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Mission Threads: Bridging Mission and Systems Engineering

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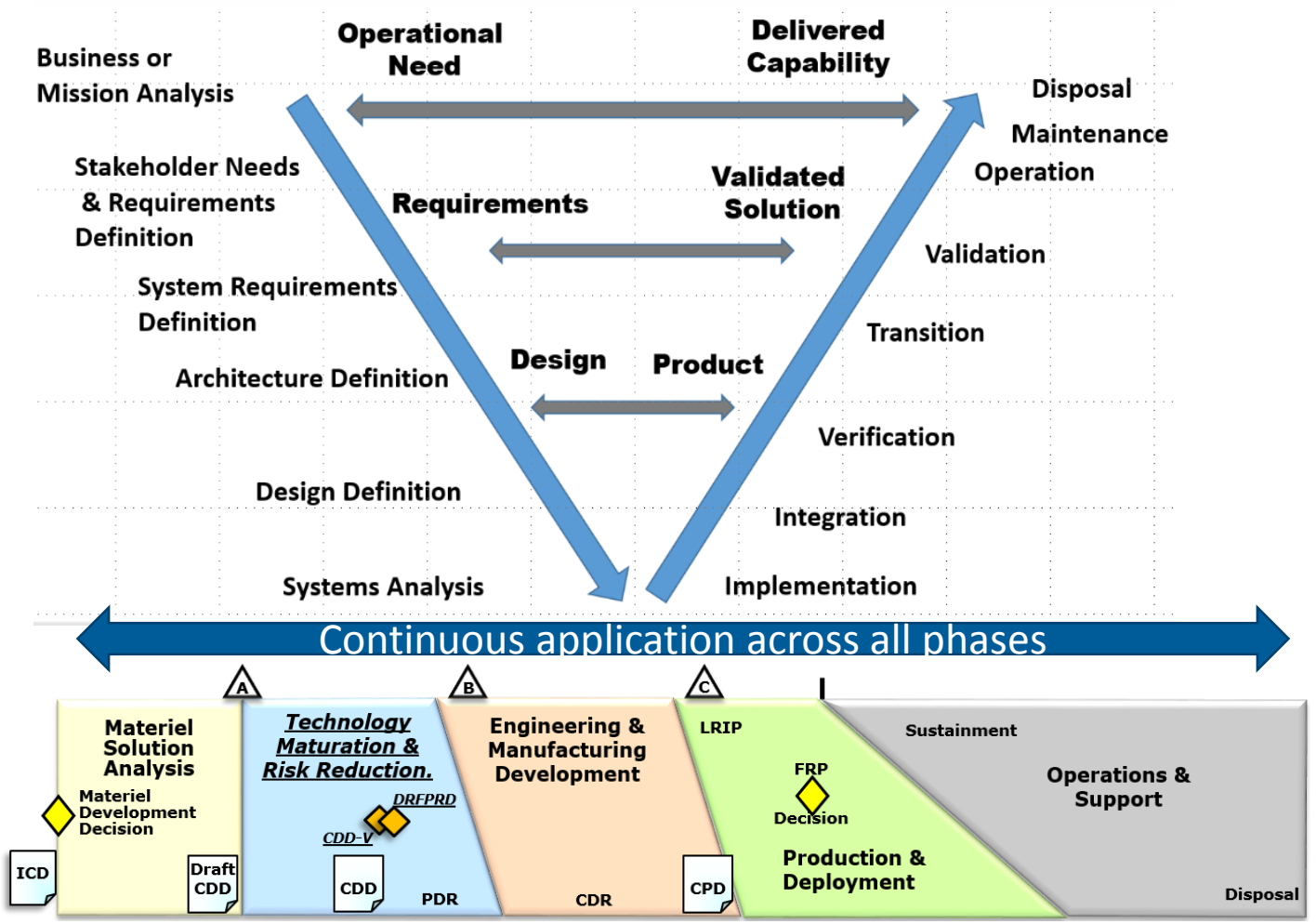
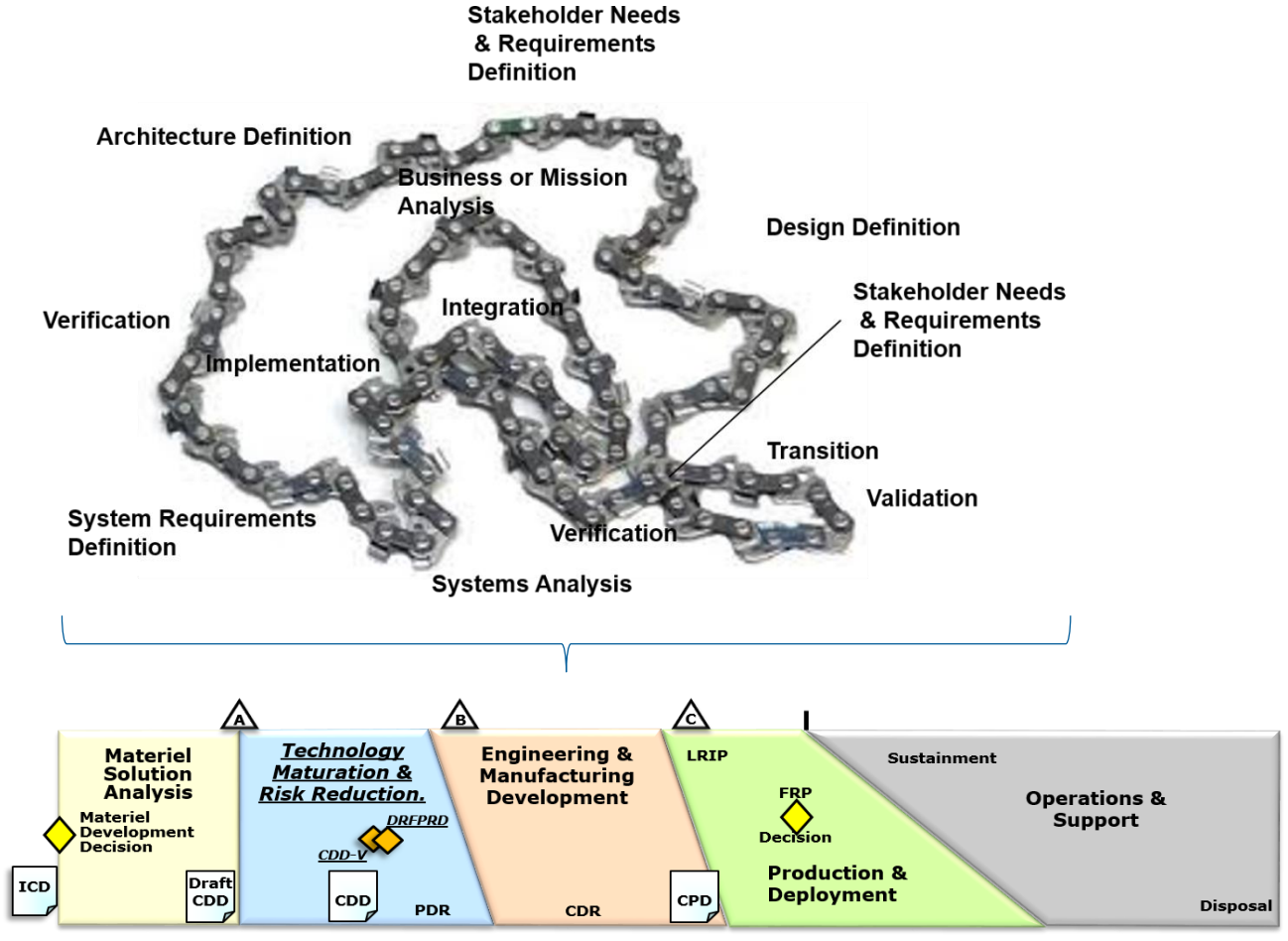
SE Technical Processes and the Acquisition Lifecycle



