Model Based Systems of Systems Engineering

Fran McCafferty
Principal Systems Engineer
fmccafferty@vitechcorp.com

System of Systems v System of Subsystems

…**The major distinction between systems as elements of an SoS and subsystems as elements of a system is therefore that the SoS comprises elements (systems) that are optimised for their own purposes before joining the SoS, whereas the system comprises elements (subsystems) that are optimised for the system's purpose (not necessarily their own).** …

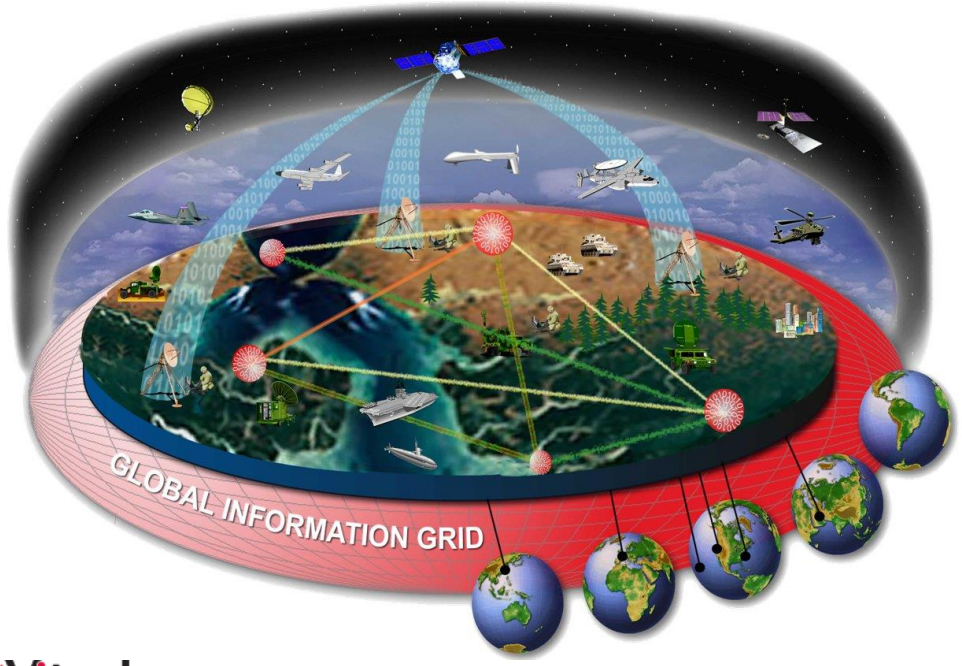
- Faulconbridge, Ian; Ryan, Michael. Introduction to Systems Engineering (Kindle Locations 268-277). Argos Press Pty Ltd. Kindle Edition.

System of Systems vs. System of Subsystems

Both comprise elements that are interconnected, *but:*

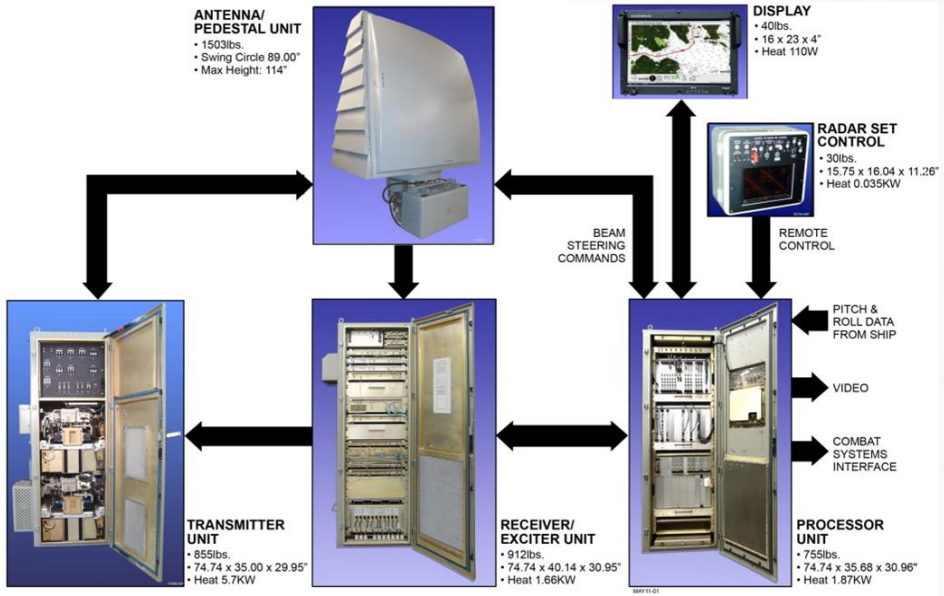
System of Systems

- Elements are systems in their own right, managerially and operationally independent
- Elements have been optimized for their own purpose



System of Subsystems

- Not independent
- Only exist to serve the parent system
- Invariably sub-optimal



What's your definition of a system?

