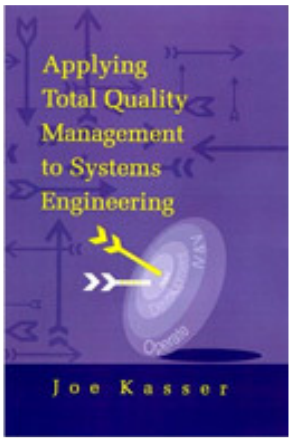
A systems thinking approach for managing complex systems
Session 6 of 6
Managing complexity

Version 1.2.2

Topics

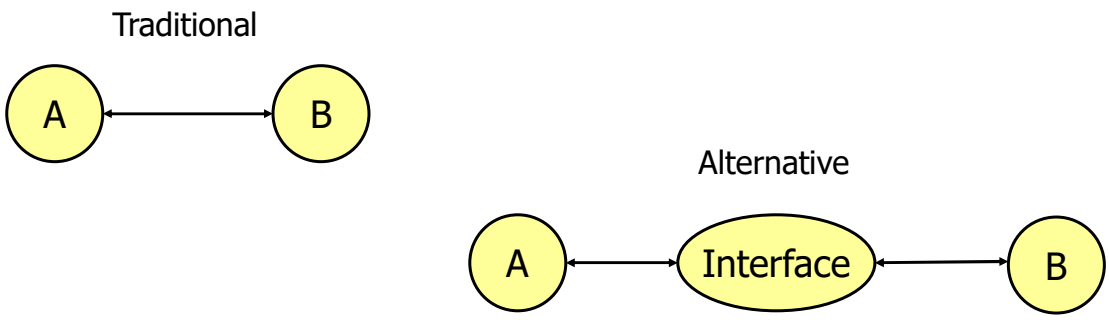
- Purpose
- Thinking and systems thinking
- Systems and system of interest
- Principle of hierarchies
- Emergence and emergent properties
- Problems and solutions
- The problem formulation template
- Complexity
- Interface partitioning
- Classification and types of problems



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

Alternative top level partitioning



Apollo program-1

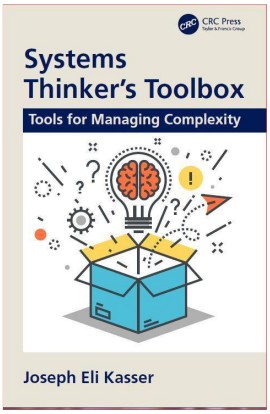
- Optimized to transfer men and scientific equipment (Apollo Lunar Surface Experiments Packages (ALSEP)) between the earth and the moon
  - in the most efficient manner within the constraints of the then available technology.
- From the *Structural* perspective
  - The system contains three top-level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

Apollo program-2

1. ***The terrestrial ~~sub~~system***
   - The NASA manned spacecraft centers, headquarters, launch and landing subsystems, etc.
2. ***The lunar ~~sub~~system***
   - 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 they were on the lunar surface
3. ***The interface ~~sub~~system***
   - The spacecraft
   - The astronauts (three while in transit, one when in lunar orbit)
   - The NASA Communications Network (NASCOM) communications subsystem

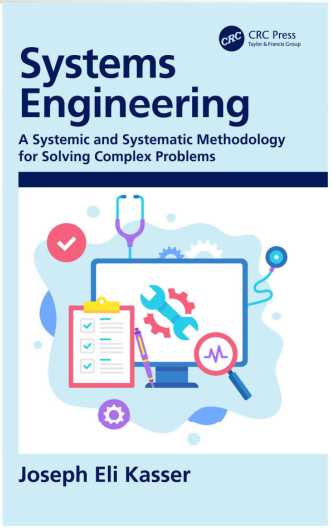
Tools, techniques and templates

	Tools, techniques and templates	Slide
1	Compliance Matrix	5
2	System of Interest (SOI)	13-36
3	Holistic Thinking Perspectives	39-43
4	Active Brainstorming	47-52
5	Principle of Hierarchies	57-73
6	Continuum of Solutions	86-87
7	Problem Formulation Template	81-95
8	Hitchins-Kasser-Massie-Mabelo Framework (HKM^{2}F)	101
9	Subjective and Objective Complexity	105-111
10	Interface partitioning	118-121
11	Mission and Support Systems Architecture	113
12	Three Structures of a Problem (well-, ill- and wicked)	
13	Iterative Problem Solving	