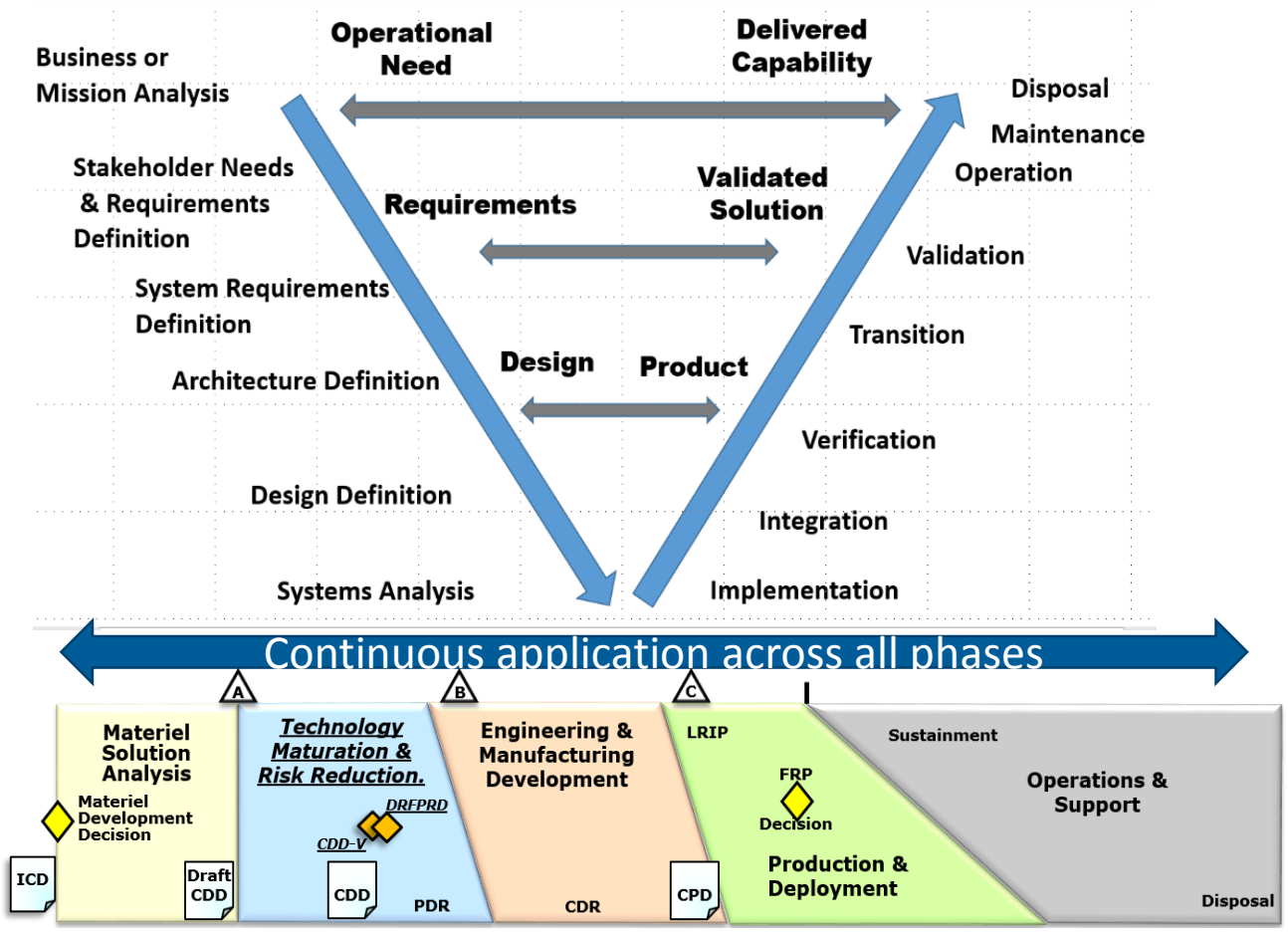
SE Processes
Not a sequence of steps

The systems engineering technical and technical management processes are not sequential

