Module 4:
An introduction to systems and the System LifeCycle (SLC)
Session 2 of 5

Rev. 3.4.5

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Knowledge

- 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
- Exercises

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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

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Man-made system

- Generally has a purpose (what it was designed for)
- A solution to a problem
- Think functions
- Total solution = functions performed by solution system (product) + functions performed to realize the solution system (process).
  - TS = Σ (f_s + f_p)
- Think product and process functions in the conceptual stages

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Thinking functions keeps options open

- "Communicating" function
- Realization options
  - Wireless
    - WiFi
    - 4G or 5G
    - Proprietary
  - Cable
    - Ethernet
  - Others
  - Combinations
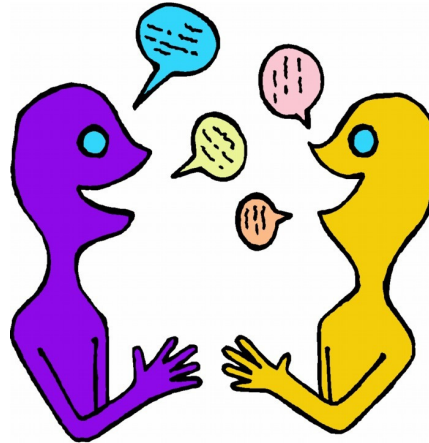
Thinking functions keeps options open

- "Destroy specific distant target" function
- Realization options
  - Piloted aircraft with various ordnance
  - UAV – automatic
  - UAV – piloted by remote control
  - UAV – mixture of manual and automatic
  - Surface to Air Missile
  - Combinations
  - Others

Creating functional subsystems

- Options or choices
  - Top down
  - Bottom up
  - Middle out
  - Combination of above
- Group functions in accordance with rules for aggregation or synthesis
  - N^2 chart is a useful tool for
    - Grouping
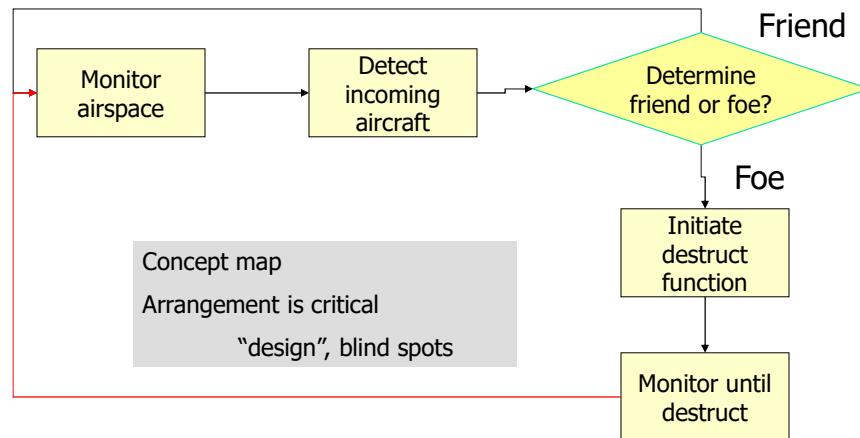   - Determining coupling between functions

Example: Air Defence System (ADS) functional operations concept

- Scenario Title
  - What the system does
    - Defend **country/city/airfield** from air attack
- Content
  - What the system does to perform its mission
    - Detects incoming aircraft
    - Launches interceptors to shoot them down
- Hierarchy

Critical

What is the support needed, how does it work?

What type?, from where?

Manned, unmanned?

Incorrect ADS Partial functional flow (mission)

Friend

| Monitor airspace | → | Detect incoming aircraft | → | Determine friend or foe? |

Foe

| Initiate destruct function |

Concept map

Arrangement is critical

"design", blind spots

| Monitor until destruct |

ADS Partial functional flow (one support scenario)

| Ensure **detection function** operates | → | Ensure **friend/foe separation function** works | → | Ensure **...** operates |
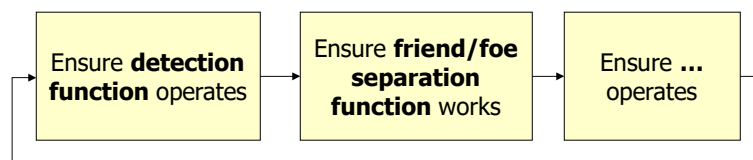
- Parallel functions or serial functions
- Depends on
- resources
- people, time, equipment
- In software, this should be run continuously in background

