Module 6: Remedying simple and complex problems: Session 1 of 2

Rev. 1.7.8

Objectives

1. To explain complexity
2. To explain the difference between simple and complex problems
3. To explain how to remedy complex problems
4. To explain how to remedy wicked problems

Knowledge

- Lecture
  - Overview and summary of readings
- Readings/videos
  - 0602 POSE Chapter 16: The nine-system model (Session 2)
  - 0603 Holistic Thinking Chapter 12: Creating your own innovative solutions to complex problems
  - 0604 How many objects does a system have to contain to be a complex system?, 2020, https://youtu.be/w7IKXnQE5nY
  - 0605 POSE Chapter 18: Guidelines for creating a system (Session 2)
- Exercises

Topics

- **Complexity**
- Managing complexity (complex problems) by
  - Using an actual number for "large" in the definition of objective complexity?
  - Separating objective and subjective complexity help remedy complex problems
- Reasons why some people can tackle complexity successfully while others cannot
- The nine-system model
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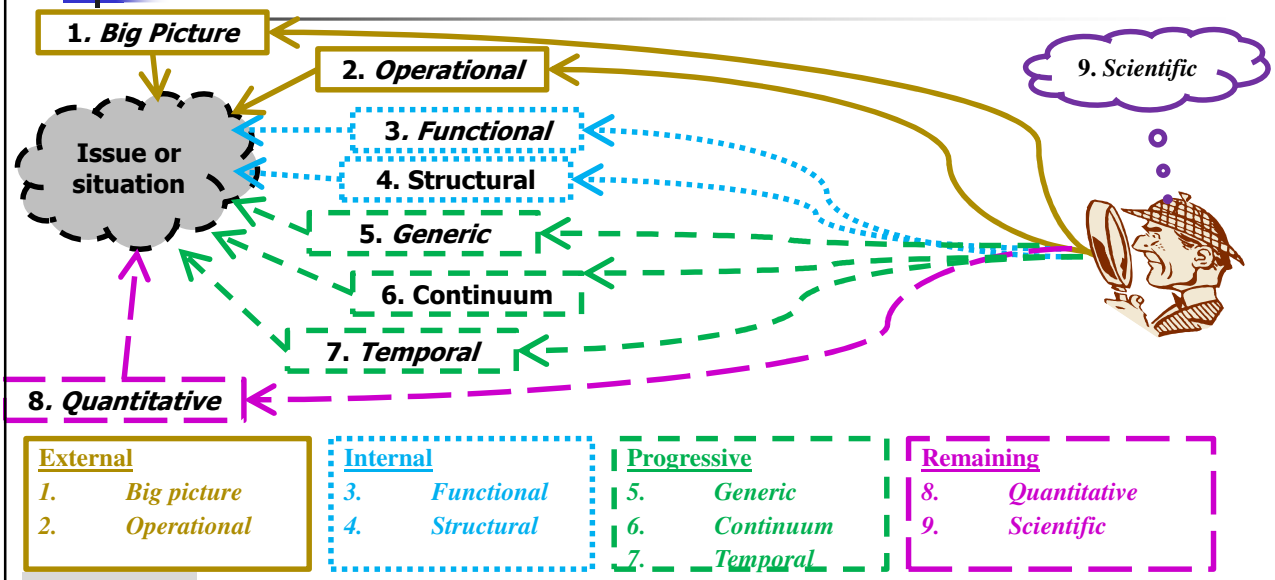
- Summary

Gaining an understanding of complexity*



External	Internal	Progressive	Remaining
1. Big picture	3. Functional	5. Generic	8. Quantitative
2. Operational	4. Structural	6. Continuum	9. Scientific
		7. Temporal	

*STT 10.1

Complexity : *Big Picture*

- Complexity is all around us
- Complexity is only a concern when there is a complex problem
  - Something undesirable
- Different definitions of complexity and complex problems
- We tend to manage complexity by ignoring non-relevant issues
- We don't understand the reason for what is being observed in some complex situations
- Assumptions
  - Complexity produces complex problems

Complexity: *Operational*

- People tackling complex problems with various degrees of success
  - Cruise ships fleets
  - Airlines
  - Oil extractions process to retailing
  - ATM for financial transactions

Complexity : *Structural*

1. Layers of complexity (the HKMF)
2. Definitions of complexity contain
   - Large number of elements
   - Interactions between elements
   - Unpredictable outcomes
   - Difficult to understand

Large is undefined

Definitions: Dictionary.com (2013)

- ***Complex***
  - Composed of many interconnected parts; compound; composite: [e.g.] a complex highway system.
  - Characterized by a very complicated or involved arrangement of parts, units, etc.: [e.g.] complex machinery.
  - So complicated or intricate as to be hard to understand or deal with: [e.g.] a complex problem.
- ***Complicated***
  - Composed of elaborately interconnected parts; complex: [e.g.] complicated apparatus for measuring brain functions.
  - Difficult to analyze, understand, explain, etc.: [e.g.] a complicated problem.