They may be
- Iterative
- Recursive
- Concurrent



Emphasis– Reality



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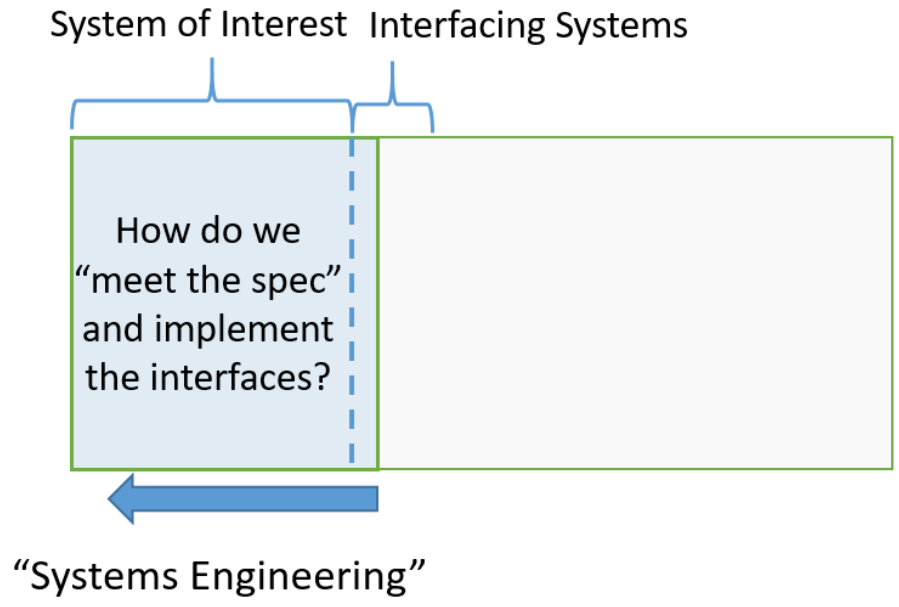
“Meet the Spec”

“Hard” documented requirements focus on system of interest (**SOI)** functionality and attributes.



Complications

- The SOI we are developing or modifying is generally part of a system of systems **(SoS)**
- The “spec” likely does **not** provide details necessary to develop an SOI that will “work” in the SoS environment

Meet the Need

Mission Engineering-- Understand and document end-to-end execution of a mission to understand how all the SOS parts work together.

Systems Engineering- -Specify, design, and develop the SOI with a firm understanding of the mission context and maintaining traceability to the mission.

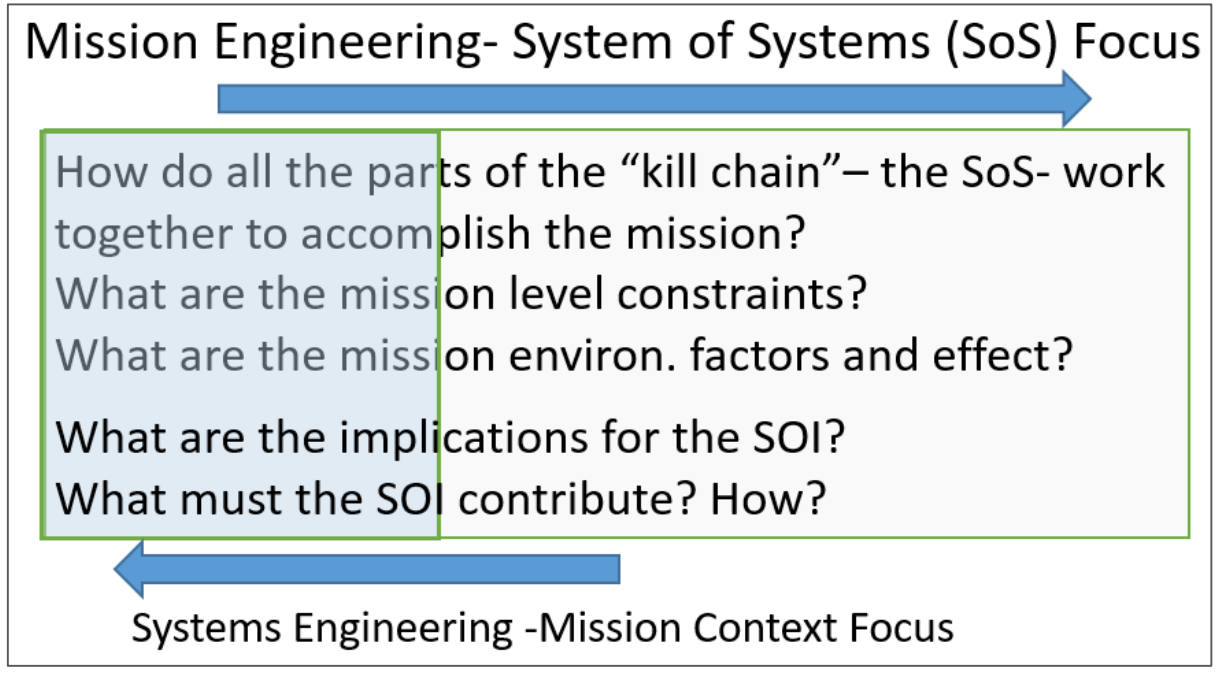
> *An external view of a system must introduce elements that **specifically do not belong to the system** but **do interact with the system**. This collection of elements is called the **operating environment or context** and can include the users (or operators) of the system.*
>
> *…The functionality of a system is typically expressed in terms of the interactions of the system with its operating environment….**
>
> INCOSE SE HB p 5-6