Capability and dependability

- Definition
  - Having the functionality needed, at the time it is needed, at the place it is needed to perform the needed mission
- Attributes of capability are also known as dependability, e.g.
  - Operational
  - Human factors
  - Reparability
  - Maintainability
  - Survivability
  - Error tolerance
  - Availability
  - Reliability
  - Safety
  - Security

> Mission and support functions cooperatively provide capability

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Non-functional dependability attributes

- Reflect the extent to which the system is
  - Operational
    - ... **performs mission functions as specified**
  - Reparable
    - ... can be repaired in the event of a failure
  - Maintainable
    - ... can be kept operational;
  - Survivable
    - ... can perform mission functions as specified whilst under hostile attack;
  - Error tolerant
    - ... can avoid and tolerate [input] errors.
- Others

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Topics

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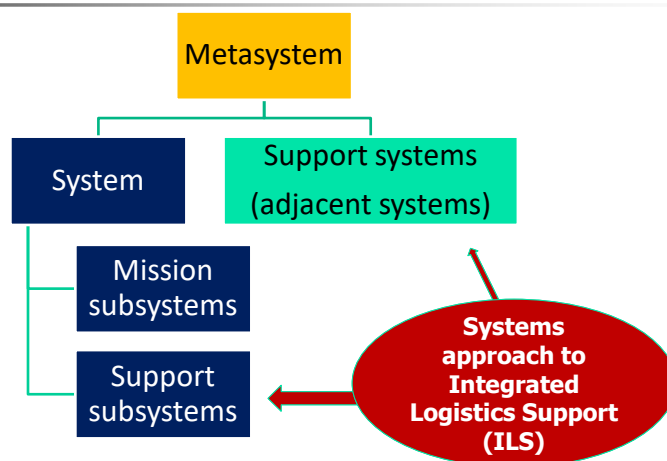- The system lifecycle
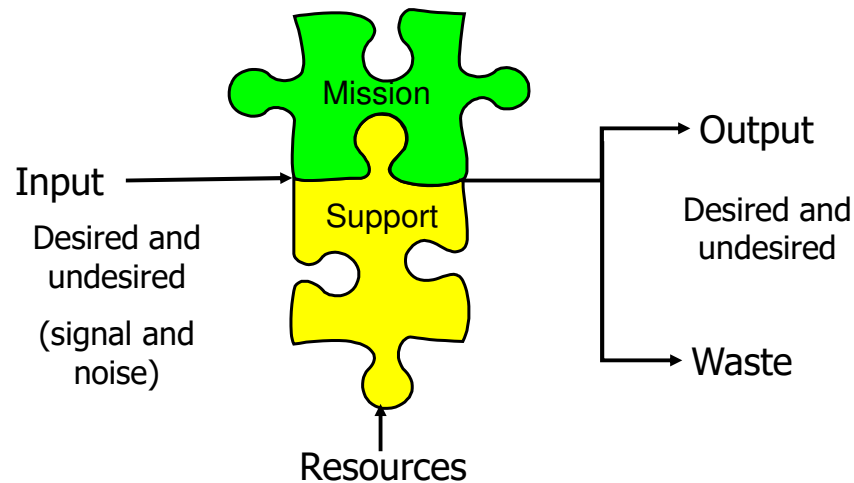
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Structure of a system

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Structural perspective: System function template

Input — Desired and undesired (signal and noise)

Mission

Support

Resources

Output — Desired and undesired

Waste

System functional template

- **Mission** – the functions which the system is designed to perform to provide a solution to the problem as and when required.
- **Support** – the functions the system needs to perform in order to be able to perform the mission as and when required.
  - **Resource management** – the functions that acquire, store, distribute, convert and discard excess resources that are utilized in performing the mission (Hitchins, 2007: pages 128-129).
  - **Viability management** – the functions that maintain and contribute to the survival of the system in storage, standby and in operation performing the mission (Hitchins, 2007: pages 128-129).

