Lecture 2:
Systems Engineering - Overview

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Systems Thinking

- **Systems thinking** is process of predicting, on the basis of anything at all, how something influences another thing.
- It has been defined as an approach to problem solving, by viewing "problems" as parts of an overall system (holistic), rather than reacting to present outcomes or events and potentially contributing to further development of the undesired issue or problem.
- It is a framework that is based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation.
- Systems thinking's focus is on effect, not cause.
- Consistent with systems philosophy, systems thinking concerns an understanding of a system by examining the linkages and interactions between the elements that compose the entirety of the system.
- Systems thinking techniques may be used to study any kind of system — natural, scientific, engineered, human, or conceptual.

http://en.wikipedia.org/wiki/Systems_thinking

Systems Engineering

- **Systems engineering** is an interdisciplinary field of engineering that focuses on how complex engineering projects should be designed and managed.
- Issues such as logistics, the coordination of different teams, and automatic control of machinery become more difficult when dealing with large, complex projects.
- Systems engineering deals with work-processes and tools to handle such projects, and it overlaps with both technical and human-centered disciplines such as control engineering and project management.

- In other words, systems engineering is a logical way of thinking.

http://en.wikipedia.org/wiki/Systems_engineering

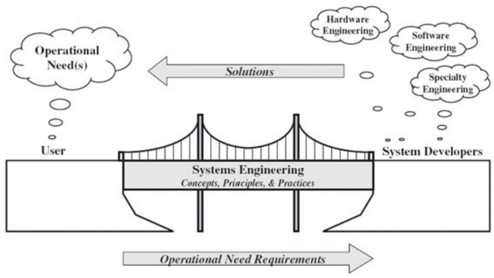


Figure 1.1 Systems Engineering—Bridging the Gap from User Needs to System Developers

Engineering Systems (1)

- Are large-scale, complex engineering challenges within their socio-political context.
- MIT defines Engineering Systems as the **engineering study dealing with diverse, complex, physical design problems** that may include components from several engineering disciplines, as well as economics, public policy, and other sciences.
- Engineering Systems is a field of study taking an integrative holistic view of large-scale, complex, technologically-enabled systems with significant enterprise level interactions and socio-technical interfaces.

http://en.wikipedia.org/wiki/MIT_Engineering_Systems_Division

Engineering Systems (2)

- A collection of engineered systems: Examples include large scale and complex engineering systems such as: the Internet, urban planning projects such as Boston's Big Dig, next generation air traffic control, healthcare reform, and network-centric warfare.
- Some Examples from India: Space Programmes, Delhi Metro, IRCTC
- An approach in engineering based on systems thinking.

- MIT defines engineering systems as a multidisciplinary approach that does the same thing as Systems Engineering but has a management, policy, or social dimension as well as a technical one.

http://en.wikipedia.org/wiki/MIT_Engineering_Systems_Division#cite_note-0

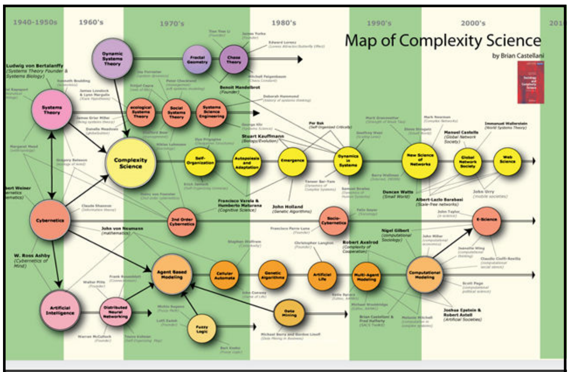
Characteristics of Engineering Systems

- Technologically enabled: Networks & Meta-systems which transform, transport, exchange and regulate Mass, Energy and Information.
- Large-scale: large number of interconnections and components.
- Socio-technical aspects: social, political and economic aspects that influence them.
- Nested complexity: within technical system and social/political system.
- Dynamic: involving multiple time scales, uncertainty & lifecycle issues.
- Likely to have emergent properties.

http://en.wikipedia.org/wiki/MIT_Engineering_Systems_Division#cite_note-0

Complexity of a System

- What are Complex Systems ?
  - Disorganized vs Organized complexity
- Examples - development of smarter control algorithms, microprocessor design, and analysis of environmental systems
- Need Methods and tools to understand and manage this complexity
- Interconnections (& feedbacks) between the sub-systems are not always clearly known



Source: http://www.art-sciencefactory.com/complexity-map_feb09.html

- System Analysis
- Statistical Analysis
- System Dynamics
- Optimization
- Reliability Analysis (incld. Redundancy)
- Simulation and Modelling

Read

“Understanding the Value of Systems Engineering”

http://www.incose.org/secoe/0103/ValueSE-INCOSE04.pdf