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

Rev. 3.5.4

Knowledge

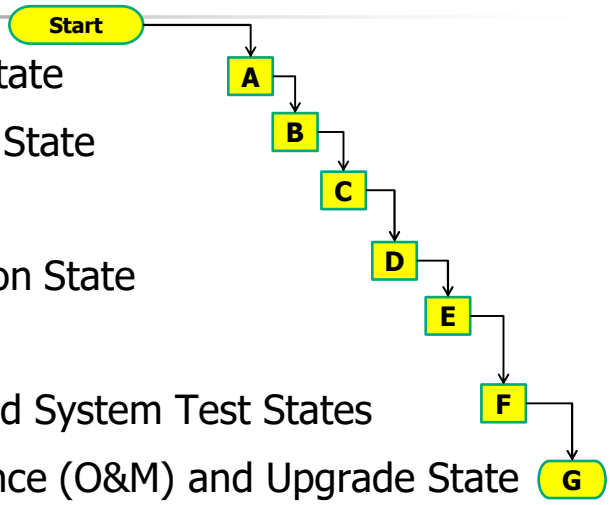
- Lecture
  - Overview and summary of readings
- Readings
  - ~~0402 Kasser J.E., Holistic Thinking: Chapter 7, The nature of systems, Createspace, 2015~~
  - ~~0403 Systems Engineering Chapter 5 An Introduction to Systems~~
  - ~~0404 Kasser J. E., Perceptions of Systems Engineering: Chapter 18, guidelines 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

Topics

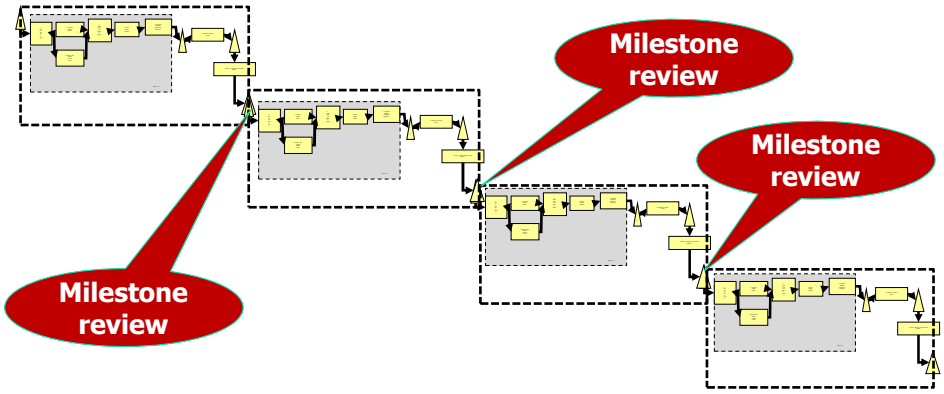
- Nature of systems
- Basic system behaviour
- Emergence
- Hierarchies of systems
- Functional view of a system
- Template for a system
- Supply chains
- Ways of creating systems for managing complexity
- **The system lifecycle (cont. from Module 2)**

The Waterfall view

A. The Needs Identification State
B. The System Requirements State
C. The System Design State
D. The Subsystem Construction State
E. The Subsystem Test State
F. The System Integration and System Test States
G. The Operations, Maintenance (O&M) and Upgrade State



The systems engineering problem-solving paradigm* in each state of the Waterfall



* Hitchins, D. K., *Systems Engineering. A 21st Century Systems Methodology*, John Wiley & Sons Ltd., Chichester, England, 2007, Figure 6.2

Summary of Milestone reviews

- **Start of project**
- ***Operations Concept Review (OCR)*** at the end of the Needs Identification State
- ***Systems Requirements Review (SRR)*** at the end of the Requirements State
- ***Preliminary Design Review (PDR)*** at the end of the Preliminary design sub-State of the Design State
- ***Critical Design Review (CDR)*** at the end of the Design State
- ***Test Readiness Review (TRR)*** at the end of the Construction State
- ***Integration Readiness Review (IRR)*** at the end of the Subsystem-Testing State
- ***Delivery Readiness Review (DRR)*** at the end of the System Integration State
- ***Acceptance Test Review (ATR)*** after the system has been installed and has been operational for a while
- **End of project**

