Contributions Towards Unifying System Semantics

Harold (Bud) Lawson
Lawson Konsult AB and Syntell AB
and
Mats Persson
Swedish National Defence College

What is a system?
What is it that characterizes a system?

Certainly as systems engineers these are vital questions to ask

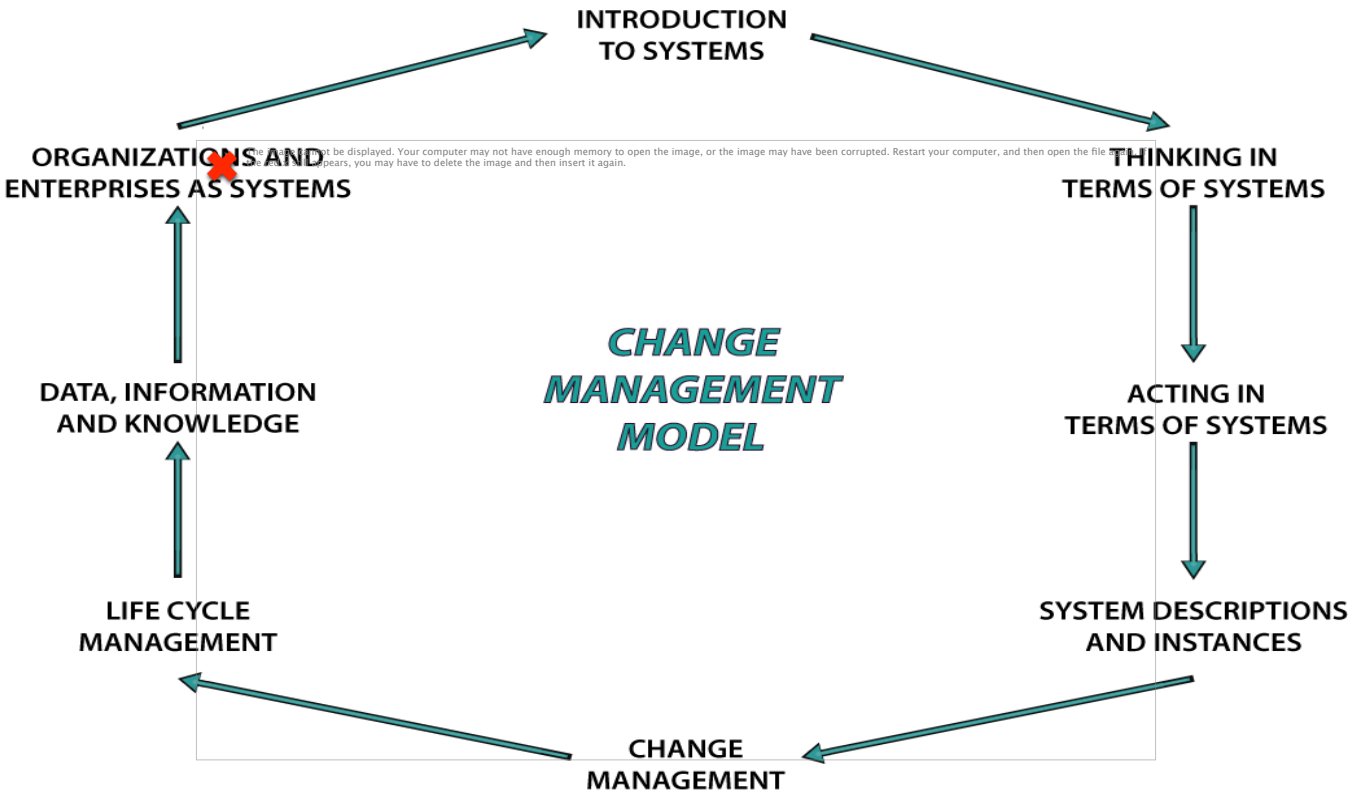
Ackoff, R. L. 1971. Towards a System of Systems Concepts. Management Science, 17(11).

Agenda

- The Systems Landscape
- Discipline Independence of Systems
- A System of Concepts
- A Systems Survival Kit
  - The System Coupling Diagram
  - Applying the System Survival Kit
  - Principles