Complexity : *Generic*

- Lack of understanding what is going on also happens in scientific research
  - First situation in scientific method
- Definitions
  - **Complexity** is in the eye of the beholder
    - Jackson, M. C. and Keys, P., "*Towards a System of Systems Methodologies*", Journal of the Operations Research Society, Vol. 35 (1984), no. 6, pages 473-486
  - A **complex** system is an assembly of interacting members that is difficult to understand as a whole
    - Allison, J. T., "Complex System Optimization: A Review of Analytical Target Cascading, Collaborative Optimization, and Other Formulations," The University of Michigan, 2004, page 2

Complexity : *Continuum*

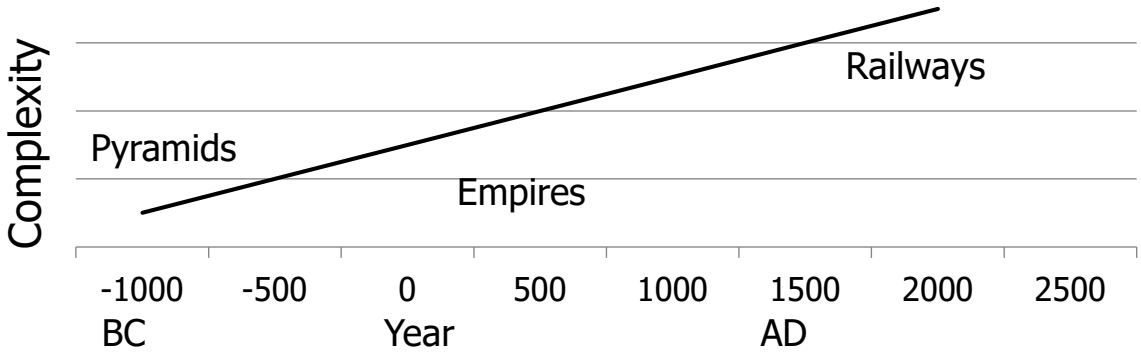
1. A dichotomy
   1. It's a major problem
   2. What's the problem?
2. Confusion between complex problems and wicked problems
3. Complexity can be split into
   1. Objective complexity
      - Based on connections and interactions
   2. Subjective complexity
      - Based on difficulty of understanding
4. Difference between a complex and non-complex system is the undefined '**large**'

Two Types of objective complexity

- **Real world complexity** - in which elements of the real world are related in some fashion, and made up of components.
  - We try to abstract out real world complexity
- **Artificial complexity** – elements of the real world that **should** have been abstracted out when drawing the internal and external system boundaries, since they are not relevant to the system (problem at hand)
  - Shown in the cartoons of Rube Goldberg or W. Heath Robinson

Complexity : *Temporal*

- Tackling problems posed by complexity has always been at the boundary of knowledge



Complexity : *Quantitative*

- Objective complexity
  - No specific numbers attached to
    - Large number of elements
    - Large number of interactions
  - General lack of weighting of contribution of element to complexity
    - All assumed to be equal
- Subjective complexity
  - Levels of difficulty of problem
  - Domain knowledge

Complexity: *key questions*

- Questions:
  1. *Quantitative* HTP
     1. What is the value of "large" in the definition of objective complexity?
  2. *Continuum* HTP
     1. Can separating objective and subjective complexity help remedy complex problems?
     2. Why can some people tackle complexity successfully while others cannot?

Topics

- Complexity
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Complexity : *Scientific*

- Answers to:
  1. **What is the value of "large" in the definition of objective complexity?**
  2. Can separating objective and subjective complexity help remedy complex problems?
  3. Why can some people tackle complexity successfully while others cannot?

Reading 0604 (video)

How many objects does a system have to contain to be a complex system?