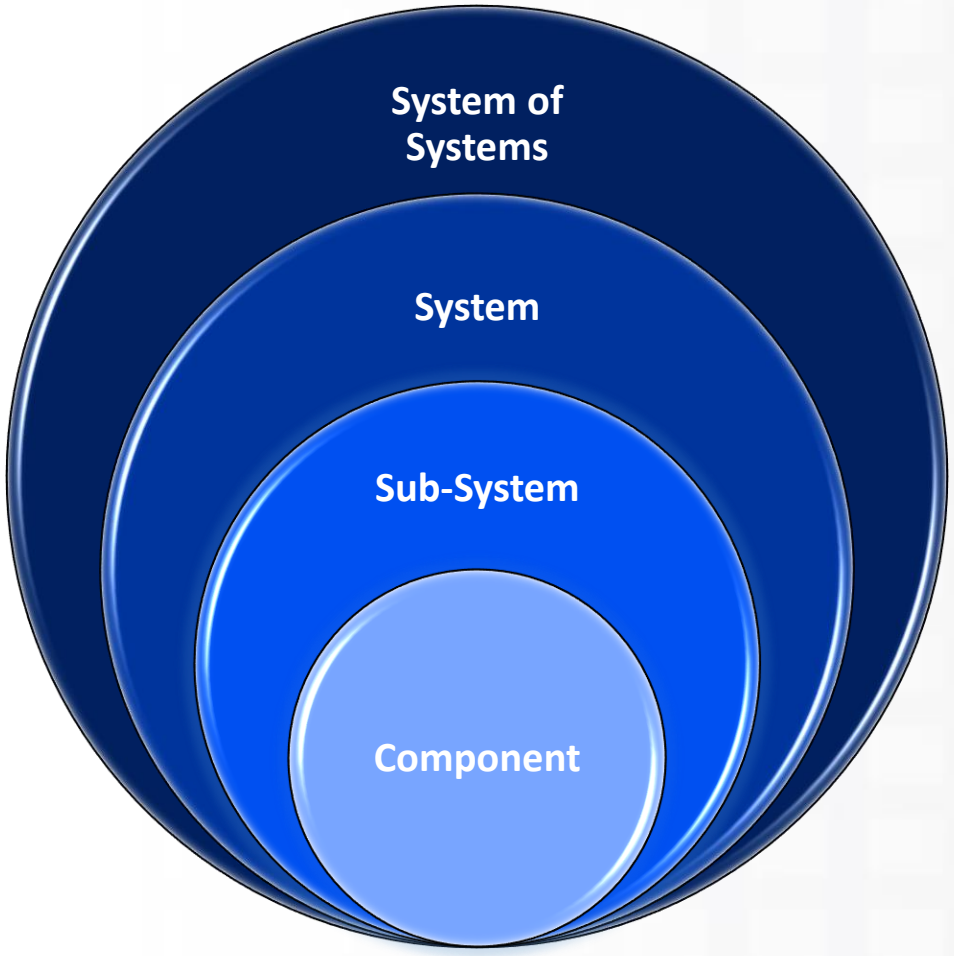
Fundamental Concepts

A System:

- Performs a function, transforming inputs to outputs
- Is a collection of interacting components with a common goal

A Subsystem:

- Can be considered a system
- Therefore, the analysis and specification of a system is hierarchical and iterative
  - System
  - Subsystem
  - Component
  - . . .



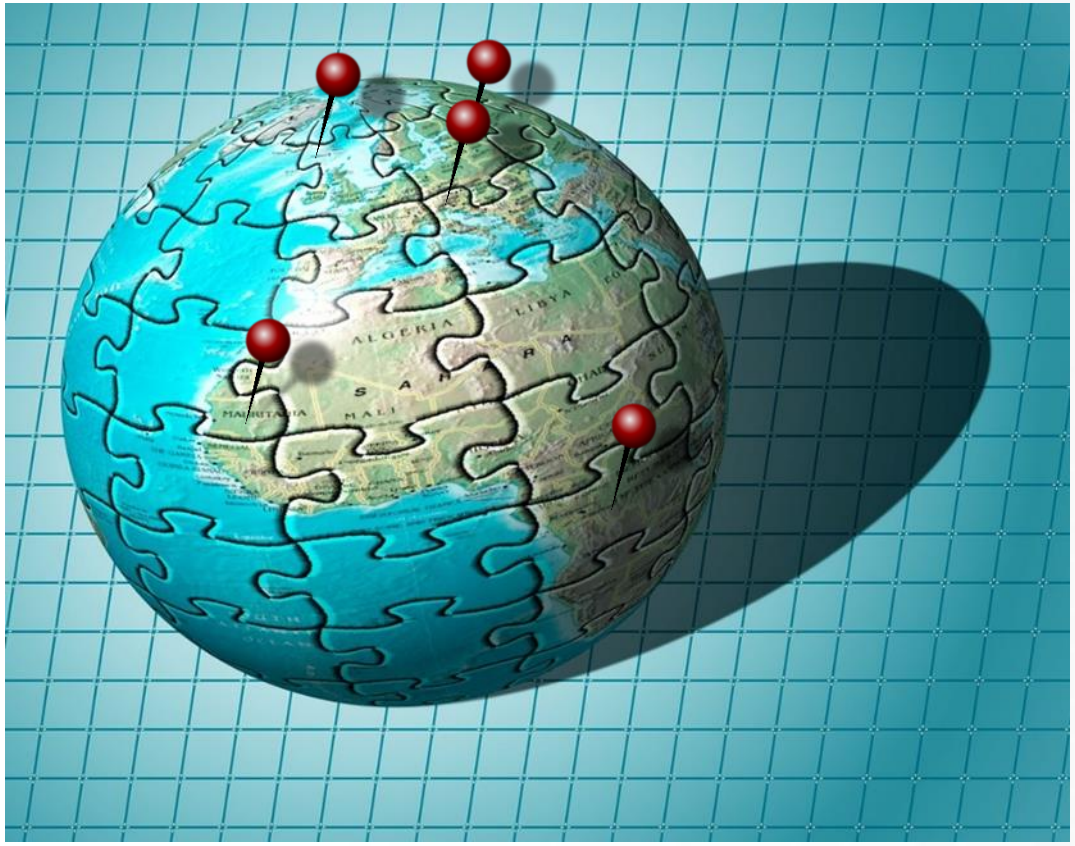
System of Systems

Multiple Cooperating Systems

- Multiple and often geographically distributed organizations
- Multiple design teams

