Module 6: Systems engineering in the Needs Identification State Session 8 of 9

Version 4.1.3

Knowledge-1

- Lecture
- Readings
  - 0602 Systems Engineering (SE) Chapter 4, Section 4.12: The seven principles for systems engineered solution systems
  - ~~0603 Meier. S.R., "Best Practices in the DoD and IC for Large-Scale Federal Acquisition Programs", Defense Acquisition University Meet the Author Speaking Event, Jan. 27, 2009.~~
  - ~~0604 SE Chapter 9 The Needs Identification State of the SDP.~~
  - 0605 SE Chapter 20 The Engaporian Air Defence (ADS) Upgrade project, Section 20.1 – 20.2. updated from POSE Chapter 21 A role playing case study the Engaporian Air Defence System upgrade

Knowledge-2

- References (updated in 2024)
  - 0650 Pre-Milestone A and Early-state Systems Engineering: - A Retrospective Review and Benefits for Future Air Force Acquisition (151 pages), 2008 http://www.nap.edu/catalog.php?record_id=12065 , accessed 19 February 2024
  - 0651 An Enhanced Framework for the Management of Information Technology Projects, PPTO-TM-002 Project Plan Template, Chief Information Officer Branch, Treasury Board of Canada Secretariat January 2000, https://publications.gc.ca/collections/collection_2018/sct-tbs/BT53-9-2018-eng.pdf, accessed 19 February 2024
  - 0652 Analysis of Alternatives Handbook, A Practical Guide to the Analysis of Alternatives, 4 August 2017, Office of Aerospace Studies, https://www.afacpo.com/AQDocs/AoAHandbook.pdf, accessed 19 February 2024
  - 0653 Systems Engineering Plan Preparation Guide "*Technical Planning for Mission Success*", Version 2.01, April 2008, Department of Defense
- Exercises

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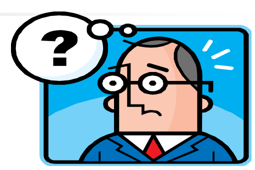
Topics



- Stakeholders
- **The three parts of the needs identification state**
- Feasibility studies
- Iterative/recursive nature of systems engineering
- The Concept of Operations (CONOPS)
- The difference between solution selection criteria and requirements
- Sensitivity analysis
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Big Picture

Complexity

Layer of complexity		A	B	C	D	E	F	G	H
Global (Planetary)	7								
Regional	6								
Socio-economic	5								
Supply chain	4								
Business	3								
System (single)	2								
Product	1								
Component	0								

Where the bulk of the systems engineering activities take place

Lifecycle States

A – Customer Needs Identification
B – System Requirements
C – Subsystem Design
D – Subsystem Construction
E – Subsystem Testing
F - Systems Integration and Test
G - Operations and Maintenance
H – System Disposal

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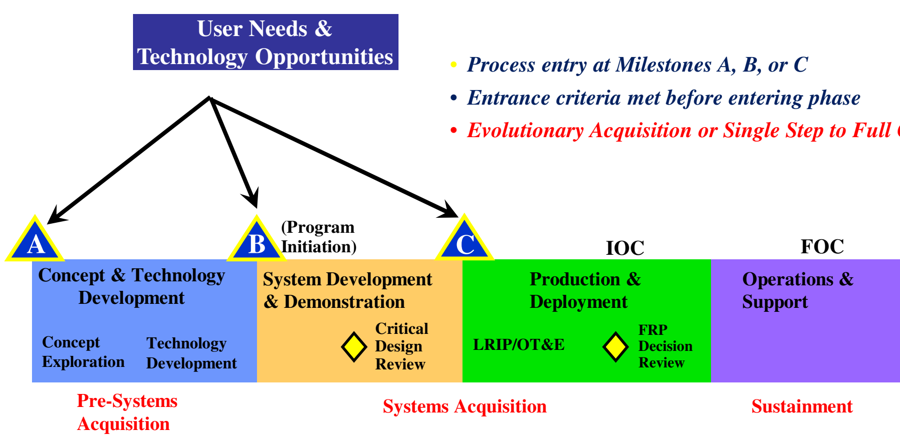
Linear thinking/single system: The 5000 Model*