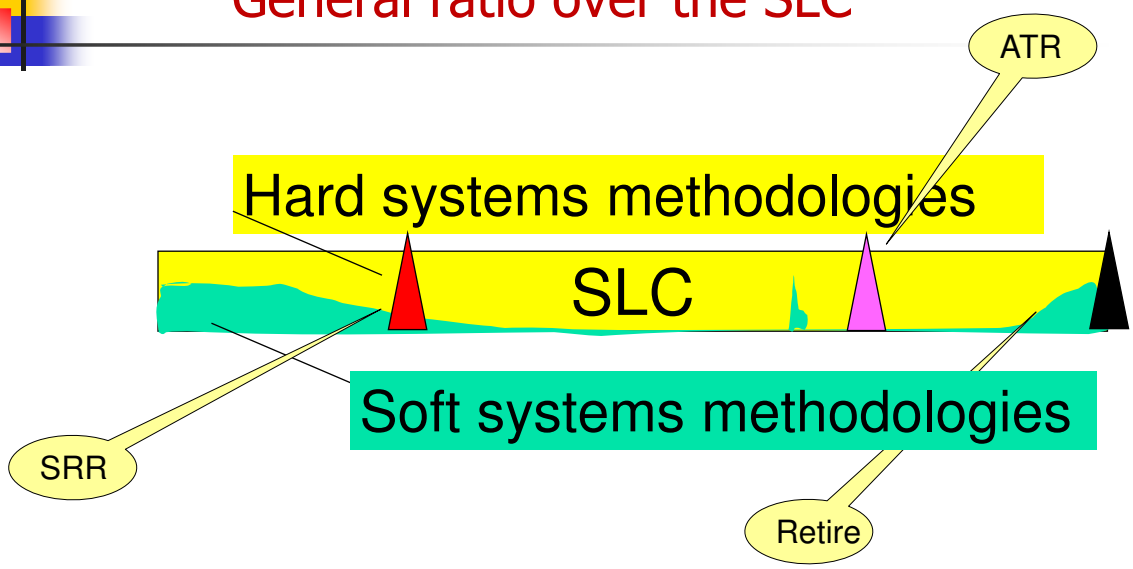
The Hitchins-Kasser-Massie-Mabelo Framework - (HKM^{2}F)

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

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

General ratio over the SLC

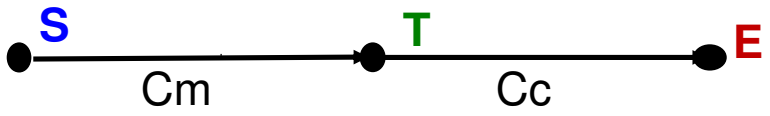


Think costs

- **Developer - supplier**
  - make a profit while supplying the product
- **Customer**
  - Product that meets specifications
    - on schedule
    - within budget
    - periodic progress reports
- **Common language of business**
- Milestone reviews are supposed to show that the system will be delivered according to estimated cost and schedule

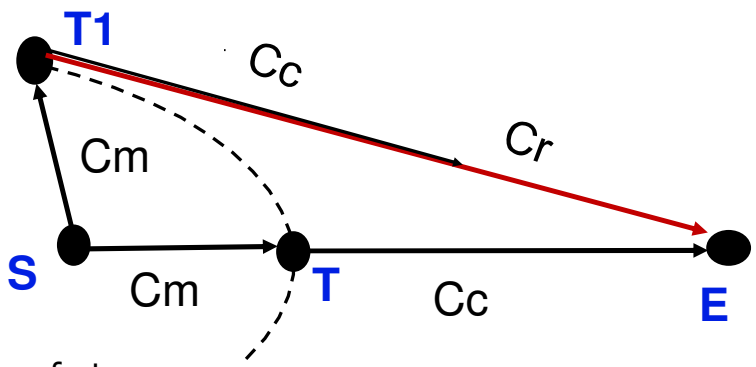
Cost of the generic process (WBS element)