Single Large System

- What was it optimized for?
  - Cost
  - Schedule
  - Legacy technology
- System partition basis
  - Functionality
  - Geography
  - Organization expertise

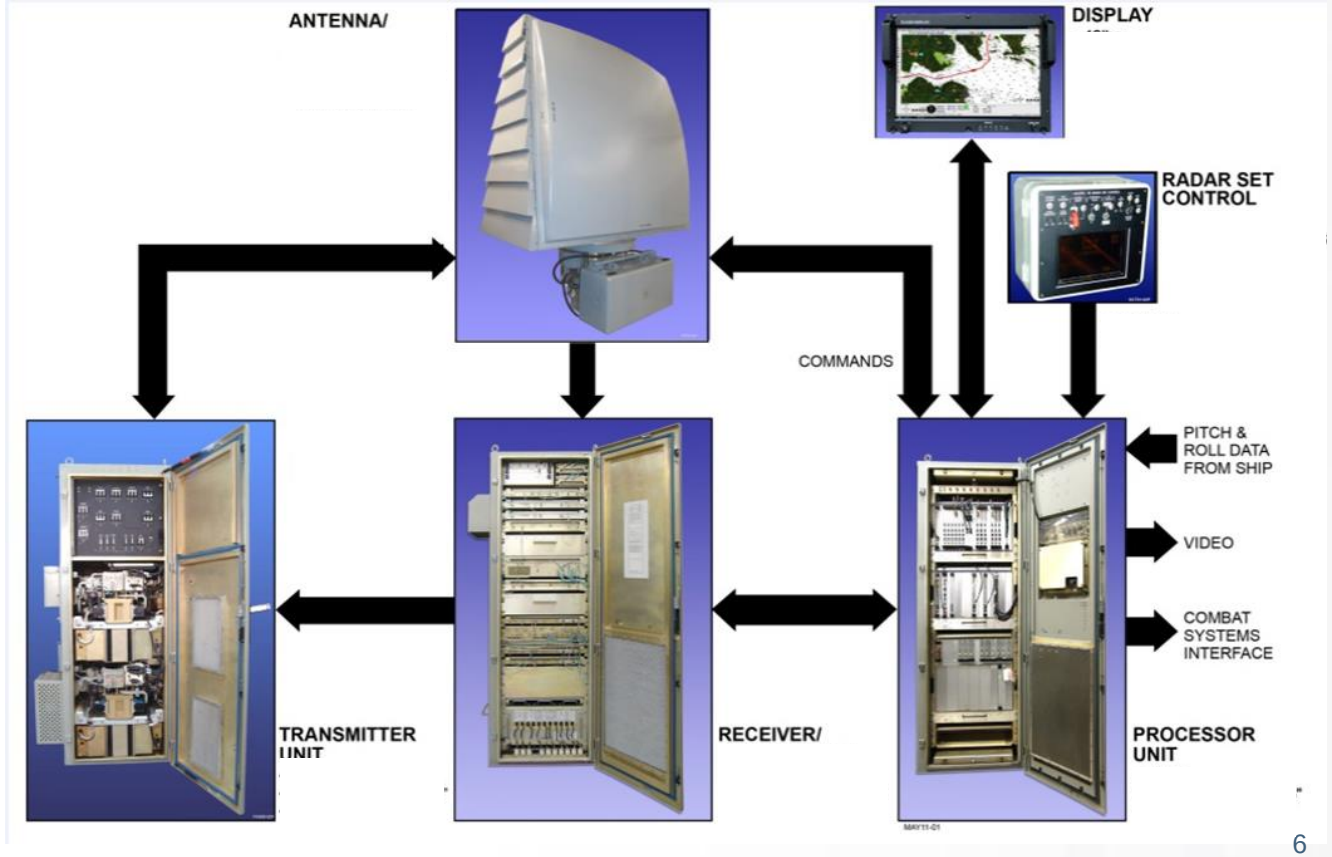


Example: Radar
Air and Surface Search Radar – Restoration Program

How does a program office support a critical system for extended periods of time from a maintenance and upgrade perspective?

What are the options?

- **Replace the entire system**
  - Design from scratch
  - Implement an existing system
- **Maintain the existing system**
  - Replace broken/failed components
  - Perform capability upgrades



What are the options?