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Complexity : *Scientific*

- Answers to:
  1. What is the value of "large" in the definition of objective complexity?
  2. **Can separating objective and subjective complexity help remedy complex problems?**
  3. Why can some people tackle complexity successfully while others cannot?

Subjective Easy – Medium – Ugly - Hard

- Reducing subjective complexity
- Increasing subject-matter (domain) expertise
- Gaining an understanding
  - Education and training
  - Experience
  - Mentors
  - Consultants

Separating subjective and objective

1. Manage subjective complexity
   - By gaining an understanding of the situation (reducing subjective complexity)
2. Manage objective complexity
   - Start by using the principle of hierarchies (reducing objective complexity) to build a mental model of the situation
     - set the architecture/structure to 5-10 system/subsystems
     - at each level in the hierarchy
3. Iteratively if necessary

Reducing objective complexity at any level in the hierarchy

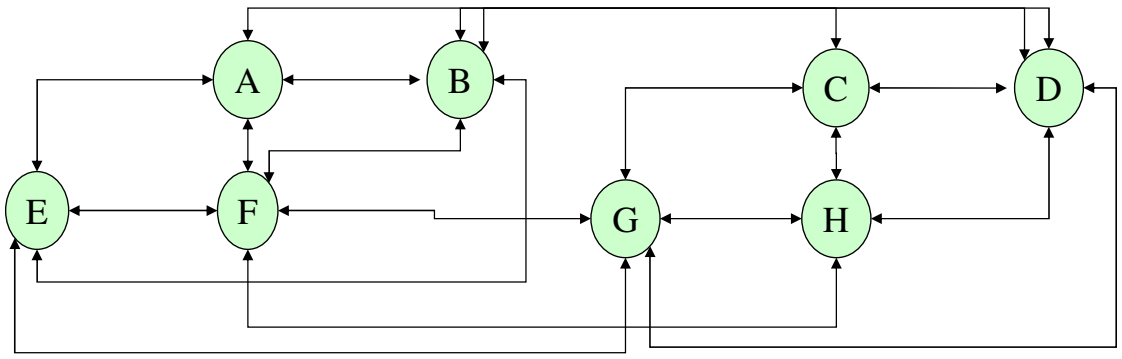
1. Abstract out non-pertinent aspects of the situation
   - Minimizes artificial objective complexity
2. Keep number of subsystems at any level to less than 7±2
   - Miller's rule for comprehension (Miller 1976)
   - Use principle of hierarchies
3. Minimize coupling between subsystems
   - Weaken interactions
4. Maximize cohesion of subsystems
5. Configure subsystems for the maximum degree of homeostasis
   - Self regulation
6. Optimize interfaces

How to do it

- Start with the undesirable situation
- Create list of entities
- List of their relationships
  - Causal loops
  - Strength of relationships if known
- Create composite causal loop
- Use principle of hierarchies to simplify perceptions of system

Example: from Module 1

- **Problem:** simplify complex system by aggregating simple low level functions (A-H) into more complex higher level functions



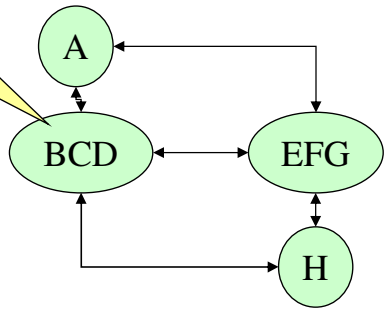
N^2 chart representation

A	o		o	o	o		
o	B	o	o	o	o		
	o	C	o			o	o
o	o	o	D			o	o
o	o			E	o	o	
o	o			o	F	o	o
		o	o	o	o	G	o
		o	o		o	o	H