Topics

- Purpose
- Thinking and systems thinking
- Systems and system of interest
- Principle of hierarchies
- Emergence and emergent properties
- Problems and solutions
- The problem formulation template
- Complexity
- Interface partitioning
- Classification and types of problems



Classification of problems

1. Level of difficulty of the problem
   - Discussed earlier (subjective complexity)
2. Research and intervention problems
3. Structure of the problem
4. Complexity of the problem
5. Others

Research problems

1. **The undesirable situation** is either
   - The inability to explain observations of phenomena
   - The lack of (need for) some particular knowledge
2. **Assumptions** are situation dependent
3. **The Feasible Conceptual Future Desirable Situation (FCFDS)** is the knowledge often in the form of the supported hypothesis
4. **The problem** is how to gain the needed knowledge
5. **The solution** is the FCFDS

- **The problem solving process** is commonly known as the Scientific Method (SM), and works forwards
  - From the current situation
  - To the FCFDS in which the knowledge has been acquired
    - You don't know where you are going until you get there and/or what you will find on the journey

Intervention problems

1. **The undesirable situation** is something needs to be changed over a period of time into a FCFDS
2. **Assumptions** are situation dependent
3. **The FCFDS** is the undesirable situation without the undesirability and usually with additional desirability
4. **The problem** is how to realize a smooth and timely transition from the current situation to the FCFDS
5. **The solution** is the FCFDS
6. **The problem solving process is created** by *working backwards* to the current problematic/undesirable situation to document:
    1. the FCFDS, and
    2. the realization plans documented as a *forward process* starting from the current situation and ending with the deployment of the FCFDS

Structure of the problem

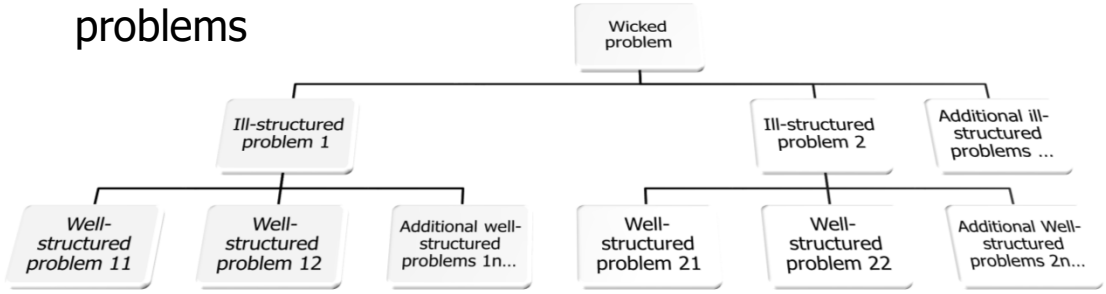
1. Well-structured
    - The existing undesired situation and the FCFDS are clearly identified
    - May have a single solution or sometimes more than one acceptable solution
2. Ill-structured
    - Either or both the existing undesired situation and the FCFDS are unclear
3. Wicked
    - Extremely ill-structured problems/situations
    - Sometime known as messy problems

Problem and sub-problems

- *Ill-structured problems cannot be solved* (Simon, 1973)
- So how to deal with them
- Ill-structured and wicked problems have to be converted to a (set of) well-structured problem(s)
  - Research problems
- (set of) well-structured problem(s) are solved via iterations of the problem-solving loop
  - Prioritize and take action
  - Intervention problems