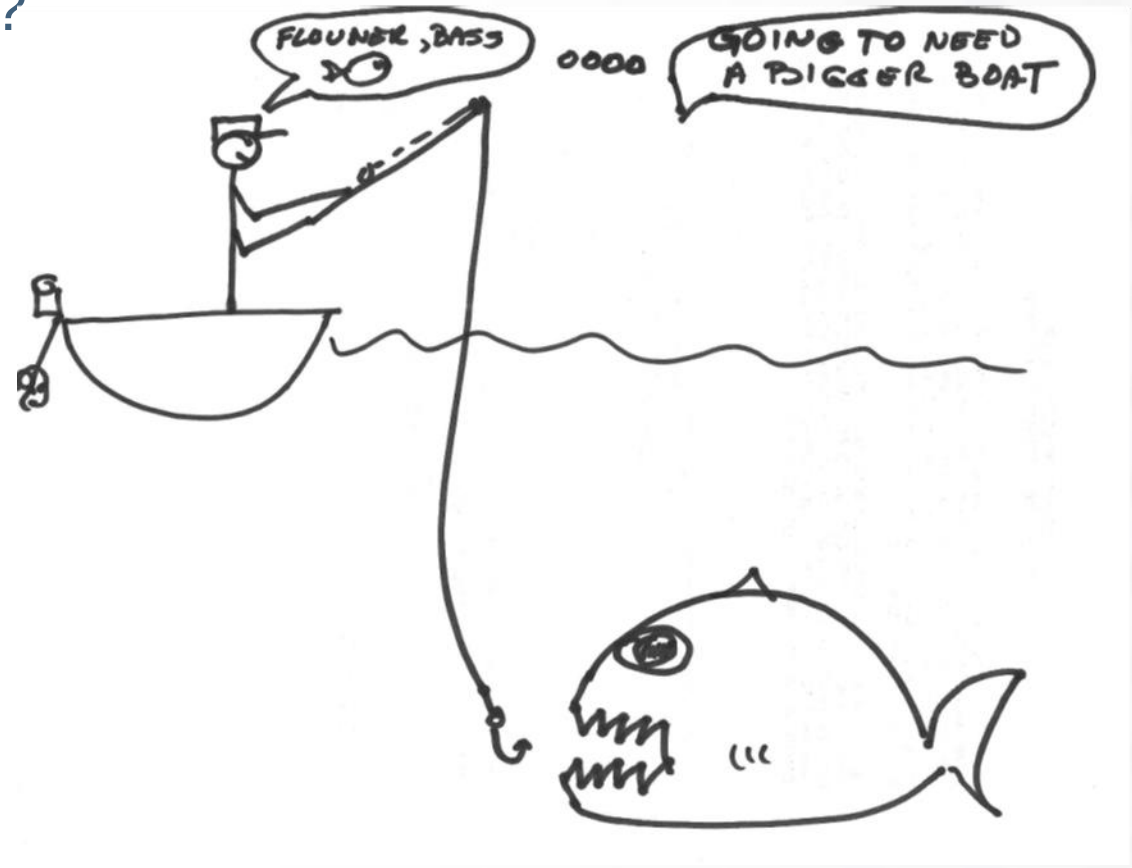
Options	Issues
Replace the entire system	
- Design from scratch	- cost, schedule, integration
- Implement an existing system	- cost, schedule, integration, capability
Maintain the existing system	
- Replace broken/failed components	- are parts available, can parts be made
- Perform capability upgrades	- do you get all of the benefits

Mission Engineering
System of Systems Engineering

Our world is far from static, so what do we do?

Do we need to evolve? Probably.

- Do we understand the problem?
- Can we afford to evolve?
- How much evolution can we stand?



System of Systems US Navy Restoration Example

Single Large System

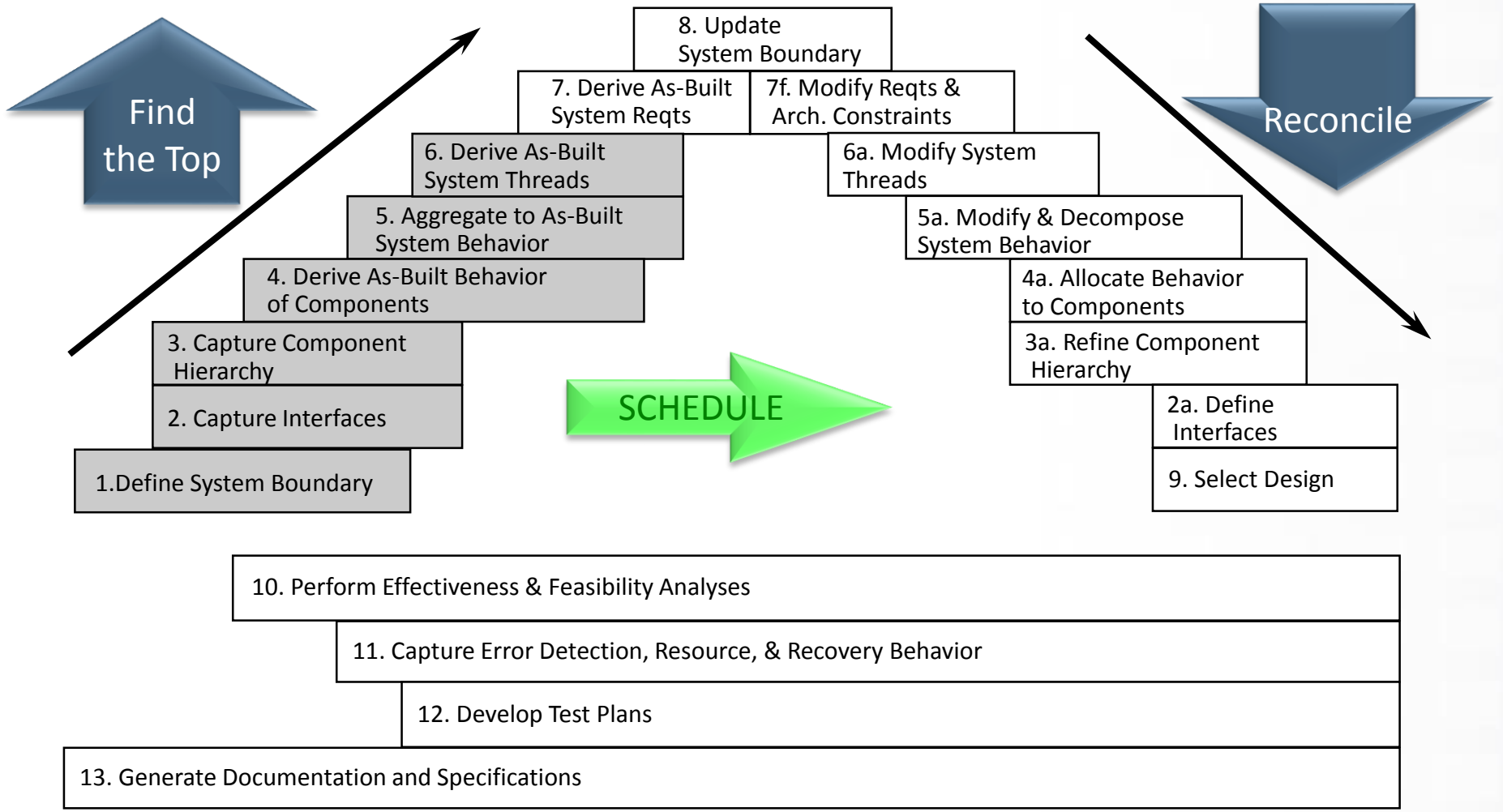
What was it optimized for?

