Lecture 2:
What is a System

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- WHAT a system is;
- WHO its users and stakeholders are;
- WHY it exists and HOW it benefits its users and stakeholders;
- HOW it is structured; and HOW it operates, is supported, and disposed.

What is a System ?

- a system is a dynamic and complex whole, interacting as a structured functional unit;
- energy, material and information flow among the different elements that compose the system;
- a system is a community situated within an environment;
- energy, material and information flow from and to the surrounding environment via semi-permeable membranes or boundaries;
- systems are often composed of entities seeking equilibrium but can exhibit oscillating, chaotic, or exponential behavior.
- A holistic system is any set (group) of interdependent or temporally interacting parts. *Parts* are generally systems themselves and are composed of other parts, just as systems are generally parts or *holons* of other systems.

Categories of Systems

- **Hard systems** — involving simulations, often using computers and the techniques of operations research.
- **Soft systems** — For systems that cannot easily be quantified, especially those involving people holding multiple and conflicting frames of reference. Useful for understanding motivations, viewpoints, and interactions and addressing qualitative as well as quantitative dimensions of problem situations.
- **Evolutionary systems** —This technique integrates critical systems inquiry with soft systems methodologies. Evolutionary systems, similar to dynamic systems are understood as open, complex systems, but with the capacity to evolve over time.

The systems approach

- Interdependence of objects and their attributes - independent elements can never constitute a system
- Holism - emergent properties not possible to detect by analysis should be possible to define by a holistic approach
- Goal seeking - systemic interaction must result in some goal or final state
- Inputs and Outputs - in a closed system inputs are determined once and constant; in an open system additional inputs are admitted from the environment
- Transformation of inputs into outputs - this is the process by which the goals are obtained
- Entropy - the amount of disorder or randomness present in any system
- Regulation - a method of feedback is necessary for the system to operate predictably
- Hierarchy - complex wholes are made up of smaller subsystems
- Differentiation - specialized units perform specialized functions
- Equifinality - alternative ways of attaining the same objectives (convergence)
- Multifinality - attaining alternative objectives from the same inputs (divergence)

What is a System?

- An integrated set of interoperable elements, each with explicitly specified and bounded capabilities, working synergistically to perform value-added processing to enable a User to satisfy mission-oriented operational needs in a prescribed operating environment with a specified outcome and probability of success.

Examples of Systems

- Economic systems
- Educational systems
- Financial systems
- Environmental systems
- Medical systems
- Corporate systems
- Insurance systems
- Religious systems
- Social systems
- Psychological systems
- Cultural systems
- Food distribution systems
- Transportation systems
- Communications systems
- Entertainment systems
- Government systems
  - Legislative systems
  - Judicial systems
  - Revenue systems
  - Taxation systems
  - Licensing systems
  - Military systems
  - Welfare systems
  - Public safety systems
  - Parks and recreation systems
  - Environmental systems

- System
  - A combination of human, products and tools
- Product
  - is typically a physical device or entity that has a specific *capability*—*form*, *fit*, and *function*—with a specified level of performance.
  - *Products* generally lack the ability (*intelligence)*
  - Contextually, however, a product may actually be a vendor's "system" that is integrated into a User's higher-level system. Effectively, you create a system of systems (SoS).
- Tools
  - a supporting product that enables a user or *system* to leverage its own capabilities and performance to more effectively or efficiently achieve mission objectives that exceed the individual capabilities of the User or system.

Representation of a System

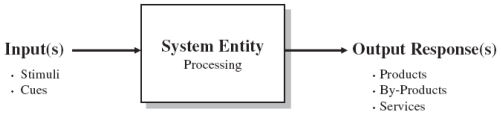


Figure 3.1 Basic System Entity Construct

An Analytical view

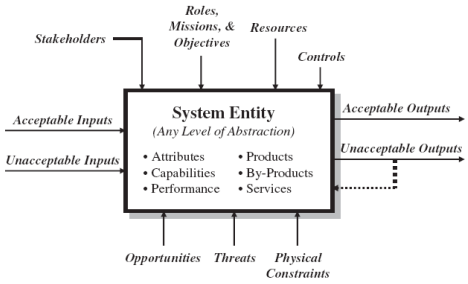
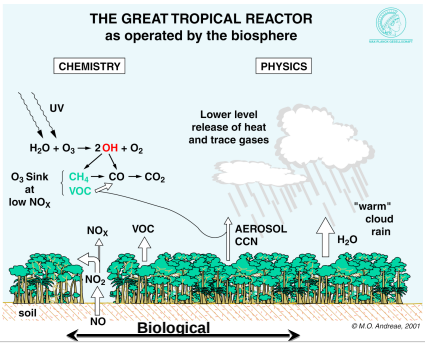


Figure 3.2 Analytical System Entity Construct

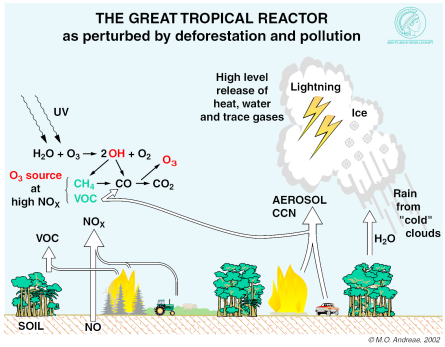
ILEAPS

Focus 2: Feedbacks between land biota, aerosols, atmospheric composition and climate



ILEAPS

Focus 2: Perturbations by human activities



- Workflow based Systems
  - Schools, hospitals, banking, manufacturing, etc
- Complex, Multi level systems
  - Analyze
  - Design
  - Develop
- *Application of analytical*, *mathematical*, and *scientific* principles are needed

- System engineering requires development of a strong foundation in understanding ***how* to characterize a *system*, *product*, or *service*** in terms of its attributes, properties, and performance.

System Concepts

- Attributes, Properties and Characteristics
- Roles and Stakeholders
- Life Cycle

How to Characterize a System?

- Attributes
  - The term *attributes* classifies *functional* or *physical* features of a system. Examples include gender; unit cost; nationality, state, and city of residence; type of sport; organizational position manager; and fixed wing aircraft versus rotor.
- Properties
  - The term, *properties*, refers to the *mass properties* of a system. Examples include composition; weight; density; and size such as length, width, or height.
- Characteristics
  - *Behavioral characteristics* examples include predictability and responsivity.
  - *Physical characteristics* examples include equipment warm-up and stabilization profiles; equipment thermal signatures; aircraft radar crosssections; vehicle acceleration to cruise speed, handling, or stopping.

Attributes

- refer to the attached PDF

System Performance

- **Objective Performance**
  - Performance that produces measurable physical evidence of system effectiveness based on pre-defined criteria.
  - For example, the temperature of the water is 108°F.
- **Subjective Performance**
  - Performance indicated by a subjective quality that varies by individual sensory values, interpretations, or perspectives.
  - For example, is the water “warm or hot”?

- Subjective Performance, examples include:
  - Quality—clarity, appearance, and color
  - Affinity
  - Likeability
  - Opinion
  - Smoothness
  - Satisfaction—enjoyment and taste

System Characteristics

1. general characteristics,
2. operating or behavioral characteristics,
3. physical characteristics,
4. system aesthetics.

System Conditions

- Prerequisite Conditions
  - System *stability*, *integrity*, and *consistency* of performance
- Initial Operating Conditions
- Static vs Dynamic
- Stabilization
- Balance of Power