- *Process entry at Milestones A, B, or C*
- *Entrance criteria met before entering phase*
- *Evolutionary Acquisition or Single Step to Full Capability*



* Bradford Brown, DoD Instruction 5000.02, 8 December 2008, Operation of the Defense Acquisition System Statutory and Regulatory Changes , DAU, Feb 2009, Version 5.4

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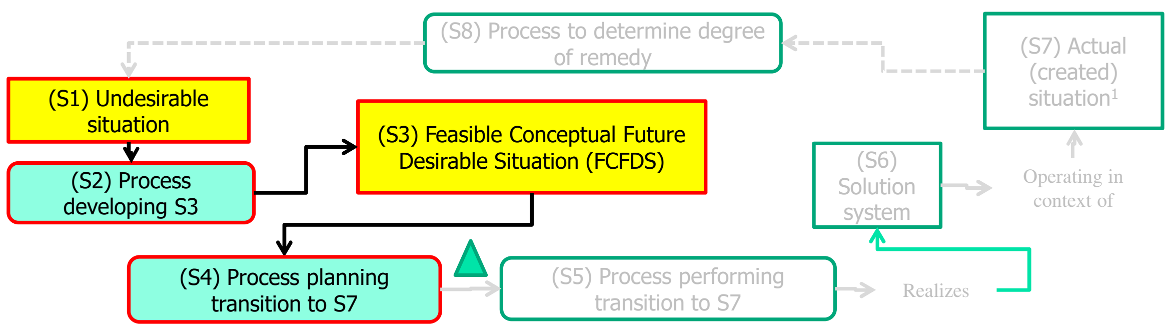
The Needs Identification State



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The 3 parts of the Needs State

A. Explores/scopes the problem (S1)
- Active brainstorming from HTPs and OARP
- Stakeholder interaction

B. Conceives the whole solution system (which 'emerges' from/ "complements" the problem) (S2)
- FCFDS (S3) and solution system operating within FCFDS (S6)

C. Designs a whole FCFDS (and CONOPS)
1. S2 developing S3 which includes S6
2. Identifies the environment, other interacting systems, the subsystems, parts, interactions, functional architecture, physical architecture, etc.
   - FRAT, HTPs
3. Formulates strategies and plans to implement (S4)
   - SPARK

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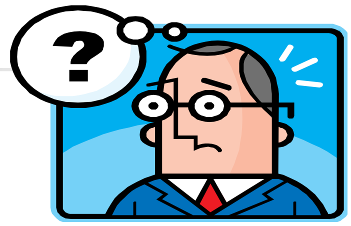
Topics



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Feasibility study-1

- Low cost future problem prevention tool
  - Conceptual risk management
- Identifies
  - Risks that preclude realization
  - If the system is really needed
  - Technical limitations
  - Consequences of deployment
  - Impact on adjacent systems
  - Return on investment (ROI)

Feasibility study-2

- Prevents building a system (unknowingly) that
  - Is not needed
  - Can't be built
  - Can't be deployed
  - Adversely impacts adjacent systems
  - Is not economic
  - Doesn't provide adequate return on investment (ROI)
- Identifies
  - Business objectives (military mission ?)
  - Fundamental reasons for developing the system
  - Potential sources of information

Typical feasibility study questions

- Why do we need the system? [Big Picture (BP)]
- What if we don't develop it? [BP]
- How will the system contribute to mission objectives? [BP]
- **What will the system do? (CONOPS) [Operational (O)]**
- **What will the system NOT do? [Continuum (C)]**
- How long will it take to develop the system? [Temporal (T)]
- How will the system impact existing and planned adjacent systems? [T]
- What are the risks and their probability of occurrence? [O, Functional (F), Quantitative (Q)]
- What are the required resources required to build the system? [O, F, Q]