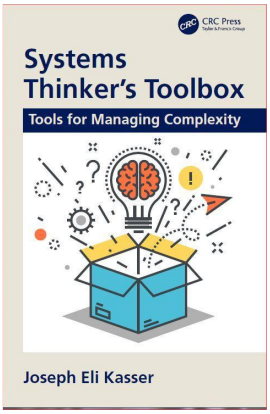
Problem decomposition

Generic HTP: system decomposition into sub-systems; problem decomposition into sub-problems



Tools, techniques and templates

	Tools, techniques and templates	Slide
1	Compliance Matrix	5
2	System of Interest (SOI)	13-36
3	Holistic Thinking Perspectives	39-43
4	Active Brainstorming	47-52
5	Principle of Hierarchies	57-73
6	Continuum of Solutions	86-87
7	Problem Formulation Template	81-95
8	Hitchins-Kasser-Massie-Mabelo Framework (HKM²F)	101
9	Subjective and Objective Complexity	105-111
10	Interface partitioning	118-121
11	Mission and Support Systems Architecture	113
12	Three Structures of a Problem (well-, ill- and wicked)	127-129
13	Iterative Problem Solving	



Confusing complexity with 'ill –structured problems"

Combined complexity

- **Objective Complexity**
  - *"A complex system usually consists of a large number of members, elements or agents, which interact with one another and with the environment"* , ElMaraghy et al., 2012
- **Subjective complexity**
  - Difficult to understand

Ill-structured problems

- Sometimes called 'ill-defined' problems or 'messy' problems are problems where either or both the existing undesirable situation and the FCFDS are unclear (Jonassen, 1997)
  - The initial feeling that something is wrong and needs to be changed
  - Where the FCFDS is unclear
  - Where different stakeholders perceive different causes of the situation and different ways of dealing with the causes

Tackling a complex situation

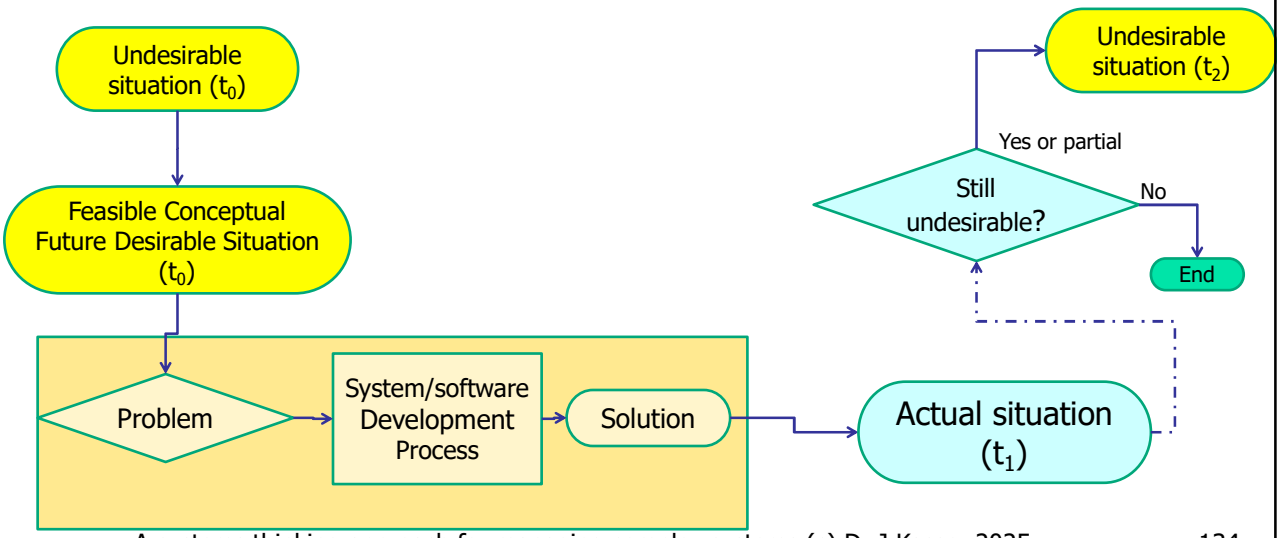
- Gain an understanding of the situation
- Determine the structure of the problem
- Proceed accordingly
  1. Convert the ill-structured and wicked problems to a set of well-structured problems
  2. Remedy the well-structured problem
  3. Decide which one to tackle
  4. Go back to step 1