PERT representation



$$Cp = Cm + Cc$$

Cost of the typical process with defects

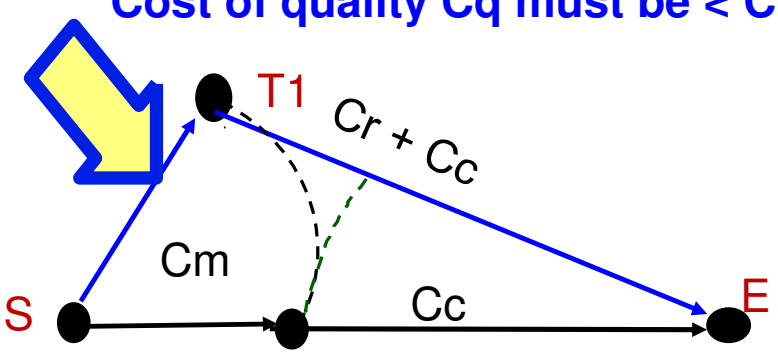


Cm cost to manufacture
Cc cost to complete
Cr cost to repair

Cp = Cm+Cc+Cr

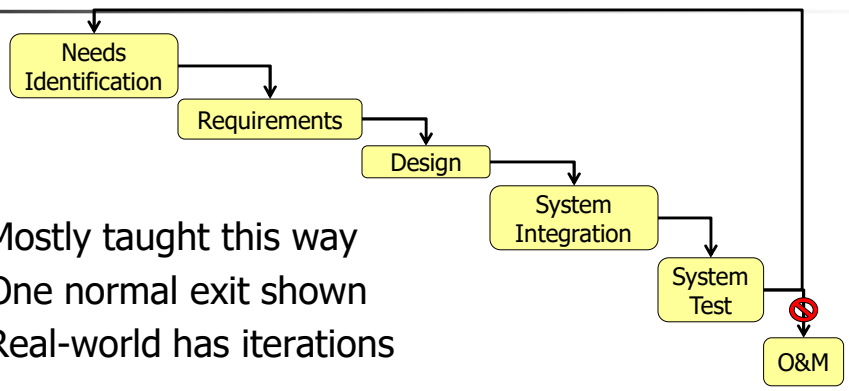
Lowering the cost of the typical process