- Cost
- Schedule
- Legacy technology

System partition basis

- Functionality
- Geography
- Organization expertise

MBSE Activities Timeline + Reverse Engineering



So what do you do?

What is in the scope of the project, and who says so?

- **Clearly define the boundaries**
  - Ensure the subsystems are fully defined from a capability, physical characteristics, and most importantly, know the interfaces.
  - Interface definition means knowing what information traverses the subsystem boundary.
  - What are the physical, logical, and functional characteristics?
- **Manage the complexity**
  - What changes?
  - How do we know?

Answer: Systems engineer it, model it!

So what do you do?

If we reverse engineer the existing system, we know the critical capabilities and constraints.

- Capture the legacy requirements
- Model
  - Physical Architecture
  - Behavior – functions, information, control, and timing
  - Interfaces
  - Links
  - Constraints

Now we know the baseline.

Answer: Systems engineer it, model it!

Do the analysis

Ask

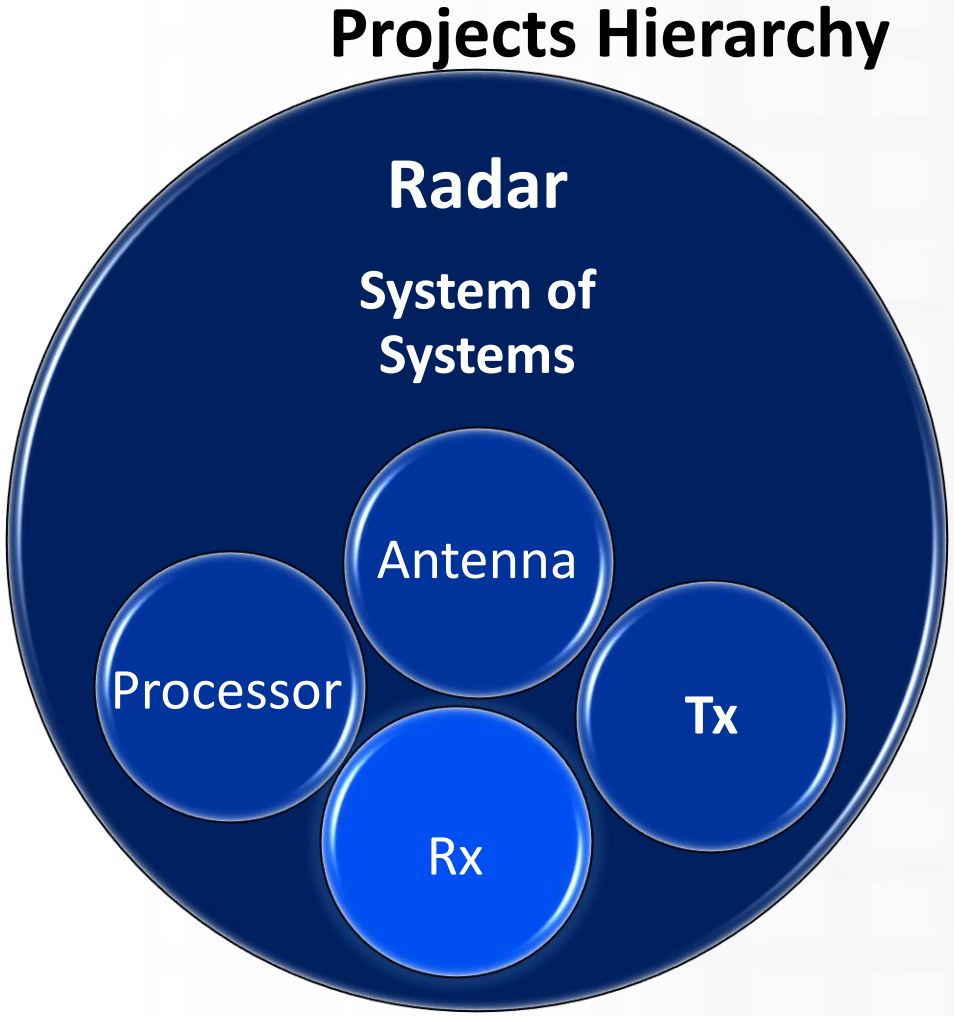
- What does the upgraded system have to do?
- How do we partition?
- At what level do we want to compete acquisition?