*especially the users.

Meet the Need- Mission Engineering

Understand and document end-to-end execution of a mission to understand how all the SOS parts work together.

- Systems with functions, players, and interactions
- The meaning of the data and the purpose of actions along the mission flow.
- Mission environmental factors/operational conditions and constraints and their impact on mission flow and performance
- Mission and data sensitivity, resiliency, and availability

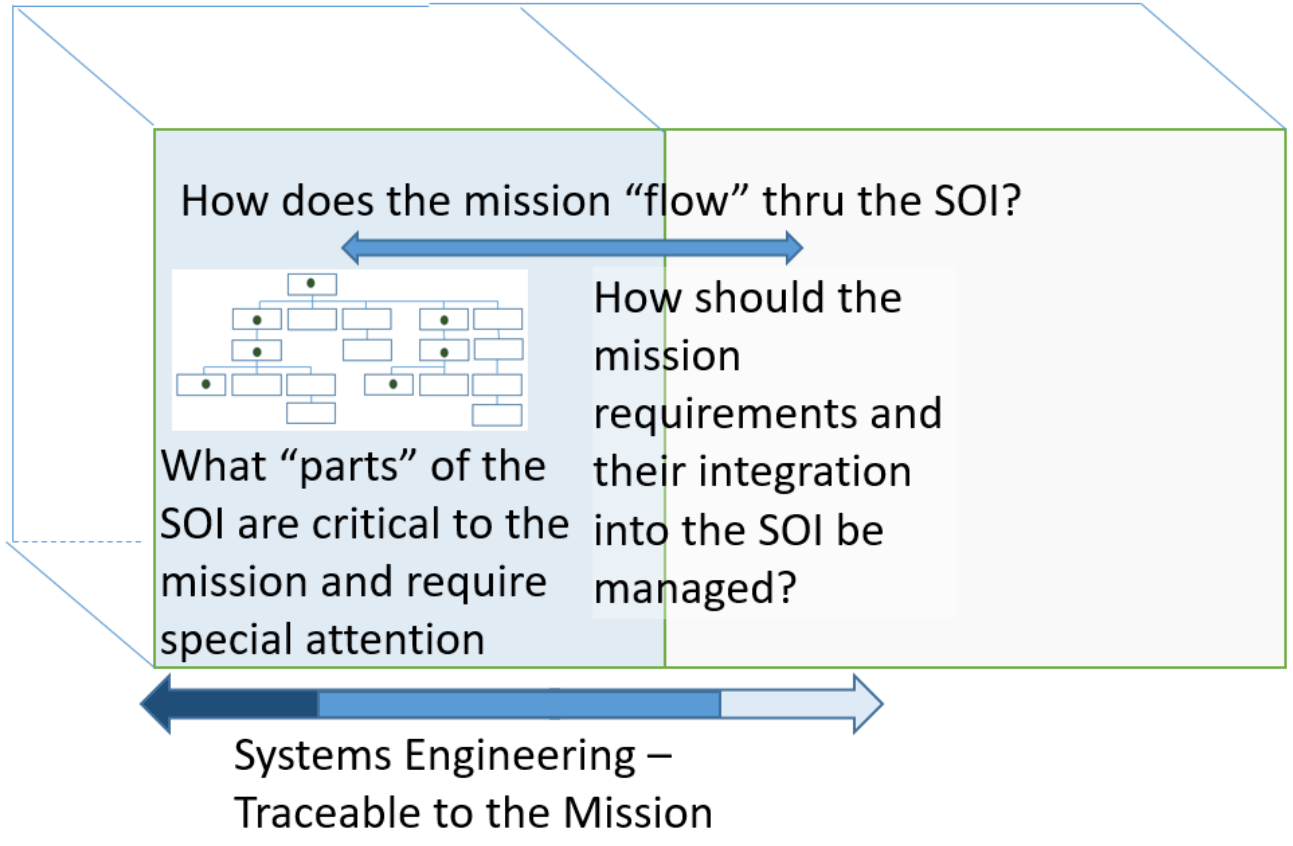


etc.

Meet the Need – Systems Engineering

Specifying, designing, and developing the SOI with a firm understanding of the mission context and maintaining traceability to the mission.

Evaluate the implications of the Mission Engineering findings on requirements interpretation and implementation.



Data sensitivity

CPI/CC

Ao

Resiliency

Timing

TTPs

Logistics

…

Definition- Mission Threads

"… an end-to-end set of steps that illustrate the technology and people resources needed to deliver expected behavior under a set of conditions…. For each mission step, the expected actions, outcomes, and assets are assembled.

Woody, C. and Albers, C. in "Evaluating Security Risks Using Mission Threads", Crosstalk September/October 2014

"… operational and technical description of the end to end set of activities and systems that accomplish the execution… of the specific missions in which the system participates."

Committee on C4ISR for Future Naval Strike Groups, National Research Council in C4ISR for Future Naval Strike Groups

Premise

Mission Threads

- Identified early in the development or modification program
- Elaborated and applied at multiple levels of abstraction across the SoS (system of systems) and SOI (system of interest)

are a useful tool for maintaining a mission focus throughout the systems engineering and acquisition lifecycles and providing end to end, traceability of requirements to mission.

Missions are typically not accomplished by a single system, but by a SoS

The systems that make up the SoS for are often developed independent of the SoS by different organizations