Aggregated (synthesized) subsystems

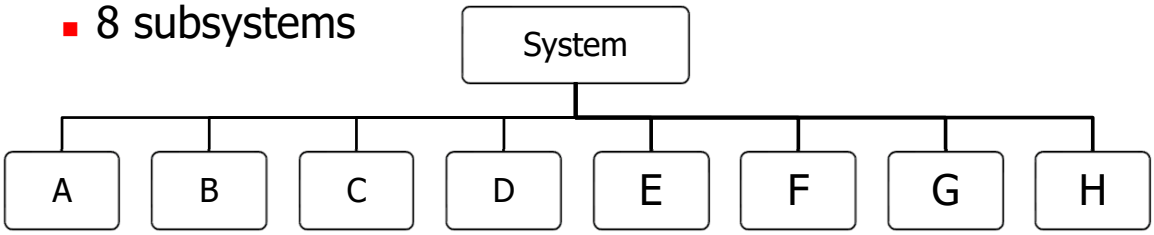
Subsystems within subsystem

A	o	o	
o	BCD	o	o
o	o	EFG	
	o	o	H



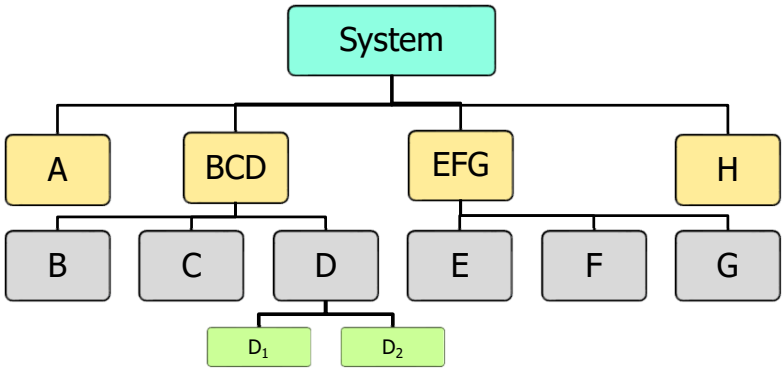
Structural HTP (before)

- System
  - 8 subsystems



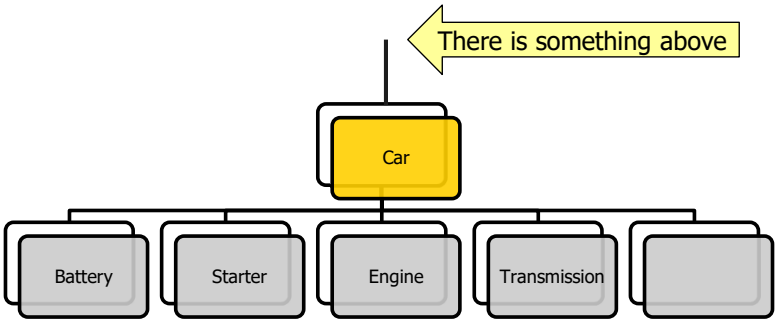
Structural HTP (after)

- System
  - 4 subsystems
    1. A
    2. BCD
    3. EFG
    4. H
- BCD
  - 3 subsystems
- EFG
  - 3 subsystems