Apply Model Based Systems Engineering

Multi-Project Roadmap

- Partitions
  - Rx
  - Tx
  - Rx
  - Antenna
- **Why**, and **benefits** v. Mega Project
  - Strata, just boundary not down to nth layer,
  - thin model,
  - black box,
  - white box,
  - Integration Perspective,
  - contractual boundaries,
  - defining lower level

  - ….Let’s have a look



Model the Requirements

Use what you have in SSS, IRS, ICD

SSS

- 3.2 System requirements
- 3.7 Major subsystems requirements

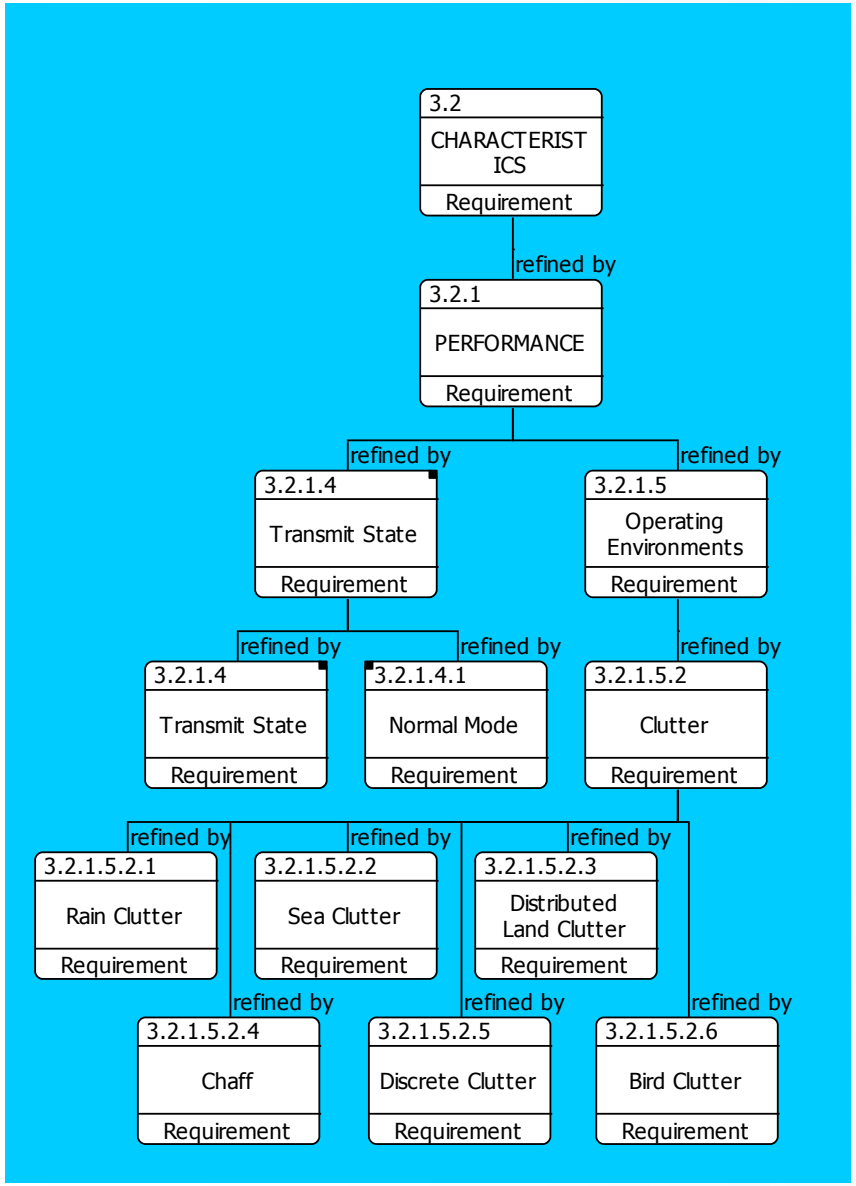


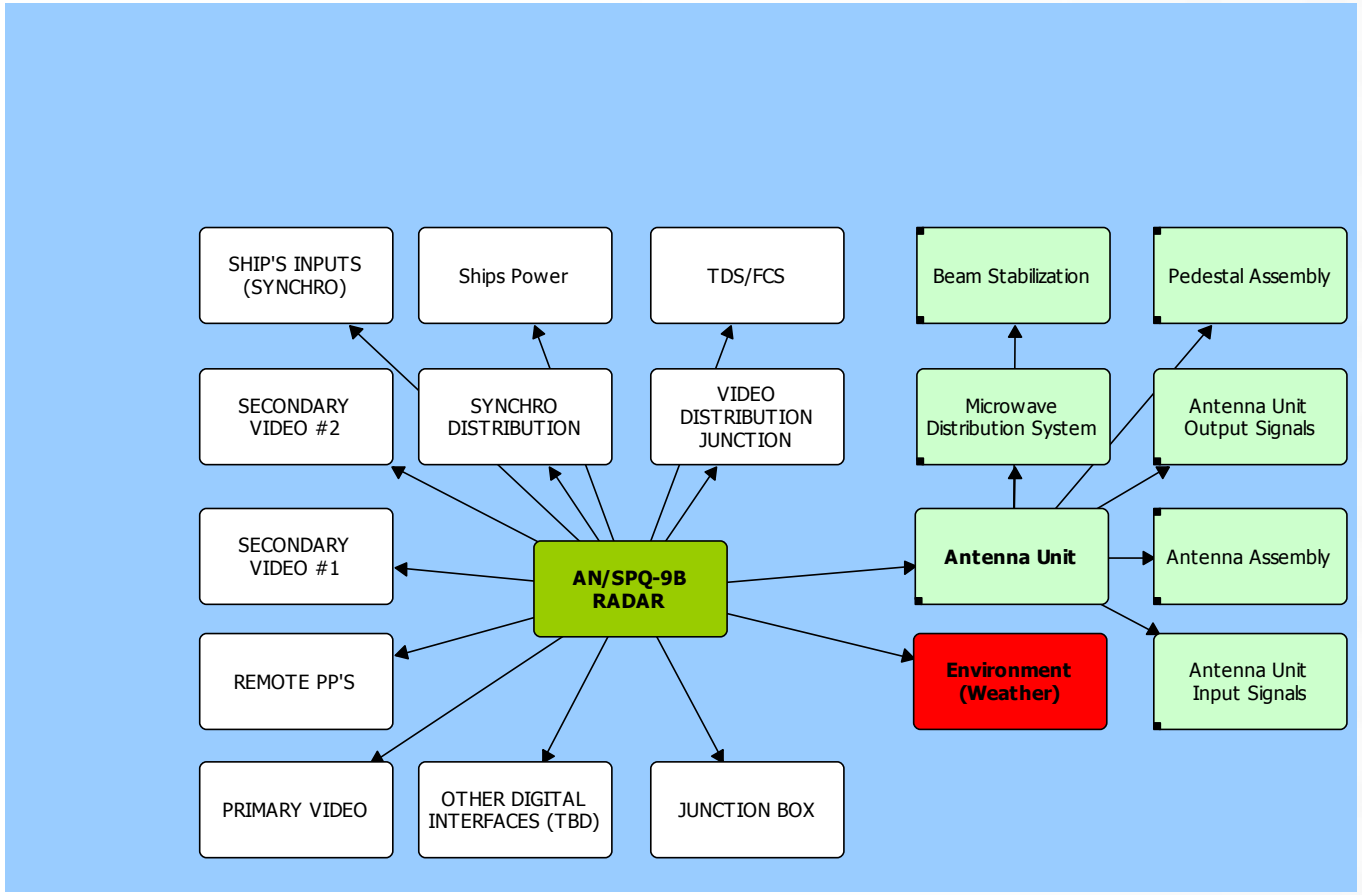
Diagram: CORE-generated requirements hierarchy diagram