Missions and support

- Missions (*Big Picture*)
  - Military
    - Peacetime
    - Wartime
  - Commercial
    - Production
    - Distribution
    - Service
  - Supply
    - Retail and wholesale

- Scenarios (*Operational*)
  - What the system does
  - What is done to support the mission
  - Drive requirements and design of system and support system
- Functions (*Functional*)
  - Activities performed in the mission and support scenarios

Aircraft scenario to function mapping

| Functions	Scenarios				
	Takeoff	Inflight	Safe landing	Ground movement	Lollygagging
Braking	M		X	X	
Controlling	X	X	X	X	
Lifting	X	X	X		
Navigating		X			
Sideways	X	X	X	X	
Thrusting	X	X	X	X	
Thumping					

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Template for a data processing system (Mission functions)
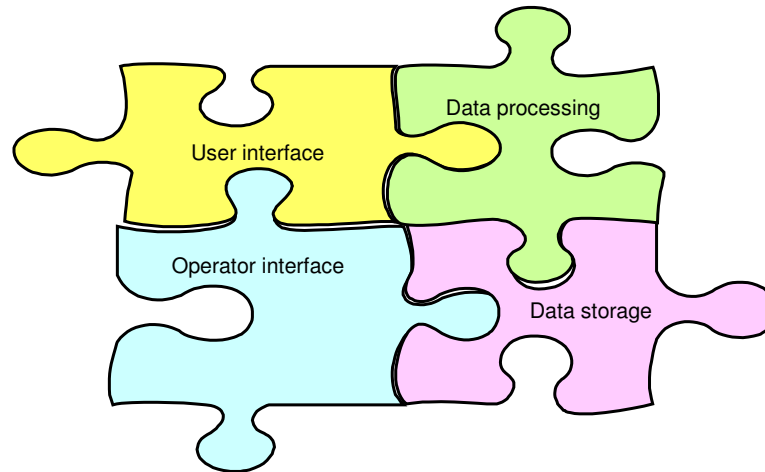
Exercise 4-21

1. Your home is a system
2. Conceptualize the mission and support systems from the Functional HTP
   1. Group them into functional mission and support systems and subsystems
      1. Use *ing, e.g. drink**ing**, eat**ing**, speak**ing**, etc.
   2. Use concept maps and N^2 charts to show how the systems and subsystems seem to be arranged
3. Prepare a <5 minute presentation containing
   1. The formulated problem per COPS problem formulation template
   2. This slide and the lesson version number
   3. A representative sample of both sets of mission and support functions
   4. The scenarios or use cases
   5. A compliance matrix for the exercise
   6. Lessons learned from exercise
4. Save as a PowerPoint file in format Exercise4-21-abcd.pptx
5. Post/email presentation as, when and where instructed

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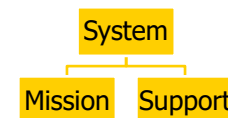
Exercise 4-22

1. Convert the mission and support systems from exercise 4-21 into physical components (*Structural* perspective)
2. Conceptualize at least 2 well-written text format requirements for 'ilities' for each physical subsystem, e.g. the availability shall be 24 hours a day, 7 days a week
3. Prepare a <5 minute presentation containing
    1. The formulated problem per COPS problem formulation template
    2. This slide and the lesson version number
    3. A representative sample of the requirements
    4. The scenarios or use cases
    5. A compliance matrix for the exercise
    6. Lessons learned from exercise
4. Save as a PowerPoint file in format Exercise4-22-abcd.pptx
5. Post/email presentation as, when and where instructed

System

Mission   Support
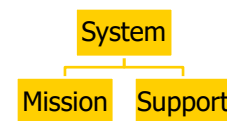
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Exercise 4-23 knowledge reading

1. Prepare a brief on two main points in reading 0403 (< 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 Exercise4-23-abcd.pptx
4. Post/email presentation as, when and where instructed
5. Brief on one main point

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Any questions ?

1. Best

2. Worst

3. Missing

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

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