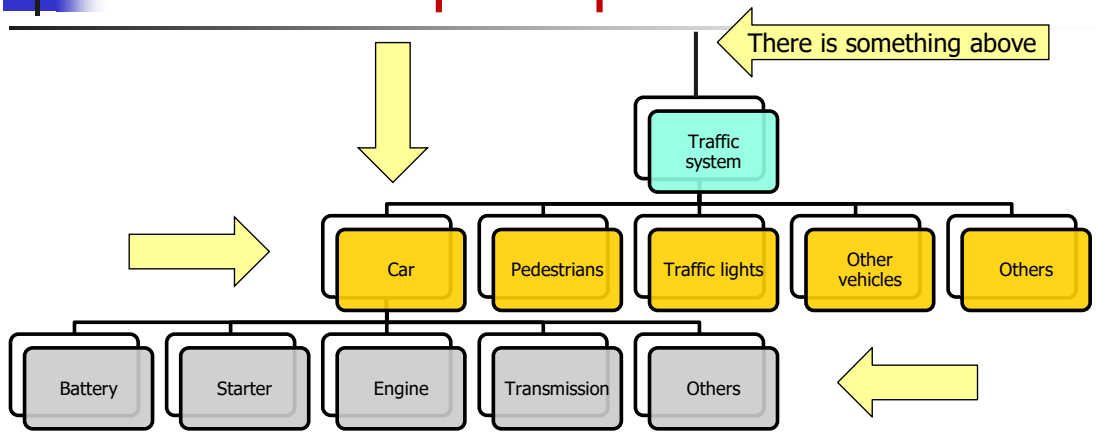
Systems of interest = working level ±1

The principle of hierarchies



Systems thinking, analysis = understanding relationships

The principle of hierarchies



Systems thinking, analysis = understanding relationships

Application of problem-solving process

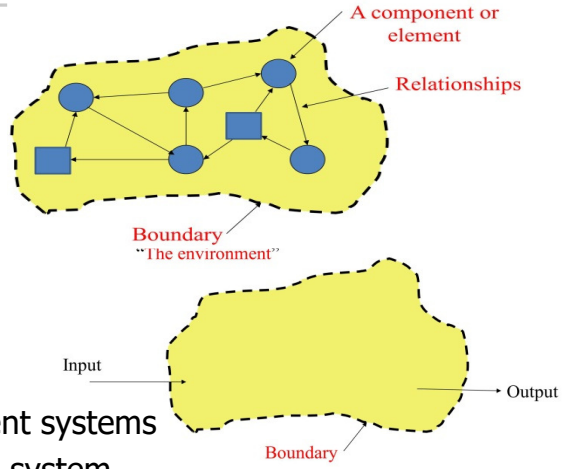
1. Defined problem space
   1. Created composite causal loop to represent understanding of situation
   2. Created N^2 chart equivalent to composite causal loop
2. Determined several solutions
   1. Different groupings in N^2 chart
3. Yet to do
   1. Determine selection criteria – next part of discussion
   2. Make selection

Gaining that understanding

- Use the principle of hierarchies
- A situation contains a number of systems
- Each system may contain a number of subsystems
- Each subsystem may be further elaborated into a number of components
  - subsystems of the subsystem
- Keep the systems and subsystems at the same respective level in the hierarchy of systems
- Abstract out or hide the internal components of systems and subsystems by using partial views of area of interest
- Each level in hierarchy has
  - Similar generic and different specific risks
  - Different emergent properties

Managing complexity via partial views

- *Functional* HTP
  - **Internal** or 'white box' view
  - Functions performed by the system
    - How the system works
  - Structure of system
    - Architecture, technology, etc.
- *Operational* HTP
  - **External** or 'black box' view
  - Big picture – meta-system and adjacent systems
  - Missions/operations performed by the system
    - What the system does



Optimize the interfaces

- Iterative step with aggregation
- Minimize interaction between subsystems at interfaces
  - Ideally a single interface between entities
    - Coupling and cohesion
- Perform grouping in N^2 accordingly

Apollo program-1

- Optimized to transfer men and scientific equipment (Apollo Lunar Surface Experiments Packages (ALSEP)) between the earth and the moon
  - in the most efficient manner within the constraints of the then available technology.
- From the *Structural* perspective
  - The system contains three top-level physical subsystems
    1. Terrestrial
    2. Lunar
    3. Interface system between the terrestrial and lunar subsystems

Apollo program-2

1. ***The terrestrial subsystem***
   - The NASA manned spacecraft centers and headquarters
2. ***The lunar subsystem***
   - Empty before the first landing
   - Contained an increasing number of Apollo Lunar Surface Experiments Packages (ALSEP), the set of scientific instruments deployed by the astronauts at each of the landing sites
   - Two astronauts while on they were on the lunar surface
3. ***The interface subsystem***
   - The spacecraft
   - The astronauts (three while in transit, one when in lunar orbit)
   - The NASA Communications Network (NASCOM) communications subsystem

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Exercise 6-11

- Identify at least 20 entities in the mission and support subsystems of this class from previous exercises (add new ones if pertinent)
- Insert in N^2 chart
- Aggregate them into subsystems using the principle of hierarchies
- Prepare presentation on
  1. This slide and version of lesson
  2. Problem formulated according to the problem formulation template
  3. Compliance matrix
  4. Lessons learned
  5. Structural view of subsystems
- Save as a PowerPoint file as Exercise6-11-abcd.pptx
- Post in the asynchronous group as instructed

Knowledge reading exercise 6-12

1. Prepare a brief on two main points in reading 0603 (< 5min)
2. Presentation to contain
    1. A summary of the content of the reading (<1 minute)
    2. The compliance matrix
    3. The problem formulated per the problem formulation template
    4. This slide and 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 Exercise6-12-abcd.pptx
4. Post/email presentation as, when and where instructed
5. Brief on one main point

Knowledge reading exercise 6-13

1. Prepare a brief on two main points in reading 0604 (< 5min)
2. Presentation to contain
    1. A summary of the content of the reading (<1 minute)
    2. The compliance matrix
    3. The problem formulated per the problem formulation template
    4. This slide and 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 Exercise6-13-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 Lesson #