First Stop in a Journey

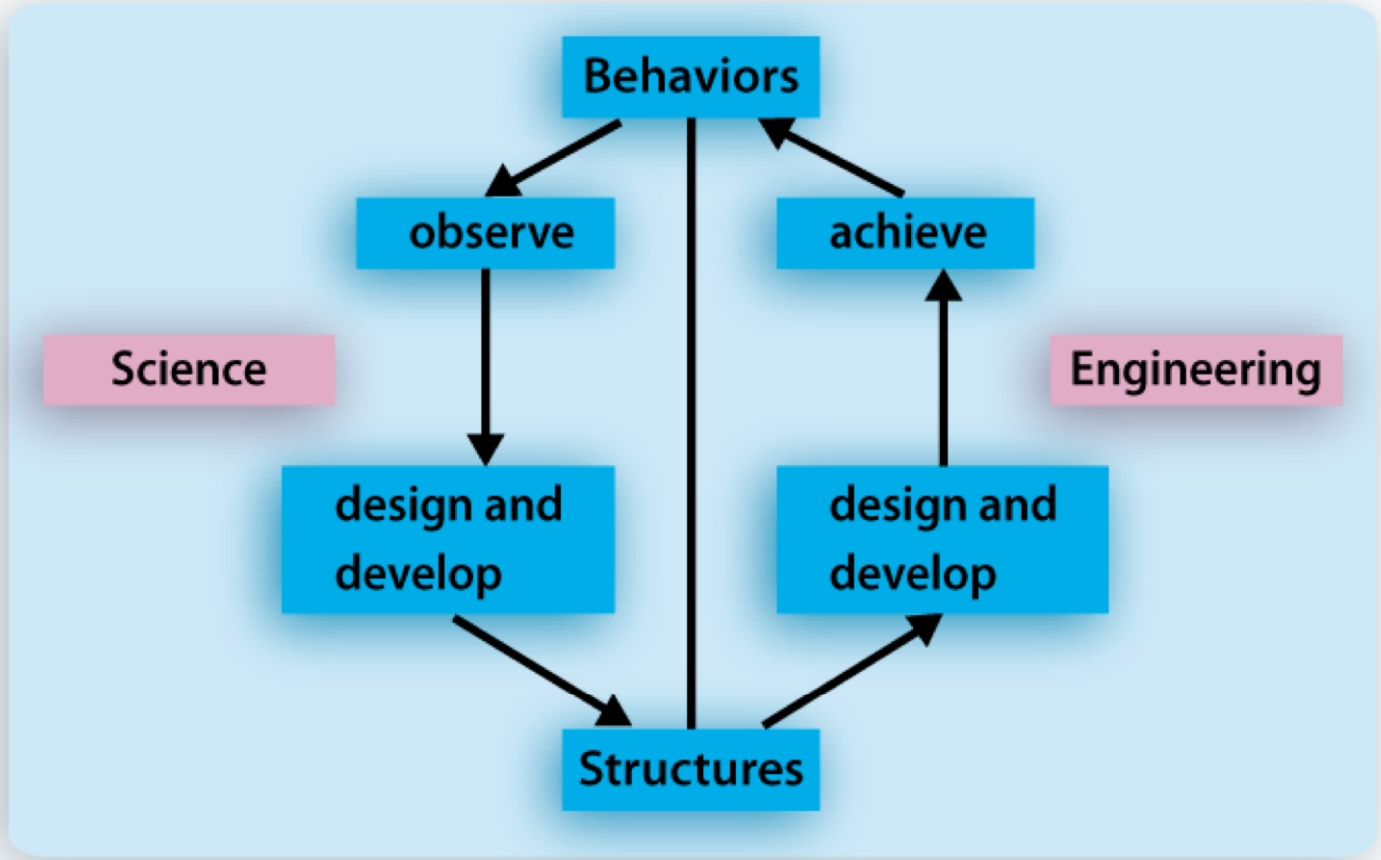
The journey about to be taken



A Journey Through the Systems Landscape

ISBN 978-1-84890-010-3

Science and Engineering Relationship to Structures and Behaviors



Some Examples

(x) Science	(y) Engineering
Biological	Electrical
Physical	Mechanical
Chemical	Chemical
Environmental	Sanitation
Management	Business Process
Computer	Software
System	Systems
Health	Health Care
Military	Military

A System of Concepts

- Fundamental Concepts
- Types of Systems
- System Topologies
- Focus (Systems-of-Interest)
- Complexity
- System Roles
  - Sustained
  - Situation/Respondent
  - Thematic

Fundamental Concepts

"We believe that the essence of a system is togetherness, the drawing together of various parts and the relationship they form in order to produce a new whole …."

John Boardman and Brian Sauser (2008)

Togetherness is the most fundamental concept and it occurs in structures as well as behaviors.