The three domains of problem-solving

1. Problem
   - Unacceptable road traffic congestion
2. Solution (selected)
   - Subway
3. Implementation
   - Tunnel boring
   - Surface traffic management

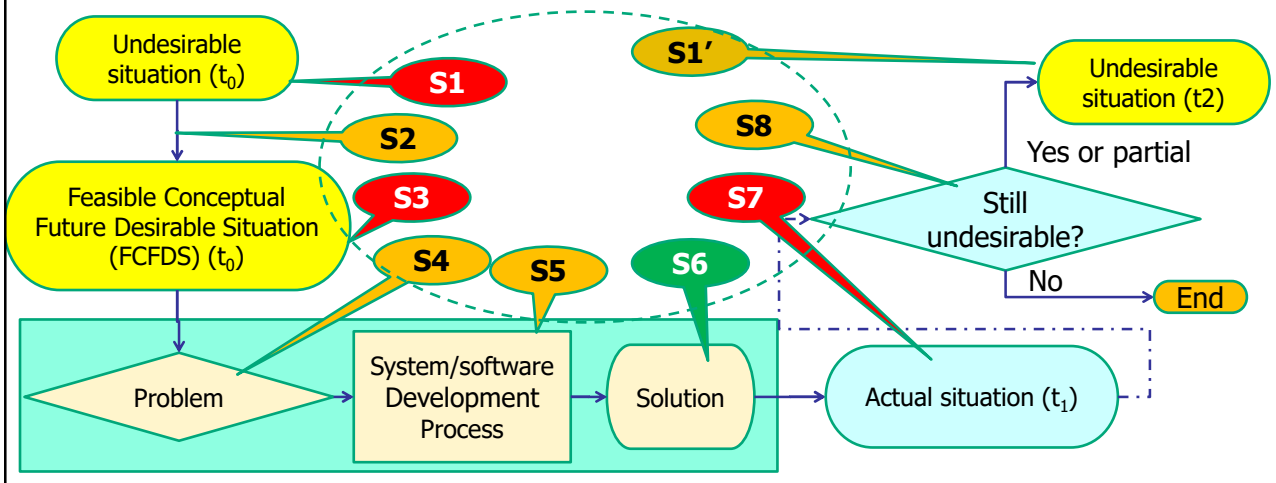
1. Problem
   - Need for specific software application in an application domain
2. Solution
   - Specific software for an application domain
   - Target platforms
3. Implementation
   - Software development environment
     - Hardware and software

The extended process (project implementation state)



A systems thinking approach for managing complex systems (c) Dr J Kasser 2025 134