Operational feasibility

- Create normal and contingency operational scenarios for mission and support functions
  - Document assumptions
  - Allocate priority and frequency of occurrence to normal scenarios
  - Allocate seriousness [of impact] values to occurrence of contingency scenarios
    - Probability of occurrence may depend on physical implementation – not known at this time)
- Obtain consensus that scenarios describe solution system as meeting the need under **all** anticipated normal and contingency operational scenarios
  - (by resolving, dissolving or solving the problem)

Economic feasibility

- Does it make economic sense to spend the money to build the solution system option?
  - Identify and estimate all capital expenditures
- Identify and estimate all fixed costs
  - Equipment, etc.
- Identify and estimate all variable costs
  - Identify people and skills required to operate
    - Wages, salaries, and benefits
- Identify and estimate project related costs, including:
  - Infrastructure development or improvements
  - advertising and promotion
  - Legal fees
  - Municipal & State development taxes
- Perform cost-benefit analysis

Similarity to previous projects.
80/20 rule for accuracy of estimates

Cost-benefit analysis

- Commercial – contractor
  - Financial factors
    - Fee provide adequate rate of return on investment (ROI)
- Commercial – new product development
  - Financial
    - Profit and loss under various situations
- Government
  - Financial in all agencies
  - Non financial in some instances (typically in Defence)
    - if the non-availability of the solution system is “not” an option

Factors to consider

- Estimated
  - Revenue
  - Costs
  - Profit Margin
  - Break-even point
  - Returns under various production, price and sales levels
- Cash flow during the start-up period
- Benchmark comparisons against competitors and/or industry averages
- Reliability of the underlying assumptions of, and data used in the financial analysis
- Limitations or constraints affecting the economic analysis

Feasibility study - Level of detail

- To be sure there is at least one feasible solution
- Detail depends on
  - Scope of problem and solution realization
  - Urgency of need
  - Realization risks
  - Other factors (e.g. political)
- Study is tailored to situation

Example: ADS feasibility study options

Technology	Build	Buy
Long range surface to air missiles (LRSAM)		
Fighter aircraft	Not feasible*	
Anti-aircraft guns		
Barrage balloons		
Lighter than air missile platforms (LAMP)		
Short range surface to air (SRSAM)		

* Lesson learnt from Israel's LAVI project

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Iterative/recursive nature of systems engineering

- Feasibility studies have to progress down SDP Waterfall during study to
  - Show that there is at least one feasible solution
  - Identify implementation risks associated with solution
  - Other factors pertinent to type of study associated with solution

Recursive nature of systems engineering

Column A activities produce → Preferred ***Feasible*** solution option
Documented in (e.g.):
- Systems Engineering Plan (SEP)
- CONOPS

Column B activities produce → Implementation strategies
Documented in SRD and plans, e.g.:
- Systems Engineering Management Plan (SEMP)
- Test and Evaluation Master Plan (TEMP)

Determination that a feasible solution exists
- Design
- Construct
- Integrate and test

Same activities as in HKM^{2}F columns B-E **but** only to level of confidence that solution is feasible

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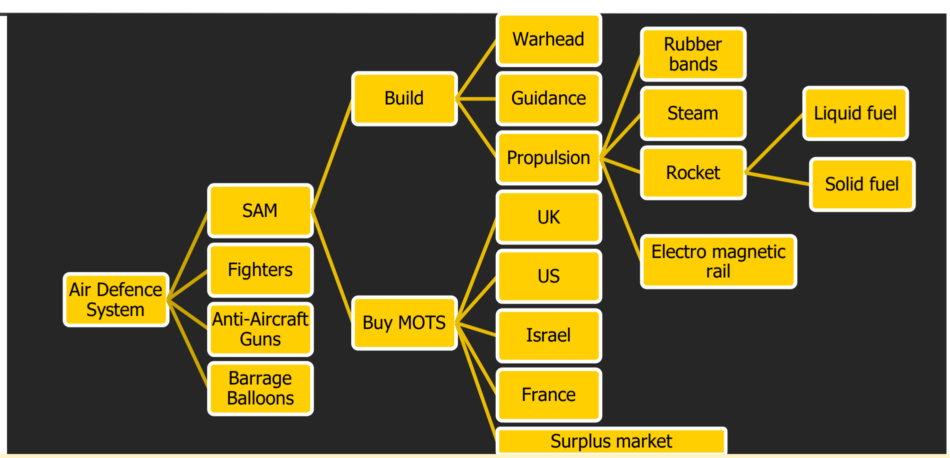
Recursive nature of systems engineering