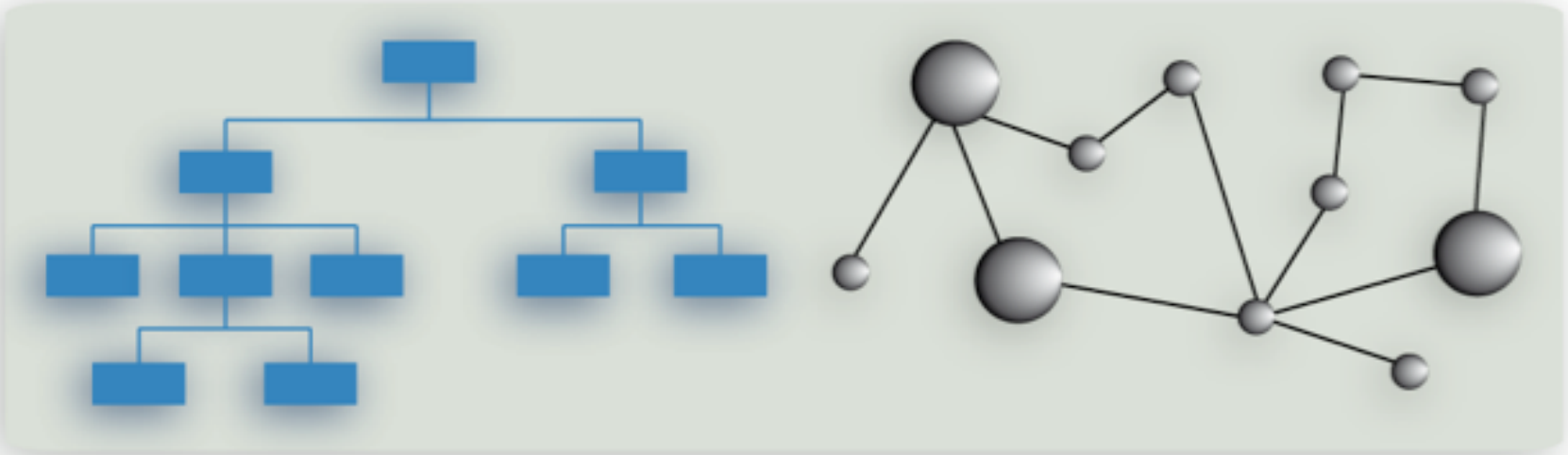
Fundamental Concepts (Continued)

- The *structure* of a system is a static property and refers to the constituent elements of the system and their relationship to each other.
- The *behavior* is a dynamic property and refers to the effect produced by a system "in operation.
- Finally, *emergence*; namely, the planned or unplanned effect resulting from the interactions of the elements of the system.

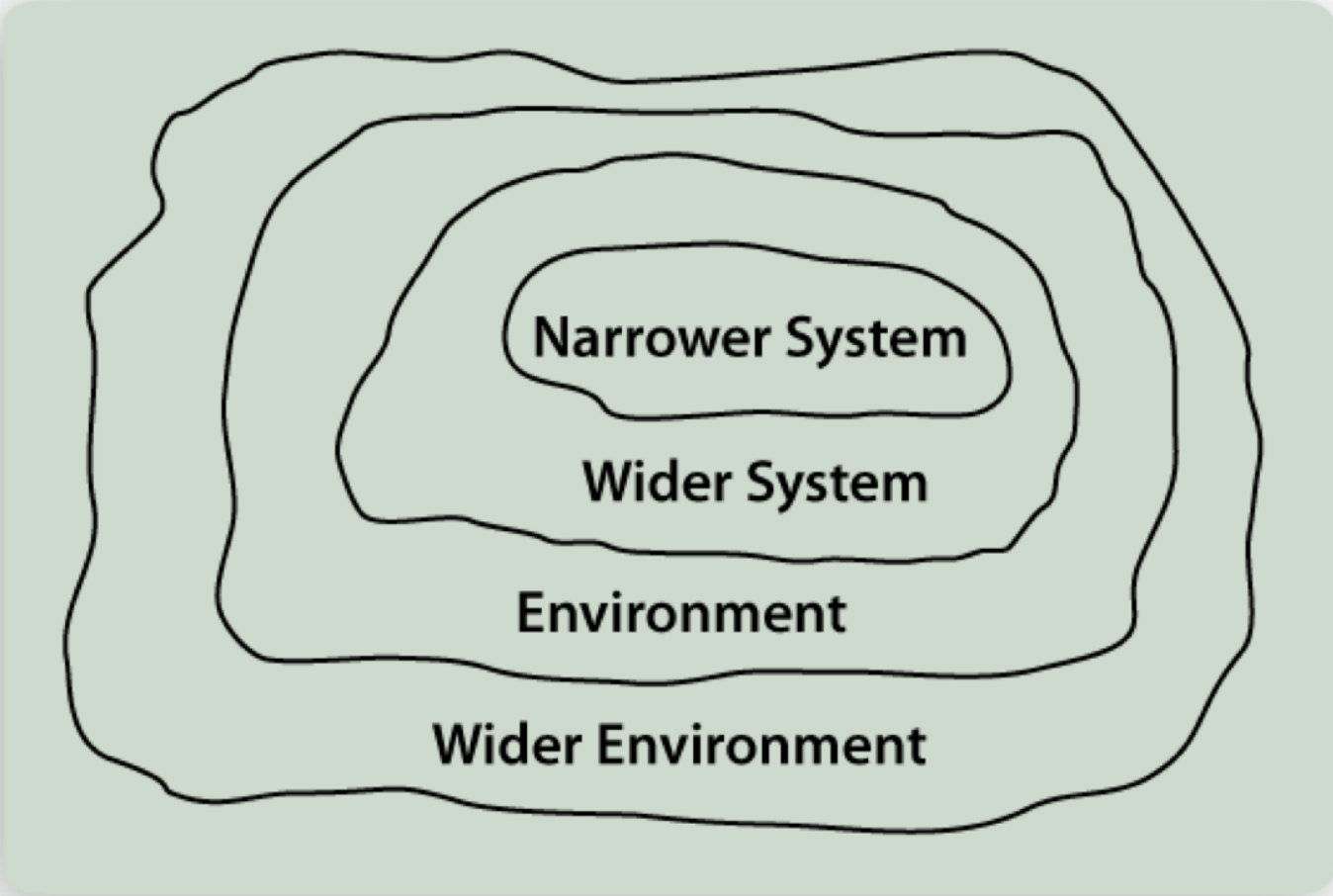
Types of Systems (Peter Checkland)