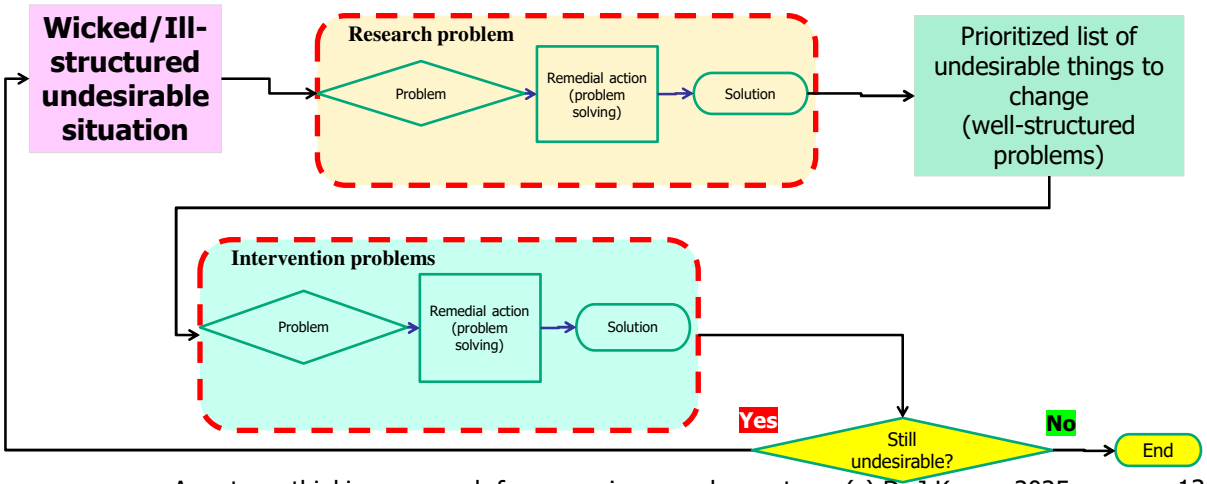
The nine system model (*Functional* view)



A systems thinking approach for managing complex systems (c) Dr J Kasser 2025 135

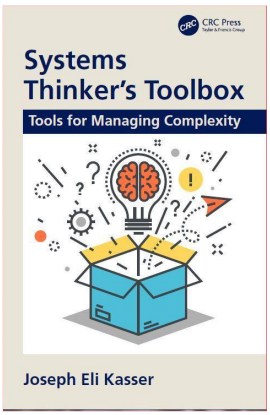
Generic iterative problem-solving

- Sequential research (1st) and intervention (2nd) problems



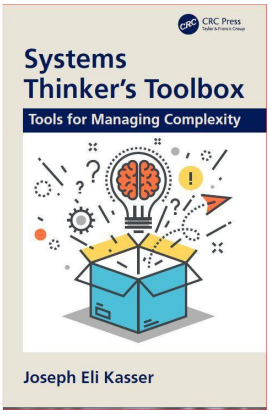
Tools, techniques and templates

	Tools, techniques and templates	Slide
1	Compliance Matrix	5
2	System of Interest (SOI)	13-36
3	Holistic Thinking Perspectives	39-43
4	Active Brainstorming	47-52
5	Principle of Hierarchies	57-73
6	Continuum of Solutions	86-87
7	Problem Formulation Template	81-95
8	Hitchins-Kasser-Massie-Mabelo Framework (HKM^{2}F)	101
9	Subjective and Objective Complexity	105-111
10	Interface partitioning	118-121
11	Mission and Support Systems Architecture	113
12	Three Structures of a Problem (well-, ill- and wicked)	127-129
13	Iterative Problem Solving	132-136



Bonus tools, techniques and templates

	Tools, techniques and templates	Slide
14	Miller's rule	14
15	Working back from the answer/solution	91,93,94
16	Need for two solutions	87
17	The three domains of problem-solving	133
18	Nine systems model	135
19	Iterative problem solving	134-136



Exercise 6 Managing complexity

1. In exercise 1 you stated an assumed problem with INCOSE
2. Think about
   1. The exercises you did in this workshop
   2. The information you identified
   3. Some of the information you still need to create an acceptable solution and where you would obtain that information
   4. All assumptions
   5. The sequence of events you would go through to realize that solution ("what" not "how")
3. Prepare presentation containing
   1. Your assumed problem reformulated according to the Problem Formulation Template
   2. The sequence of events you would go through to realize that solution ("what" not "how")
   3. Compliance matrix for exercise
   4. Lessons learned in this lesson
   5. The knowledge you gained in this workshop (summary)
   6. A copy of this slide and the version number of the lesson
4. Save file as yourlastname-firstname-6.pptx (e.g., mouse-michael-6.pptx)
5. Email file to Beyondsystemsthinking@yahoo.com