An Approach- Overview

Examine the evolving threads and system in the context of the

- Mission Need
- SOS
- SOI

Step 1: Do the Mission Engineering, develop a SoS thread for each mission that the SOI supports (Context Mission Thread)

For each mission

- Step 2-1: Develop a use case with focus on the SOI (System Level Mission Use Case)
- Step 2-2: Identify the flow, system elements, actors, and external/interface dependencies for the main path thru the System Level Mission Use Case (Base Mission Thread)
- Step 3: Develop flows for the alternate paths thru the use case (Scenario Specific Mission Thread)
- Step 4: Identify operational conditions that impact "quality" of mission thread performance and map to the appropriate threads
- Step 5: Elaborate and refine mission threads to lower levels of abstraction, identifying how lower level system elements support the mission

Step 1: Do the Mission Engineering and Develop Context Mission Threads

Identify and analyze each mission in in which an SOI participates

For each mission, capture

- How the mission flows through the system of systems – players, functions, and interactions
- Mission environmental factors that impact the actions taken to accomplish the mission or the “quality” of the mission conduct
- Details of expected functions/actions and interactions for which the SOI is responsible in accomplishing the mission

with an eye for what is likely to influence how to SOI needs to work with the other elements of the SoS in the operational environment

Step 1: Do the Mission Engineering and Develop Context Mission Threads - Example

The SOI in this example is the surveillance and warning aircraft in the left of the graphic.

The SOI participates in several missions, one of which is Threat Detection and Neutralization

Step 1: Do the Mission Engineering and Develop Context Mission Threads – Example (continued)

"… a sequence of activities and events beginning with an opportunity to detect a threat or element that ought to be attacked and ending with a commander's assessment of damage after an attack."