Model the Architecture Using Components, Establish Interfaces/Links

Use what you have in SSS, IRS, ICD

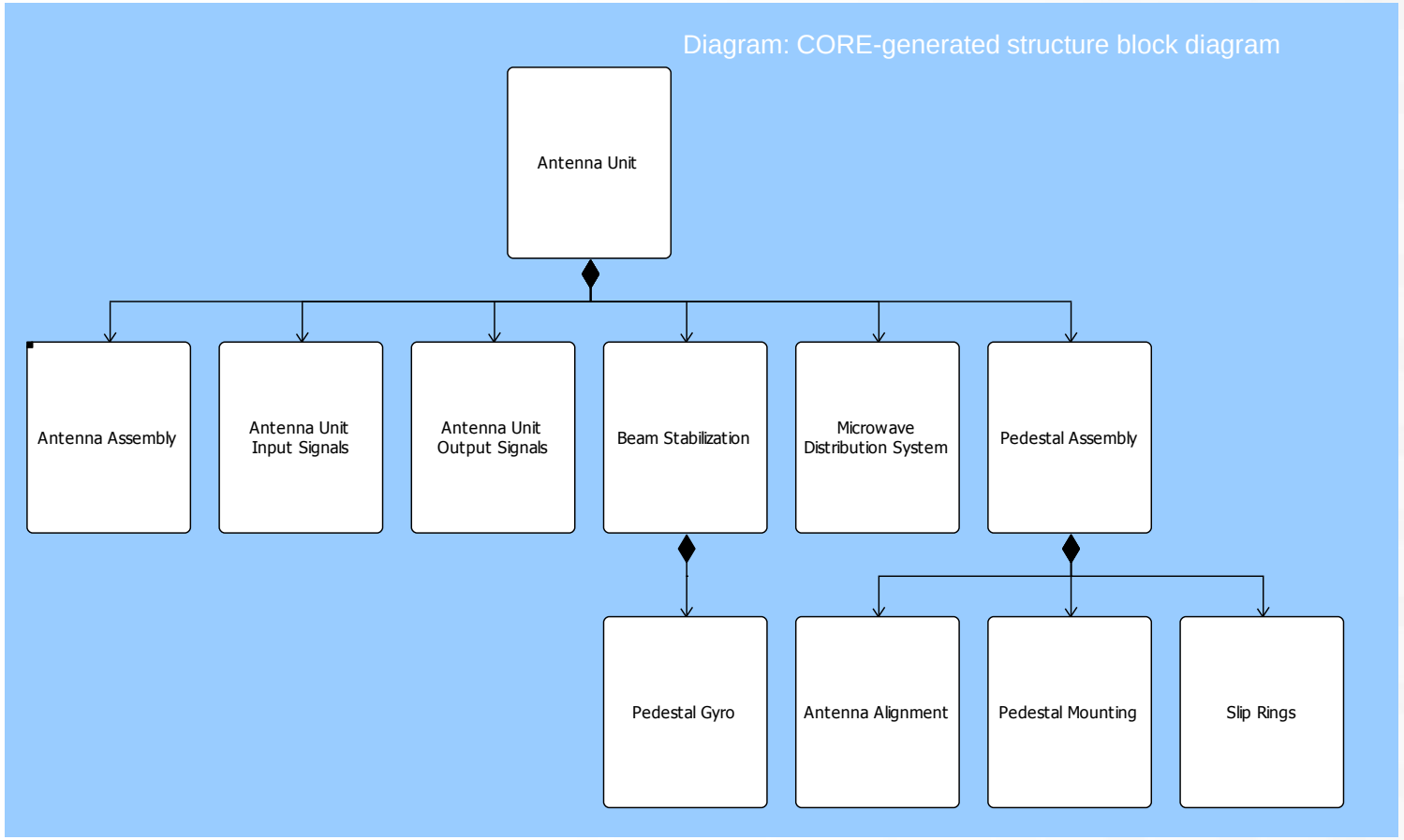
SSS

- 3.2 System requirements
- 3.7 Major subsystems requirements

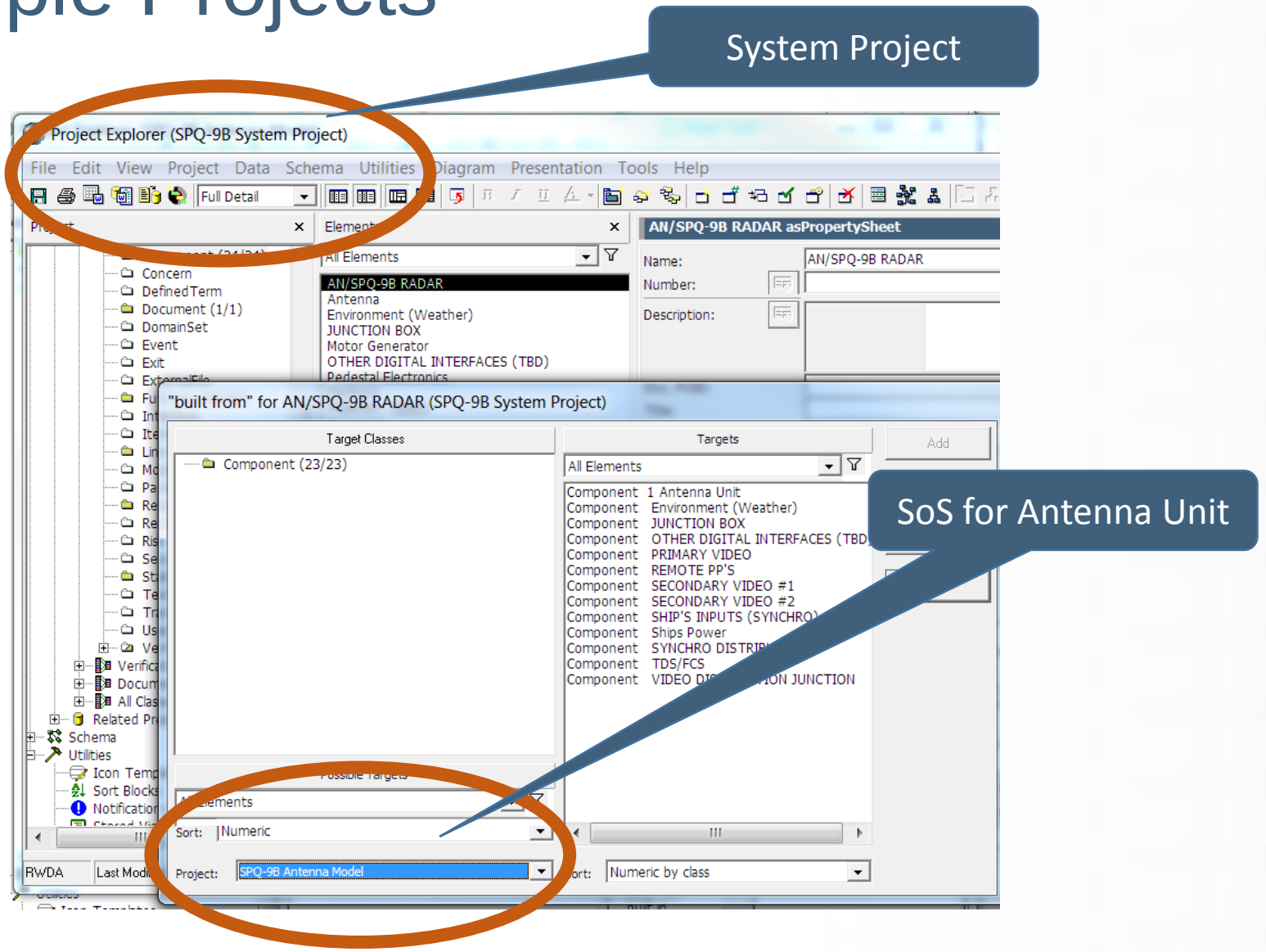


Antenna– Project

- Separate projects – maintains system context and subsystem boundaries.
- Link projects through components.
- Use “built from” relationship.
- Recall, a context function, is automatically generated, + can also be a decomposition of the radar.



Create Multiple Projects



Tiered Projects

Separate projects

- Maintains system context
- Identifies subsystem boundaries

Link projects through components

- Use “built from” relationship
- Recall, a context function, is automatically generated, + can also be a decomposition of the radar.

Specifications linked to specific project

- System Specification
- Antenna Unit– Subsystem Spec (SSS, or in the old days, B Spec)
  - Allows for the Antenna Unit to be easily severable,
  - Supports subsystem level acquisition strategies,
  - Provides context for technology insertion / and sustainment

Summary

- System of Systems and Mission Engineering similarities.
- Separate but linked projects provide context and linkage.
- Independent projects enable clearly understandable subsystems.
  - Higher fidelity of requirements, traceable but not overwhelming
  - Clear interfaces between subsystems
  - Physical hierarchy shows transition from one design/support group to another
- Promotes separation of concerns, while maintaining traceability and consistency
- PMO Support
  - Enables PMO to generate RFP from models
  - Radar Restoration is considering requiring a model as part of proposal package

For more information:

Vitech website: http://www.vitechcorp.com/
Blog: http://community.vitechcorp.com/home/
Presenter: fmccafferty@vitechcorp.com
540.951.3322 x304 or 856.217.9963

We invite your comments and questions.

THANK YOU!