In order to choose an option, you have to
- Fill out all the boxes for the candidate solutions during the feasibility study in the Needs Identification State to the point of determining their non-feasibility
- Can stop after one feasible path is found

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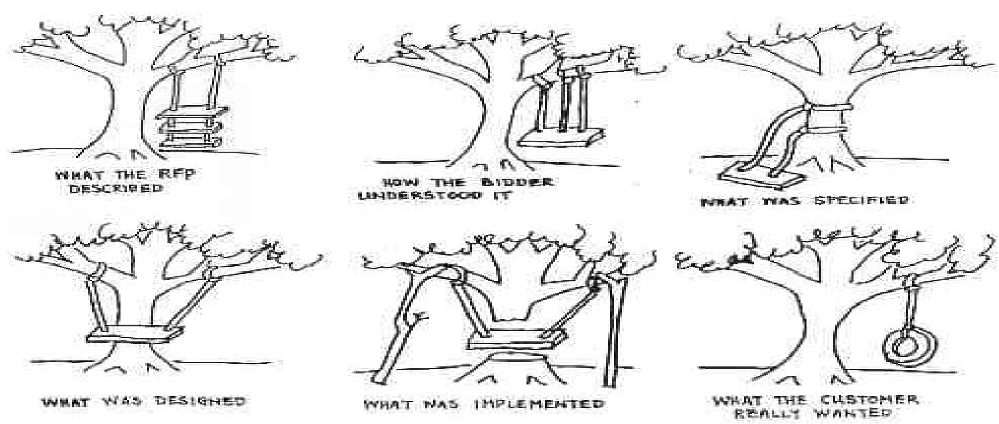
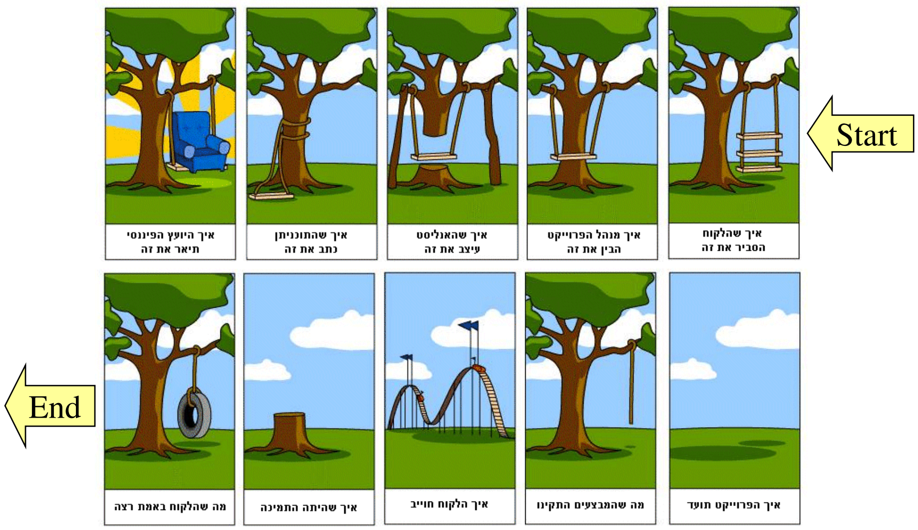
Consequences of not having a CONOPS