Cost of quality Cq must be < Cr



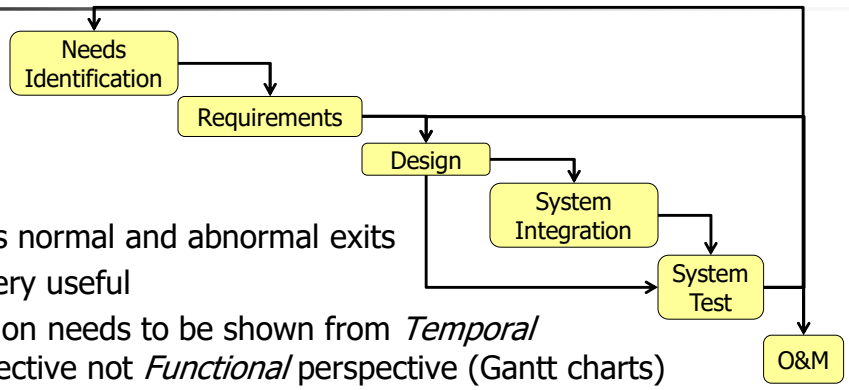
Cp = Cm+Cc+Cr

Functional perspective



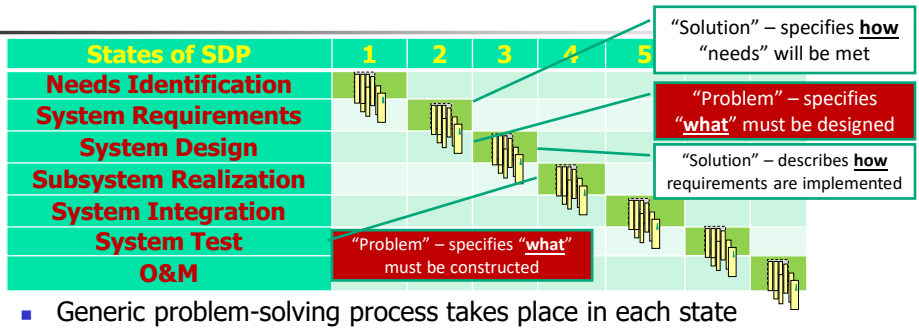
- Mostly taught this way
- One normal exit shown
- Real-world has iterations

Functional perspective



- Shows normal and abnormal exits
- Not very useful
- Iteration needs to be shown from *Temporal* perspective not *Functional* perspective (Gantt charts)
- Covered in 0406 Systems Engineering Chapter 9 ('nuts and bolts')

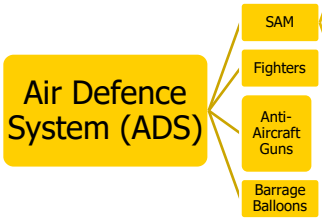
Waterfall, What's and How's



- Generic problem-solving process takes place in each state
  - Different activities and products
- Wording in egg diagram does not apply in later states
- Problem perspective is recursive and fractal
- What: problem faced at the start of the state
- How: solution at end of state, becomes problem for next state
- Ideal situation, no problems during SDP, nice for teaching

Recursive nature of systems engineering

In order to choose an option, you have to fill out all the boxes for the other candidate solutions during the Feasibility Study in the Needs Identification State to the point of determining their feasibility



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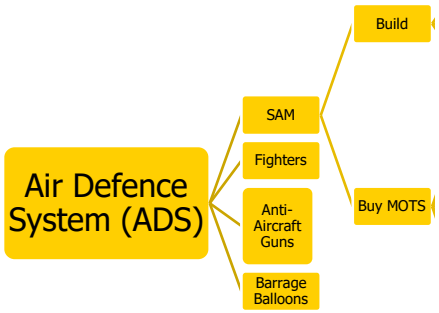

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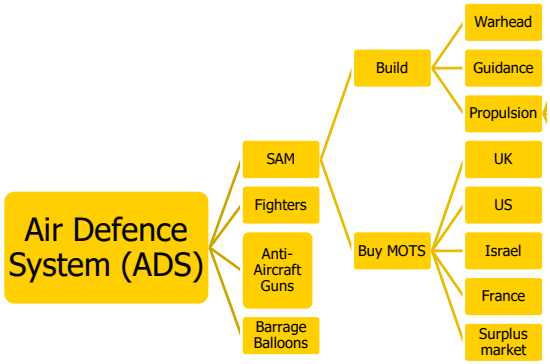

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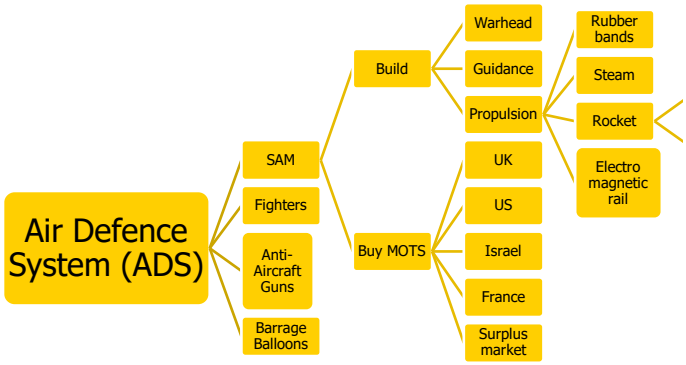

