year (IBM)
- 50% world's food supply never makes it to consumers
- Nearly 35% of water frivoled away by poor agricultural management

Defence and space systems

- International travel and global communications brings cultures together
- Resources through constant global trade
- Terrorism by ethnic or religious entities
- Information system attacks

5. The Interdependencies of Systems Engineering and Systems Science (page 1 of 2)

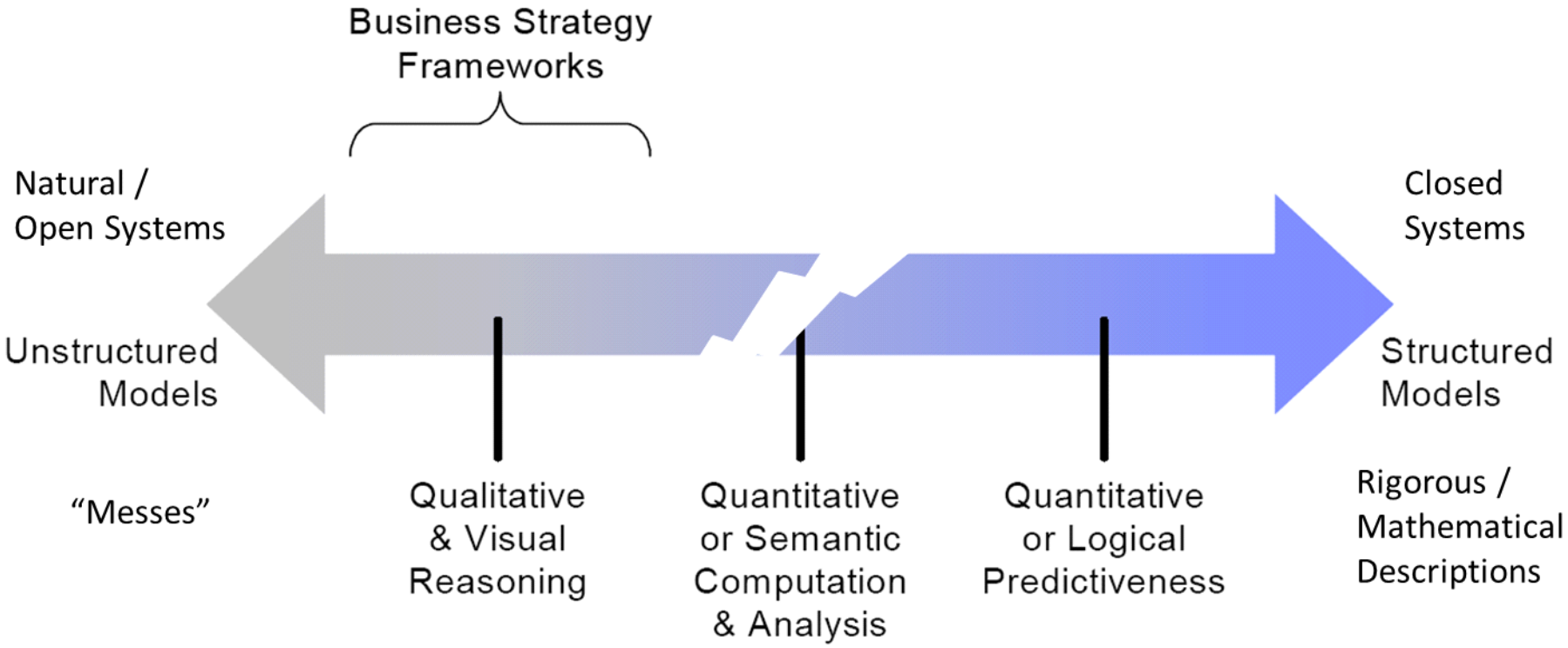
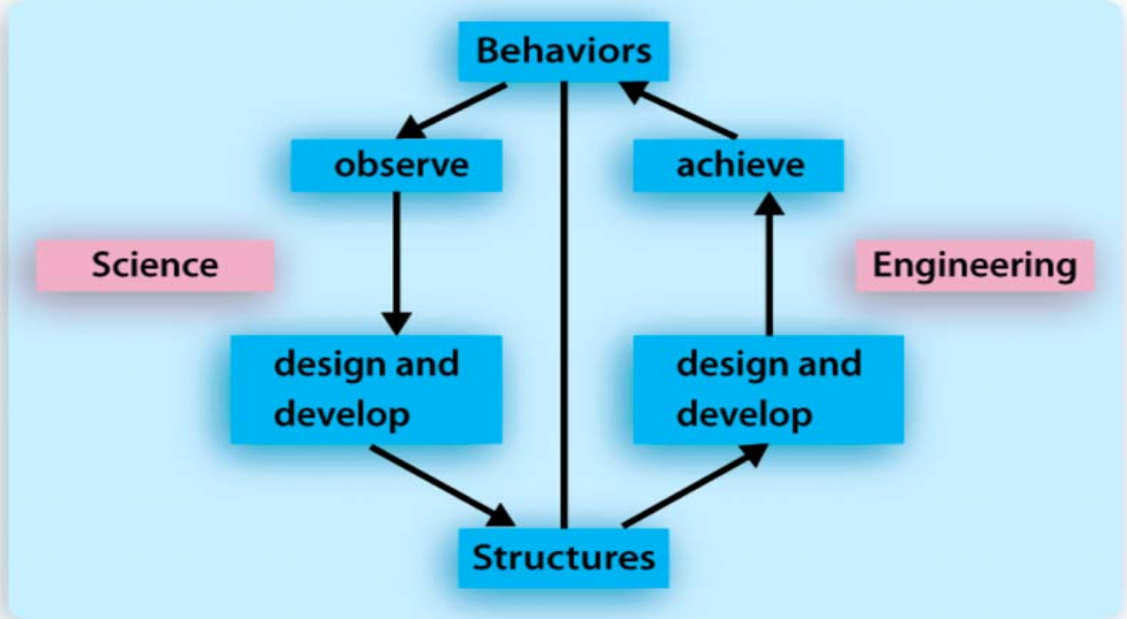


Figure 1. Diagram describing a spectrum of models, from conceptual to rigorous. Adapted from IBM Research. (n.d.) Services science: A new academic discipline? http://www.almaden.ibm.com/asr/resources/facsummit.pdf, p. 49.

5. The Interdependencies of Systems Engineering and Systems Science (page 2 of 2)



Lawson (2011)

In Science the major task is to examine behaviors and to explain these behaviors by identifying fundamental structures that cause the behavior. The expression of the structures can be in the form of notation (mathematical, chemical, etc.), models or even natural language text.

In Engineering the goal is to identify fundamental structures (building blocks) that can be, via design and development, integrated into a system that when instantiated and operated delivers desired behaviors

… science and engineering ... got separated historically in our educational systems. In practice, they are intimately interconnected.

6. Initial Conclusions

- Professions
- Institutions / organizations

environments evolve → need to adapt

- New possibilities from new ideas or technological advances?
- Inability to solve new problems → change?

- In absence of change, a fade to obscurity?

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