Activity	Performing Entity
Surveillance and warning – threat detection and assessment	Surveillance and warning platform
Strike warfare commander (SWTC) assesses threat and time sensitivity of threat, identifies it as a strike target, and makes request for interdiction to Composite Warfare Commander (CWC). Approved target passed to Air Resource Element Coordinator (AREC)	Maritime Operations Center (MOC)- Composite/strike warfare commander (STWC/CWC)
Evaluate and issue Air Tasking Order (ATO)	Air Resource Element Coordinator (AREC) which in our example is the carrier commander or similar
Manage safe passage, strike and aircraft in operational area	Tactical Air Control Center (TACC)
Provide target updates to TACC and aircraft	Surveillance and warning platform
Perform battle damage assessment and report to command element and Air Operations Center (AOC)	Surveillance and warning platform

Step 1: Do the Mission Engineering and Develop Context Mission Threads – Example (continued)

Flow is described as "… a sequence of activities and event… with an opportunity to detect a threat or element that ought to be attacked… with a commander's …ssessment of damage after an attack."

Activity	Performing Entity
Surveillance a… detection and assessment	Surveillance and warnin… tform
Strike warfare commander (SWC)… time sensitivity of threat, identifies it as a strike target, and … interdiction to Composite Warfare Commander (CWC). … target passed to Air Resource Element Coordinator (A…C)	Maritime Operat… SC)-Compo… e commander (CTW…
Evaluate and issue Air Tasking Order (ATO)	Air Resource Element Coordinator (AREC) which in our example is the carrier commander or similar
Manage safe pass… aircraft in operation…	Tactical Air Control Center (TACC)
…target upda…s to TACC and aircraft	Surveillance and warning platform
…age assessment and report to command eleme… and Air Op… C)	…illance and warning platfor…

Target threat and type identification reliability

Expected standoff and sensor range

Location accuracy

Comm interoperability

Data format and sensitivity

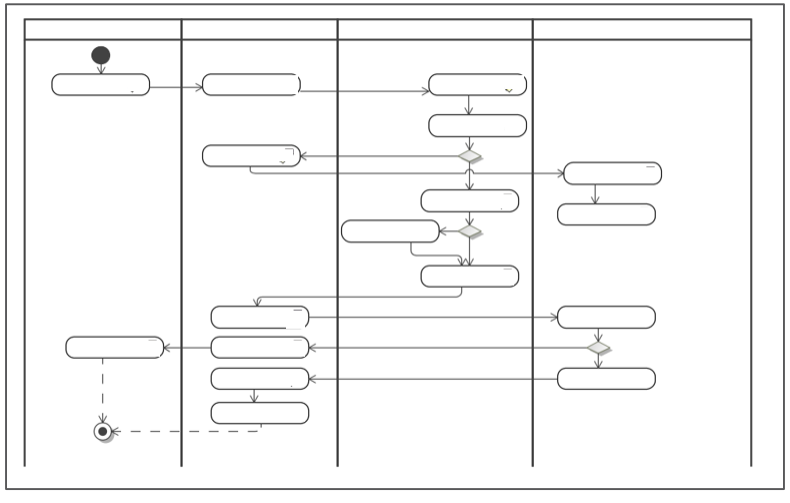
End to End Mission Ao

Time constraints

Step 2-1: Develop Mission Use Case

System level, SOI focused, narrative that elaborates on

- The role of the SOI and
- Its interactions and dependencies with the SoS



1. **Use Case Name**
   The use case name. Suggest using the name of the mission in the form of what is being done (e.g. action – object)
2. **Definitions, Acronyms, and Abbreviations**
   *Define terms, acronyms, and abbreviations required for a reader without domain experience to be able to understand and properly interpret the **Use Case Specification**.*
3. **Actors**
   - **3.1. Users**
     Identify each relevant user type and provide a short description of their role.
   - **3.2. Systems (or internal system elements as required to describe the flow)**
     Identify each system/system element that participates in the mission and provide a short description of its role.
4. **Flow of Events**
   Provide a textual summary of how the use case is realized in terms of collaborating actors and how they are related
   - **4.1. Triggering Event.**
     Identify what triggers execution of the use case
   - **4.2. Base Flow/Main Success Scenario**
     Describe the main mission flow. It is written assuming that no errors or alternatives exist. Identify the major steps in the flow. Provide a short discussion for each regarding what should be accomplish and how it is accomplished (e.g. the activities/contributions of the actors). Identify interaction between actors.