- **Natural systems** – These systems have their origin is in the universe and are as they are as a result of forces and processes which characterize the universe.
- **Defined physical systems** – These systems are the result of conscious design aimed at satisfying some human purpose.
- **Defined abstract systems** – These systems do not contain any physical artifacts but are designed by humans to serve some explanatory purpose.
- **Human activity systems** – These systems are observable in the world of innumerable sets of human activities that are more or less consciously ordered in wholes as a result of some underlying purpose or mission.

System Topologies



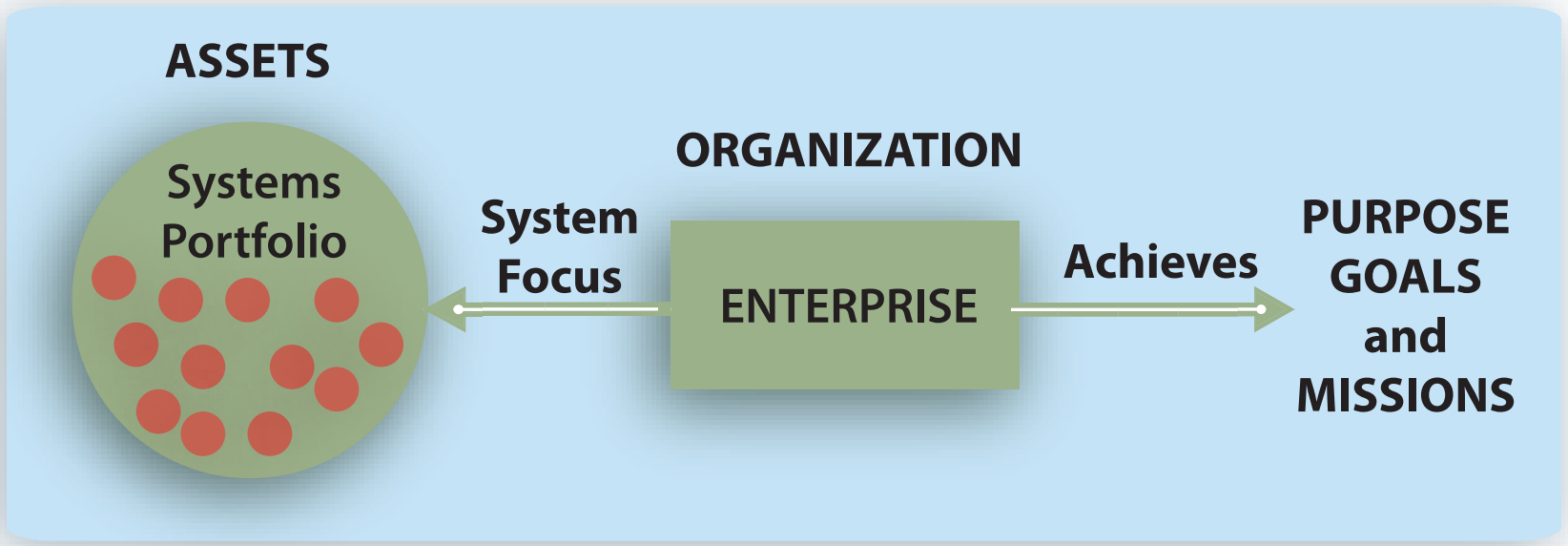
Focus (Systems-of-Interest) Flood and Carson



