Module 4:
An introduction to systems and the System LifeCycle (SLC)
Session 1 of 5

Rev. 3.4.7

Why this Module is in the course

- Situations arise in systems
- Systems are products and processes
  - Process of converting undesirable situation to desirable situation is a system
- FCFDS is made up of a number of [sub]systems operating together in harmony
- Systems development passes through several states of the (system lifecycle [SLC]) known as the systems development process (SDP) or sometimes as the systems engineering process (SEP) or the System Development LifeCycle (SDLC)

Objectives

1. To explain the nature of systems
2. To introduce and use the functional view of a system
3. To introduce and explain a template for a system
    1. integrates mission, viability and resource management into the system at the start of the system development process
    2. instead of adding those functions as bolt-ons later in the system development process
4. To introduce and explain ways of creating systems
5. To provide the background for the activities performed by systems engineers in the various states of the SLC

Knowledge-1

- Lecture
    - Overview and summary of readings
- Readings
    - 0402 Kasser J.E., Holistic Thinking: Chapter 7, The nature of systems, Createspace, 2015
    - ~~0403 Systems Engineering Chapter 5 An Introduction to Systems~~
    - ~~0404 Kasser J. E., Perceptions of Systems Engineering: Chapter 18, guidelines for creating a system, Createspace, 2015~~
    - ~~0405 Systems Engineering Chapter 8 The Systems Lifecycle~~
    - ~~0406 Systems Engineering Chapter 17 The nuts and bolts of systems~~

Knowledge-2

- References
  - 0450 MIL-D-18300.H - Design Examinations, Engineering Avionic Systems/Equipment, General Requirements for, 1970, http://everyspec.com/MIL-SPECS/MIL-SPECS-MIL-D/download.php?spec=MIL-D-18300H.042296.PDF, accessed 23 March 2016
  - 0451 MIL-STD-882E - DoD Standard Practice for System Safety, 2012, https://acc.dau.mil/adl/en-US/683694/file/75173/MIL-STD-882E%20Final%202014-05-11.pdf, accessed 23 March 2016
  - 0452 MIL-STD-1472G - Human Engineering, 2012, https://contracting.tacom.army.mil/majorsys/bss/MIL-STD-1472G.pdf, accessed 23 March 2016
- Exercises

Topics

- **Nature of systems**
- Basic system behaviour
- Emergence
- Hierarchies of systems
- Functional view of a system
- Template for a system
- Supply chains
- Ways of creating systems for managing complexity
- The system lifecycle

System

- Literature contains many definitions of the word 'system';
  - For example Webster's dictionary provides 51 definitions
    - (Webster, 2004).
- Definitions have changed over the last 40 years and are still changing
  - FUSE Section 17.1
- These definitions contain or imply the following minimum set of common elements:
  1. An external environment or containing system
  2. An external boundary
  3. Internal components
  4. Relationships between the components
  5. Inputs
  6. Outputs

Definition of a System

- **An abstraction (from the real world)**

Noun

To remind us that the system must be viewed in its context

Definition of a System

- **An abstraction (from the real world) of a set of objects,**

The components of the system

Definition of a System

- **An abstraction (from the real world) of a set of objects, each at some level of decomposition,**

Each component is of itself an abstraction of an aggregate of components (down to the sub-atomic particle level)

Definition of a System

- **An abstraction (from the real world) of a set of objects, each at some level of decomposition, at some period of time,**

The system and its components need to be considered at the same period (instant) of time

Definition of a System

- **An abstraction (from the real world) of a set of objects, each at some level of decomposition, at some period of time, enclosed in an arbitrary boundary,**