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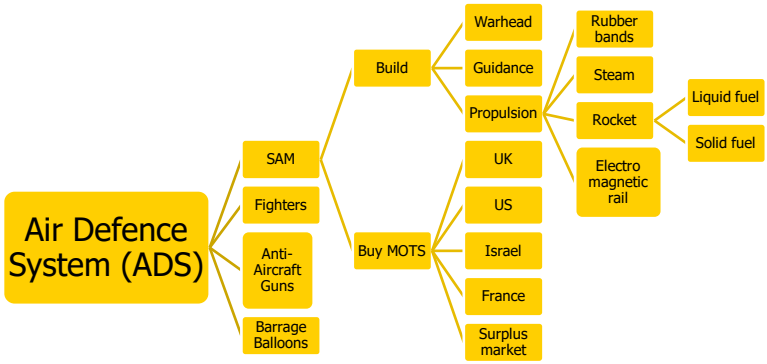
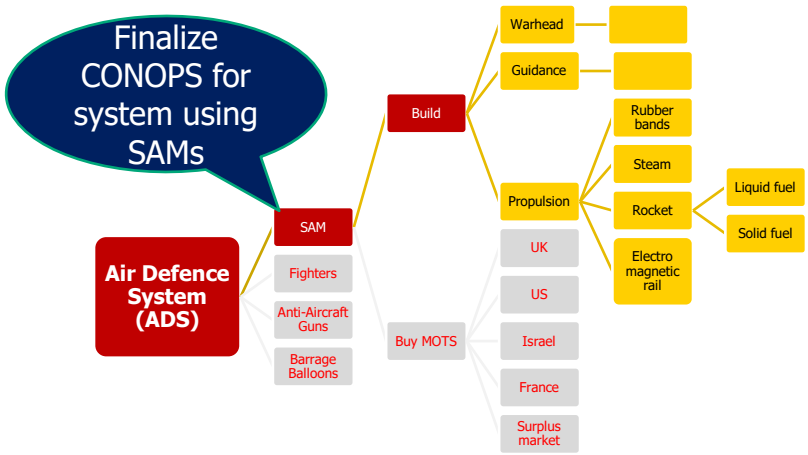
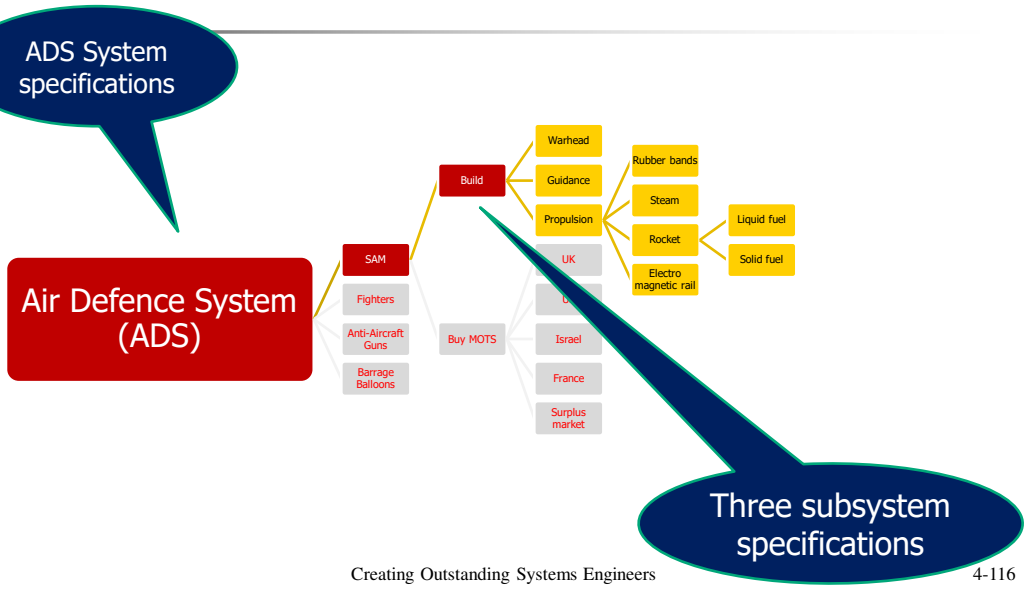