Complexity (Weaver ++)

- **Organized simplicity** occurs when there are a small number of essential factors and large number of less significant and/or insignificant factors. Initially a situation may seem to be complex, but on investigation the less significant and insignificant factors are taken out of the picture and the hidden simplicity is found.
- **Organized complexity** is prevalent in defined physical and defined abstract systems where the structure of the system is organized in order to be understood and thus be amenable to scientists in describing complex behaviors as well as for structuring the engineering and life cycle management of complex systems.
- **Disorganized complexity** occurs when there are many variables that exhibit a high level of random behavior. It can also represent the product of not having adequate control over the structure of heterogeneous complex systems that have evolved due to inadequate architectural control over the system life cycle (complexity creep).
- **People related complexity** where perception of any system fosters a feeling of complexity. In this context, humans become "observing systems". We could also relate this category to systems in which people are elements and can well contribute to organized simplicity, organized complexity or disorganized complexity. The rational or irrational behavior of individuals in particular situations is of course a vital factor in respect to complexity.

Organization/Enterprise System Assets



Roles of Systems

- Sustained - Institutionalized systems must be properly *sustained* over long periods of time in order to be in such condition that when put into operation (instantiated) are ready to deliver the desired effect.
- Situation - Systems can arise as a *situation* that may be short-term but may have a long longevity. The situation may be thought of and even described in terms of a network of contributing elements and relationships.
- Respondent - In order to counter-act the situation that has arisen a *respondent* system is created and put into operation.
- Thematic - Another form of situation system is *thematic*. That is, they are constructed for the purpose of studying the systemic aspects of a potential problem or opportunity situation as a theme. That is (what if ?) a particular problem situation or opportunity arises.

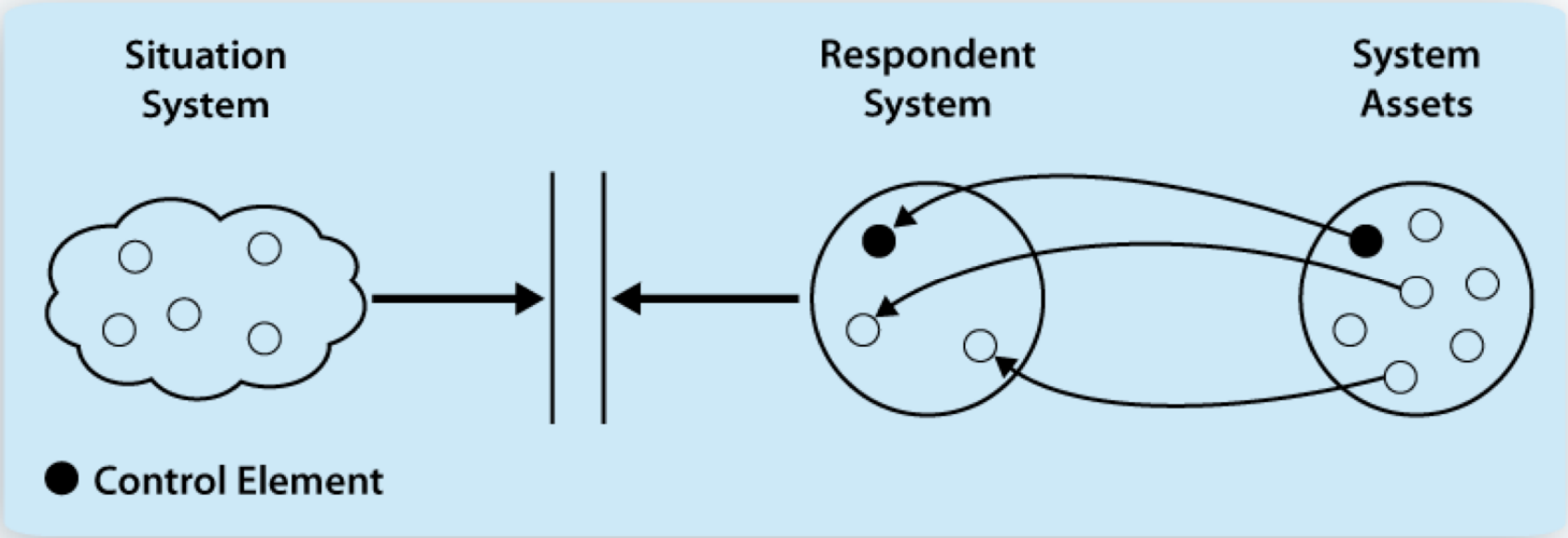
A System of Concepts (The Survival Kit)