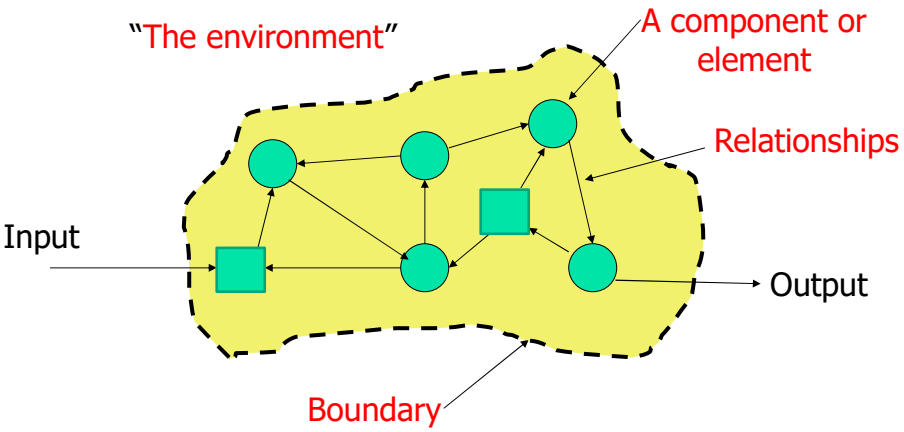
The boundary is defined by the observer

Definition of a System for the purpose of teaching

- **An abstraction (from the real world) of a set of objects, each at some level of decomposition, at some period of time, enclosed in an arbitrary boundary crafted for a purpose.**

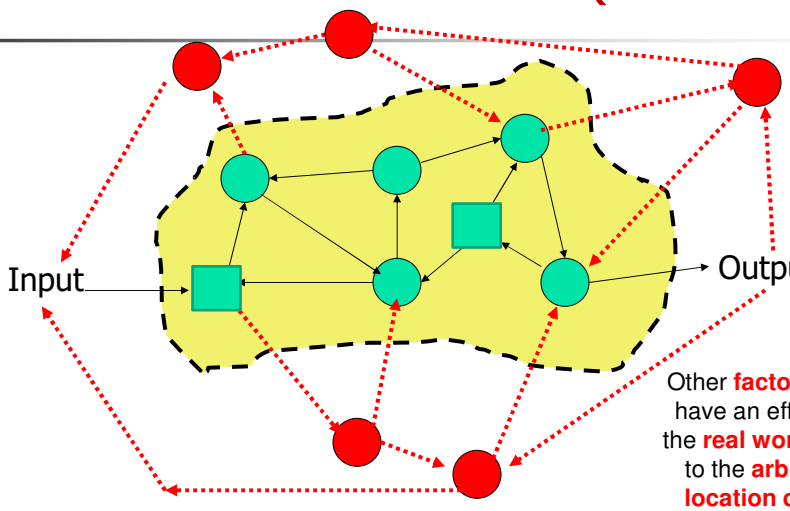
The system does not have to have a purpose. The boundary is defined by the reason for the system in the mind of the observer

Common Elements of a System*



* Flood and Jackson, 1991

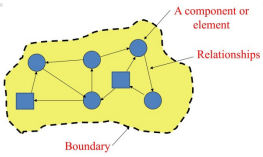
The Real World (context)

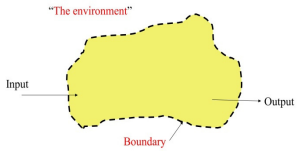


Other **factors** may have an effect on the **real world**, due to the **arbitrary location of the system boundary**

Open and closed systems

- Two views of same system
- Closed (S6)
  - **Internal** or 'white box' view
  - Functions performed by the system
    - How the system works
  - Structure of system
    - Architecture, technology, etc.
- Open (S6 in S7)
  - **External** or 'black box' view
  - *Big Picture* – meta-system and adjacent systems
  - Missions/operations performed by the system
    - What the system does





Kasser, J.E., Lerner B., Two major misconceptions of systems thinking exposed, *British Computer Club Webinar*, April 2023.

Topics

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System behaviour

- Behaviour of
  - Parts
  - Interactions between parts
- Behaviour can be
  - Desired
  - Undesired
  - Known
  - Unknown
  - Stable
  - Unstable
- COPS Module 3

Homeostasis

- Self-regulating
- Steady state
- Maintaining a predetermined position
  - Goal seeking
  - May oscillate about the position

Behavioural classification of systems*

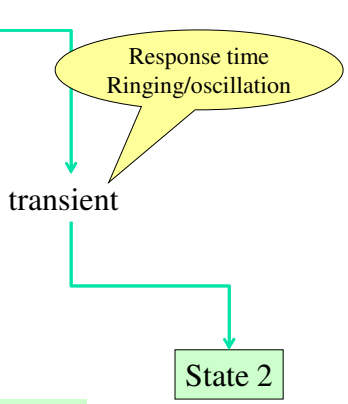
Type of System	Behaviour of System	Outcome of Behaviour
State-Maintaining	Variable but determined (reactive)	Fixed
Goal-Seeking	Variable and chosen (responsive)	Fixed
Multi-Goal-Seeking and Purposive[1]	Variable and chosen	Variable but determined
Purposeful[2]	Variable and chosen	Variable and chosen

1. A multi-goal-seeking system, the different goals of which have a common property
2. One which can produce the same outcome in different ways in the same (internal or external) state and can produce different outcomes in the same and different states.