Lack of a common vision of the solution

International problem



Seven principles for systems engineered solution systems

SE Chapter 4.12

1. There shall be a clear, singular objective or goal.
2. There shall be a CONOPS from start to finish of the mission describing the normal and contingency mission functions as well as the normal and contingency support functions performed by the solution system that remedies the problem.
3. The solution system shall be designed to perform the complete set of remedial mission and support functions for the operational life of the system.
4. The solution system design may be partitioned into complementary, interacting subsystems.
5. Each subsystem is a system in its own right, and shall have its own clear CONOPS, derived from, and compatible with, the CONOPS for the whole.
6. Each subsystem may be developed independently and in parallel with the other subsystems provided that fit, form, function and interfaces are maintained throughout.
7. Upon successful integration of the subsystems, the whole solution system shall be subject to appropriate tests and trials, real and simulated, that expose it to extremes of environment and hazards such as might be experienced during the mission.

Concept of operations CONOPS*

- States the objectives of the system. (BP and T)
- Contains a general discussion of how those objectives will be met.
- Describes the system (F, Structural (S) and Q)
  - text, flow charts and block diagrams, as appropriate
- Identifies the users of the system. (BP and T)
- States how the users interact with the system. (O)
- Defines the interfaces with external entities and describes how they interact. (O)
- Describes how the system operates by means of normal and contingency mission and support. (O, and Q)
- Describes the end-to-end **functional flows** through the system. (F)

* Kasser, 1995, Applying TQM to Systems Engineering (Atqm2se) section 12.2

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Continuum HTP

- Normal operation
  - Thinking task switch or change perspective to Operational perspective
  - Thinking task switch to Functional perspective
- Abnormal (contingency) operation (built-in up-front risk analysis)
  - Thinking task switch to Operational perspective
    - Accidents and failures
  - Thinking task switch to Functional perspective
    - Failures
- Domain knowledge is critical to understanding consequences of failure inducing events (risks)
  - Functional and performance, behaviour of materials over time, etc.

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Abnormal: accident and failure prevention and mitigation

- Operational
  - What can happen (Fault Tree analysis - FTA)
    - External interaction with operator
    - Externally induced failures
- Functional
  - What can happen (Failure effects Mode Analysis - FEMA)
    - Internal damage due to aging components
- Temporal (lessons learned)
  - History of what did happen in the past
  - What needs to be improved this time around
- Generic (lessons learned)
  - What might happen as a result of examining similar systems

Some uses of the CONOPS

- During the planning and design states:
  - Documents the customer's needs
    - Feeds into the system requirements document
  - Guides the designers
  - Drives the design
  - Describes the design at the appropriate level of detail
- During the development states:
  - Keeps the design focused on the operational needs
  - Assists in the resolution of design tradeoffs
  - Provides the basis for developing test plans and procedures
  - Provides the basis for operator training

Exercise 6-81

1. Reverse engineer the CONOPS for each candidate solution listed in SE Section 20.2 (POSE Section 21.9)
2. Focus on the mission and support functions, ignore everything else
3. Don't spend more than two hours on the exercise
4. Make realistic justified assumptions (from the text and your knowledge)
5. Prepare a <5 minute presentation
    1) This slide and version number of session
    2) Problem formulated per COPS problem formulation template
    3) Compliance matrix
    4) Outline mission and support scenarios in the CONOPS
        Use N^2 chart and scenario/function mapping table, etc.
    5) Lessons learned from the exercise
6. Save as a PowerPoint file in format Exercise6-81-abcd.pptx
7. Post/email presentation as instructed

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Exercise 6-82 knowledge reading

1. Prepare a brief on two main points in reading 0602 (< 5min)
2. Presentation to contain
    1. Reformulated 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 version number of session
    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 session and source of learning e.g. readings, exercise, experience, etc. (<2 minutes)
3. Save as a PowerPoint file as Exercise6.82-abcd.pptx
4. Post/email presentation as 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> BWM Session #