Concept Categories	Concepts	Definitions
Fundamental	Togetherness	Two or more elements are related resulting in a new whole.
	Structure	The constituent elements and their static relationship.
	Behavior	The effect produced by the elements and their dynamic element relationships in operation.
	Emergence	The predictable or unpredictable behavior occurring as the result of a system in operation.
Types	Defined Physical System	Two or more physical elements are integrated together producing a new whole.
	Defined Abstract System	Two or more abstract elements are related resulting in a new whole.
	Human Activity System	Two or more elements, at least one involving a human activity are integrated resulting in a new whole.
Topologies	Hierarchy	A level-wise structure of systems and system elements that is defined recursively.
	Network	A node and links structure of system elements and their interrelationships.
Focus	Narrow System-of-Interest (NSOI)	The system upon which focus is placed in respect to a view.
	Wider System-of-Interest (WSOI)	The systems that directly affect (including enabling) the NSOI in respect to a view.
	Environment	The context that has a direct influence upon the NSOI and WSOI.
	Wider Environment	The context that has an indirect influence upon the NSOI and WSOI.

A System of Concepts (Continued)

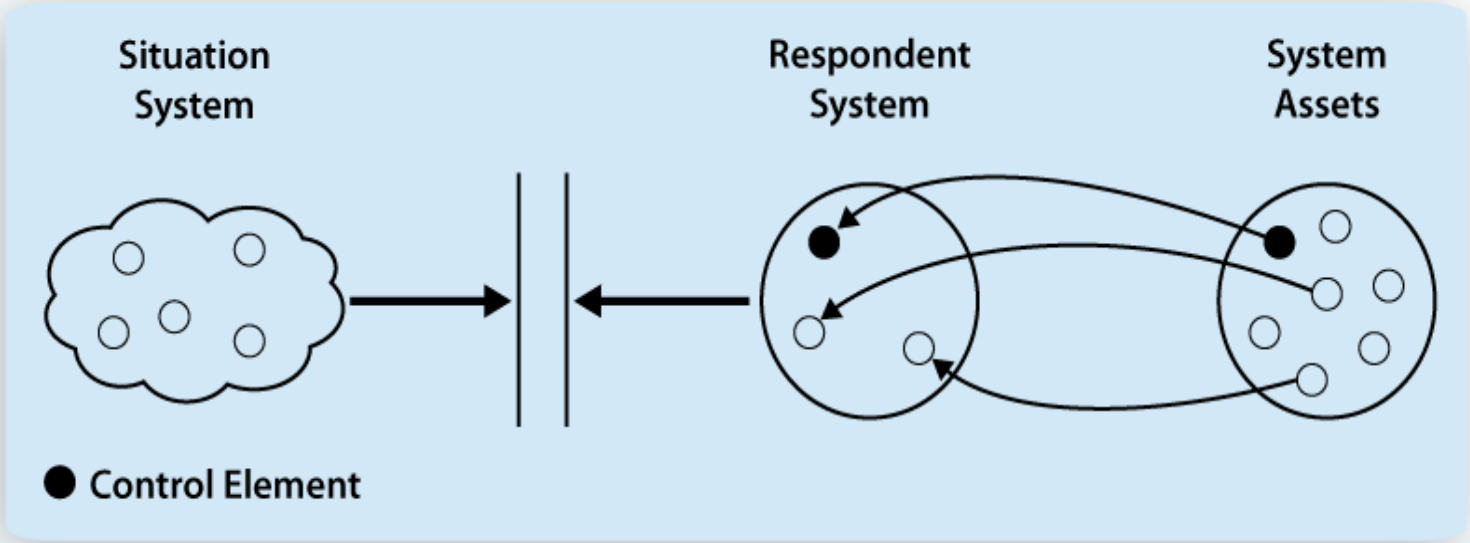
Complexity	Organized Simplicity	There are a small number of essential factors and large number of less significant and/or insignificant factors.
	Organized	The structure is organized in order to be understood and thus be amenable for describing complex behaviors.
	Disorganized	There are many variables that exhibit a high level of random behavior. Can be due to not having adequate control over the structure of heterogeneous complex systems (complexity creep).
	People Related	Perception of the system fosters a feeling of complexity. Also, rational or irrational behavior of individuals in particular situations.
Roles	Sustained System Asset	A system that is life cycle managed and when instantiated provide system services.
	Situation System	Two or more elements become related together resulting in a problem or an opportunity. Alternatively, an objective or end state that defines a desirable situation is established.
	Respondent System	A system composed of two or more elements that are assembled in order to respond to a situation.
	Thematic System	A system that is composed for the study of possible outcomes of a postulated situation system as well as one or more respondent systems (“what if”).