* Ackoff, R. L., *Towards a system of systems concepts*, Management Science 17 (1971), no. 11, page 665

System stability

- Inertia
- Momentum
- Homeostasis
  - Point of equilibrium
- Mode changes
  - Ice, water, steam
  - Ship, storm, ship'
  - Government, election/revolution, government'
  - Family, baby, family'
  - Country, earthquake/tsunami, country'
  - Situation, policy, situation'
  - System, failure, system'
  - System, upgrade, system'
  - Amplifier, transient, oscillator



Transient may be considered as a state if appropriate

Topics

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Emergence

- The process of coming forth, issuing from concealment, obscurity, or confinement*
  - * Oxford English dictionary
- Functionality emerges from the components and the interactions between the components
  - Example
    - Wires, transparent container, inert gas or vacuum
    - Power source
- Property of a system as a whole, not of a component
- Principle: a property of level in hierarchy that is not observed at a lower level

Emergent properties

1. **Known (observed or predicted)**
   1. **Desired** – being the purpose of the system
   2. **Undesired** – based on experience and should be
      1. Prevented (designed out)
      2. Mitigated (compensated for)
   3. **Don't care**
2. **Unknown** (which once discovered turn out to be)
   1. **Undesired** – functionality performed by the system, also known as 'side effects'.
   2. **Serendipitous** – beneficial and desired once discovered, but not part of the original design
   3. **Don't care**

Systems behaviour

- Sum of behaviour: functions performed by
  - Subsystems
  - Interactions between subsystems
- Principle of hierarchies applies
  - In next section

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Principle of Hierarchies-1 of 3

1. All systems of a relatively stable character, display hierarchical organisation of levels
2. Systems exist within meta-systems (containing systems)
3. Systems contain subsystems
4. A subsystem of a system may be a system with its own subsystems
5. What a system does (or will do) is defined in the meta-system

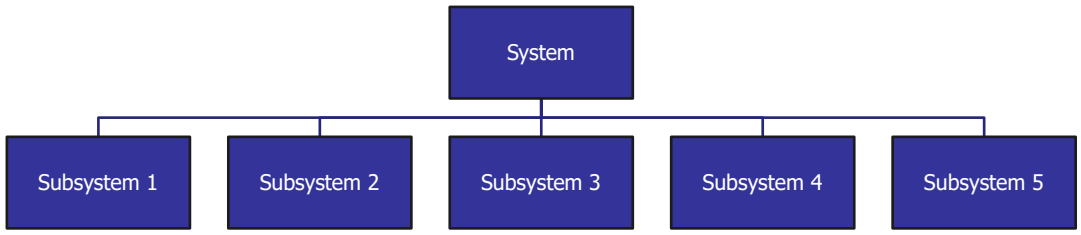
Systems Thinker's Toolbox Section 3.2.7
COPS Module 6 Section 1

Principle of Hierarchies-2 of 3

6. The properties at any level are different to the properties of other levels
7. The properties at any level consist of the combination of
   1. The properties of the subsystems/components in the next lower level
   2. The interactions between the subsystems/components in the next lower level (emergent properties)
8. When looking up from the perspective of the next lower level or when creating the system
   1. Some of the emergent properties at any level can be predicted
   2. Some of the emergent properties at any level cannot be predicted

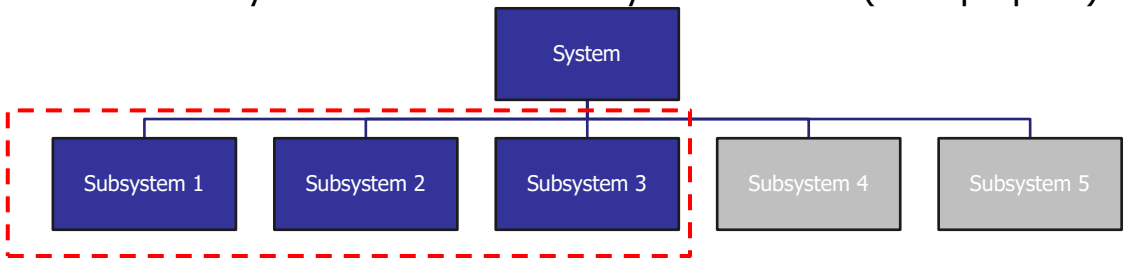
Principle of Hierarchies-3 of 3

9. A disturbance introduced into the system at any one level can reverberate in other levels
10. A system of interest (SOI) is made up of two or more of the subsystems of the system



Principle of Hierarchies-3 of 3

9. A disturbance introduced into the system at any one level can reverberate in other levels
10. A system of interest (SOI) is made up of two or more of the subsystems of the system
11. The boundary of the SOI is crafted by the observer (for a purpose)



The Siphonaptera

Big fleas have little fleas,
Upon their backs to bite 'em,
And little fleas have lesser fleas,
and so, ad infinitum.