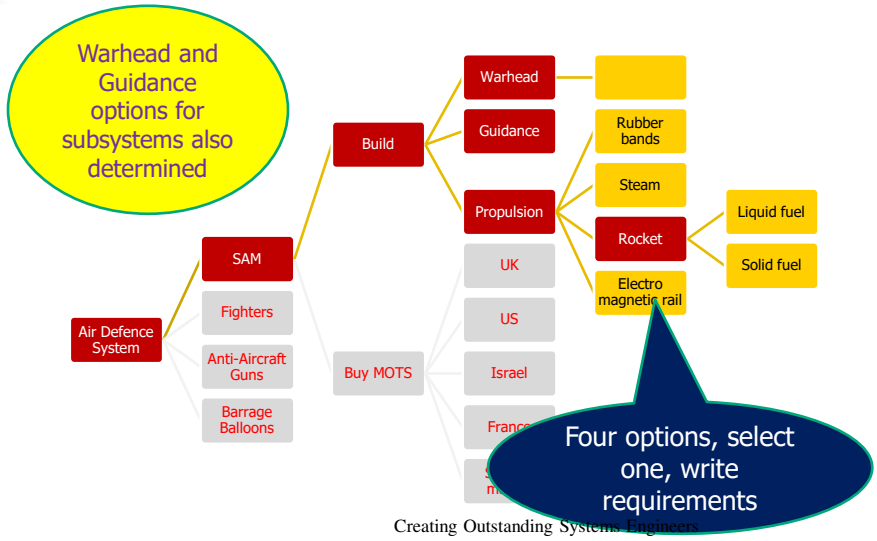
Acquisition strategy decision (end of Needs Identification State)



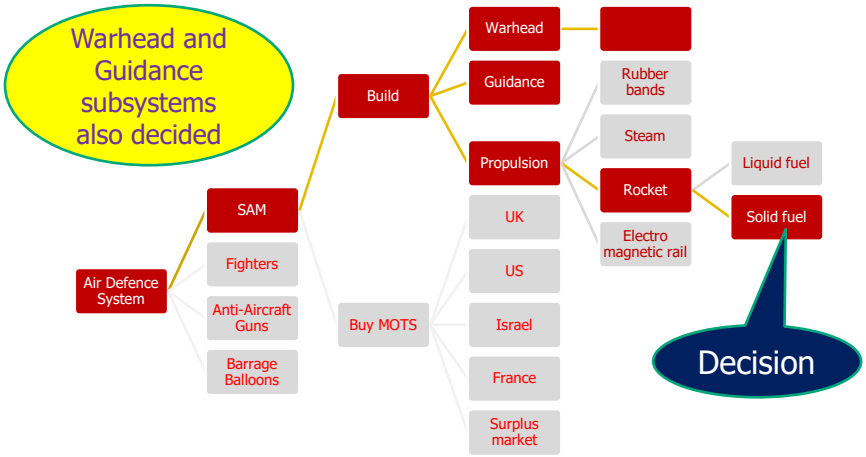
Acquisition strategy decision at SRR



Acquisition strategy decision at PDR



Acquisition strategy decision at CDR



Exercise 4-51 knowledge reading

1. Prepare a brief on two main points in reading 0405 (< 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 Exercise4-51-abcd.pptx
4. Post/email presentation as, when and where instructed
5. Brief on one main point

Exercise 4-52 knowledge reading

1. Prepare a brief on two main points in reading 0406 (< 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
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Summary

- 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
- Exercises

Meeting the objectives

1. Explained the nature of systems
2. Introduced and used the functional view of a system
3. Introduced and explained a template for a system
   1. that integrated mission, viability and resource management into the system at the start of the system development lifecycle
   2. instead of adding those functions as bolt-ons later in the system development lifecycle.
4. Introduced and explained ways of creating systems
5. Provided the background for the activities performed by systems engineers in the various states of the SLC

Lessons Learned: Systems will be used in ways the designers never envisaged

Any questions ?

1. Best
2. Worst
3. Missing
4. ~~Questions~~

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