System-Coupling Diagram



Applying the System Coupling Diagram

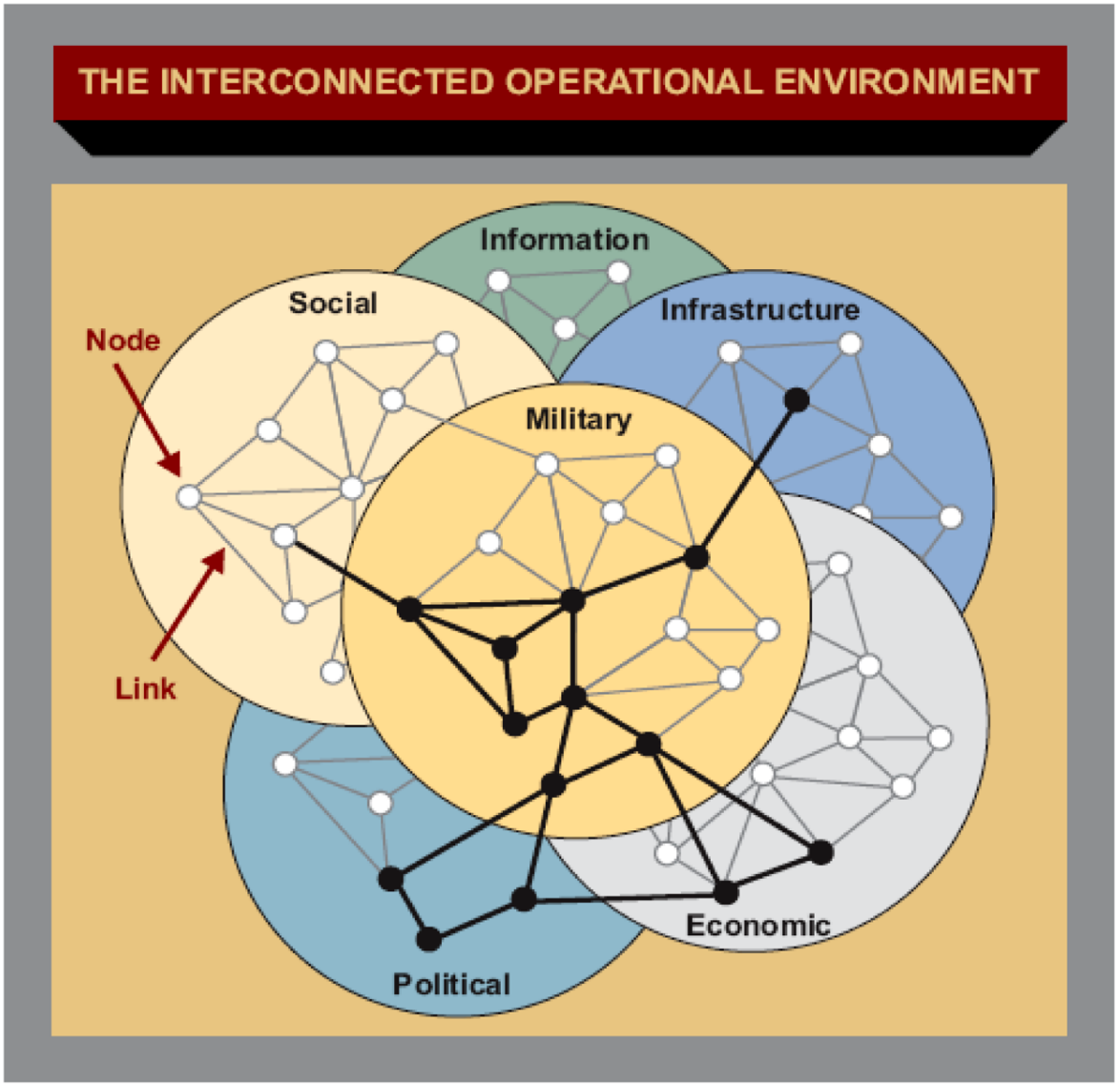
Project, Mission, Task Force



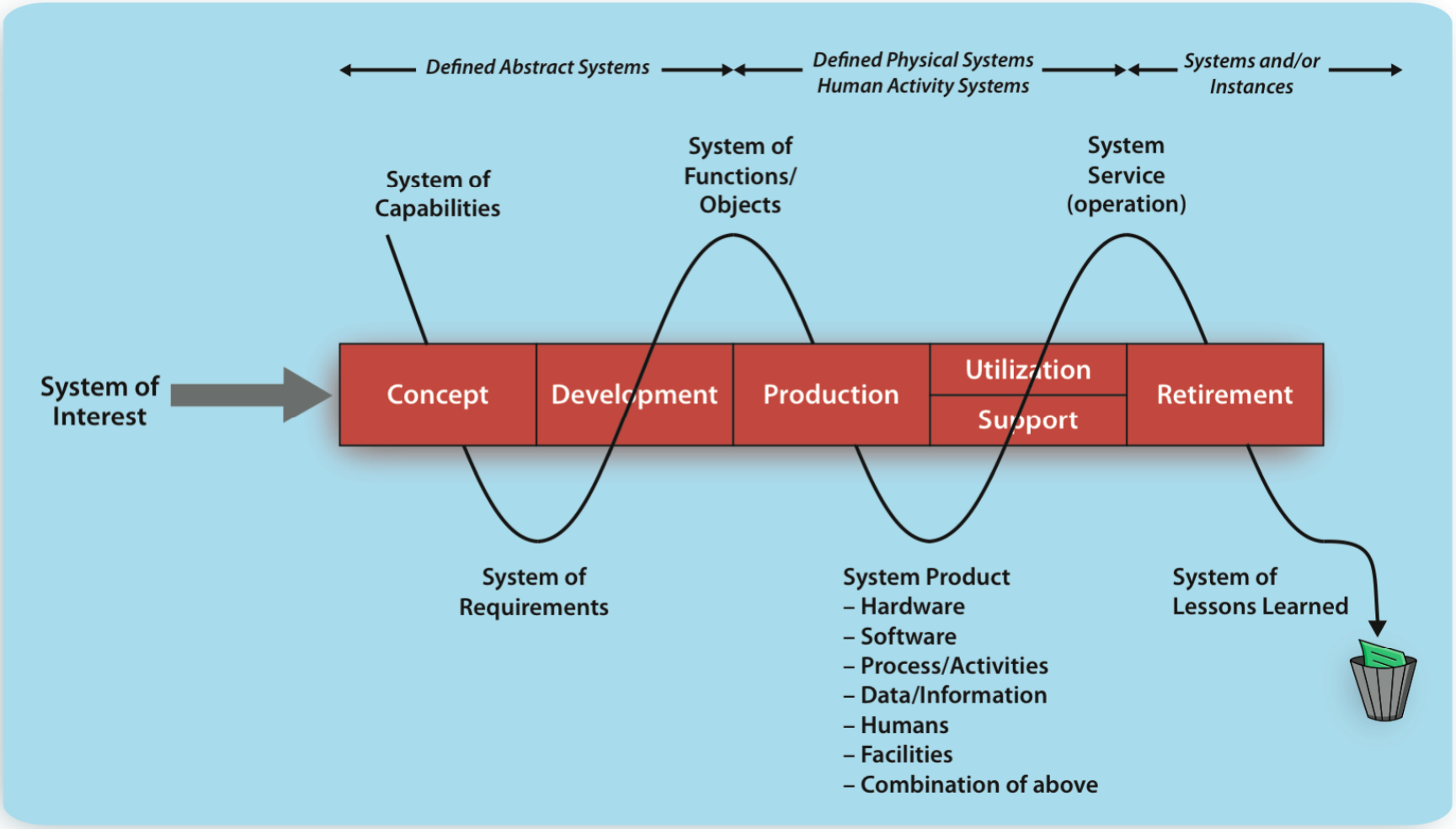
Unplanned Situation
Accident, Crises, Bug, Virus, Labor Dispute, Denial of Service Attack

Planned Situation
Requirements, Code, Integration, Testing, Production, Marketing

Network of Political, Military, Economic, Social, Infrastructure and Information Elements



Planned Life Cycle Transformations (System-of-Interest Versions)



Principles

- All systems are composed of two or more elements that constitute togetherness
- Systems are composed of structural elements or behavior elements
- Defined elements and relationships can be abstract, physical or human activities
- Systems are organized as a hierarchy or a network
- Bounding of systems in respect to views are defined by a Narrow System Of Interest, its Wider System Of Interest, their Environment and Wider Environment
- Complexity can be reduced by the identification of essential factors (concepts and principles)
- Complexity is addressed by proper organization in describing complex behaviors
- Complexity rises when systems are disorganized resulting random behavior

Principles (Continued)

- People have various perceptions of complexity as well as potentially participating in a system resulting in the addition of complexity
- Situation systems result from (problems or opportunities) or from defined objectives in the form of end states
- Respondent systems are developed and utilized to handle situation systems
- Sustained system assets are instantiated and deployed in respondent systems
- One of the elements of a respondent system must provide control

Learn How to Survive in the World of Complex Systems

Travel in the Systems Landscape

Questions or Comments ???