And the great fleas, themselves, in turn
Have greater fleas to go on;
While these again have greater still,
And greater still, and so on.

The nursery rhyme is closely based on lines by Jonathan Swift from his long satirical poem "On Poetry: a Rhapsody" (1733), Wikipedia, accessed 14/2/2011

Using the Principle of Hierarchies-1

- Abstract out or hide the non-pertinent internal components of systems and subsystems
- Organize the components into a hierarchy
  - Remember Miller's and Military rules (5-10 items)
    - You may be able to handle more, but thousands of years ago, before George Miller (1986), smart people determined the average person's cognitive limit and used it in the military and in civil government organizations (e.g., hierarchical feudal system)
  - Optimize the interfaces
    - Overcomes (dissolves) systems optimization paradox

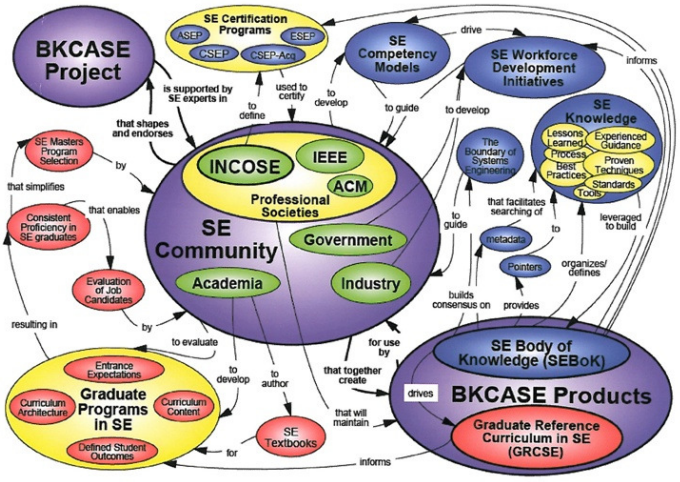
Using the Principle of Hierarchies-2

- Keep the systems and subsystems at the same level in the hierarchy of systems.
- Abstract out or hide the internal components of systems and subsystems in any one view
- You only have to deal with three levels
  - Meta level
  - System level
  - Subsystem level

You are always here

Ignoring principle of hierarchies

- Creates artificial complexity
- Ignores Miller's rule
- Combines *Hierarchical* and *Operational* perspectives
- 3 levels in hierarchy in drawing
- Missing links
- Ambiguous
- Wishful thinking



Exercise 4-11

1. How many airport systems can you see in the picture in the following slide?
2. What are they?
3. Perceive (imagine) the situation from the HTPs
4. Prepare <5 minute presentation
    1. This slide
    2. The version number of the lesson
    3. Perceptions of the systems – documented by descriptive HTP
    4. Formulated problem per COPS problem formulation template
    5. Number of airport systems
    6. List of the airport systems
    7. Lessons learned from exercise
    8. The compliance matrix
5. Save as a PowerPoint file in format Exercise4-11-abcd.pptx
6. Post/email presentation as, when and where instructed

Exercise 4-11 cont.

Exercise 4-12 knowledge reading

1. Prepare a brief on two main points in reading 0402 (< 5min)
2. Presentation to contain
    1. Formulated problem per COPS problem formulation template
    2. A summary of the content of the reading (<1 minute)
    3. The compliance matrix
    4. This slide and the lesson version number
    5. A list of the main points
    6. The two briefings
    7. Reflections and comments on reading (<2 minute)
    8. Comparisons of content with other readings and external knowledge
    9. Why you think the reading was assigned to the module
    10. Lessons learned from module and source of learning e.g. readings, exercise, experience, etc. (<2 minutes)
3. Save as a PowerPoint file as Exercise4-12-abcd.pptx
4. Post/email presentation as, when and where instructed
5. Brief on one main point

Any questions ?

1. Best
2. Worst
3. Missing

Email:
beyondsystemsthinking@yahoo.com
Subject: <class title> BWM Session #