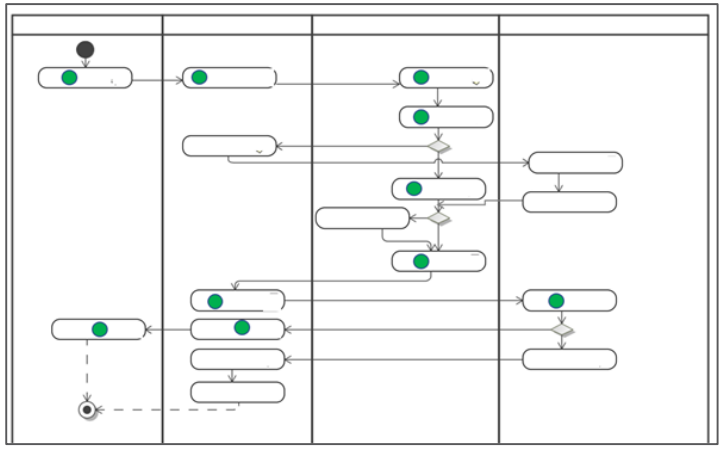
     Workflow step 1
     Workflow step 2
     ...
   - **4.3. Alternate Flows**
     Describe each alternative path and identify the conditions that lead to the alternate path being exercised. For each alternate flow include
     - *Name of alternate flow*
     - *Event or condition that causes the alternative flow to be exercises, with short description*
     - *Workflow Steps*
     - *Include all steps in the flow, including those that are also part of the base mission flow*
     - *As was done in the Base Flow, for each step, provide a short discussion of what is accomplished and how it is accomplished.*
5. **Special Requirements**
   The special requirements that apply to the use case that are not adequately addressed in any of the above sections.
6. **Operational Conditions and Scenarios**
   These are operational conditions and scenarios that will affect the execution of the base and/or alternate mission flows and are not adequately addressed in any of the above sections.

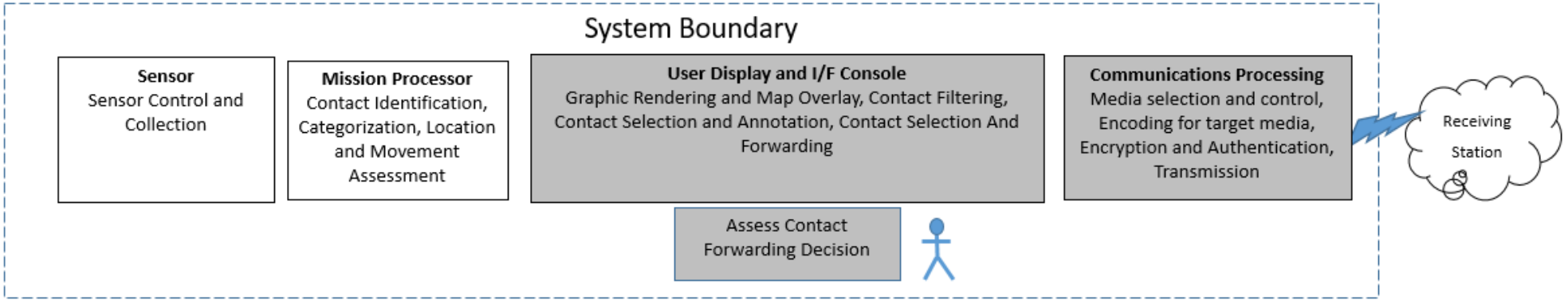
Step 2-2: Develop Base Mission Thread

Focus on the *standard flow* without regard to variations driven by the operational environment

Identify the top-level system elements and the associated functionality required to perform the specific mission.

Document data critical to mission success and its associated creation, modification, and usage.

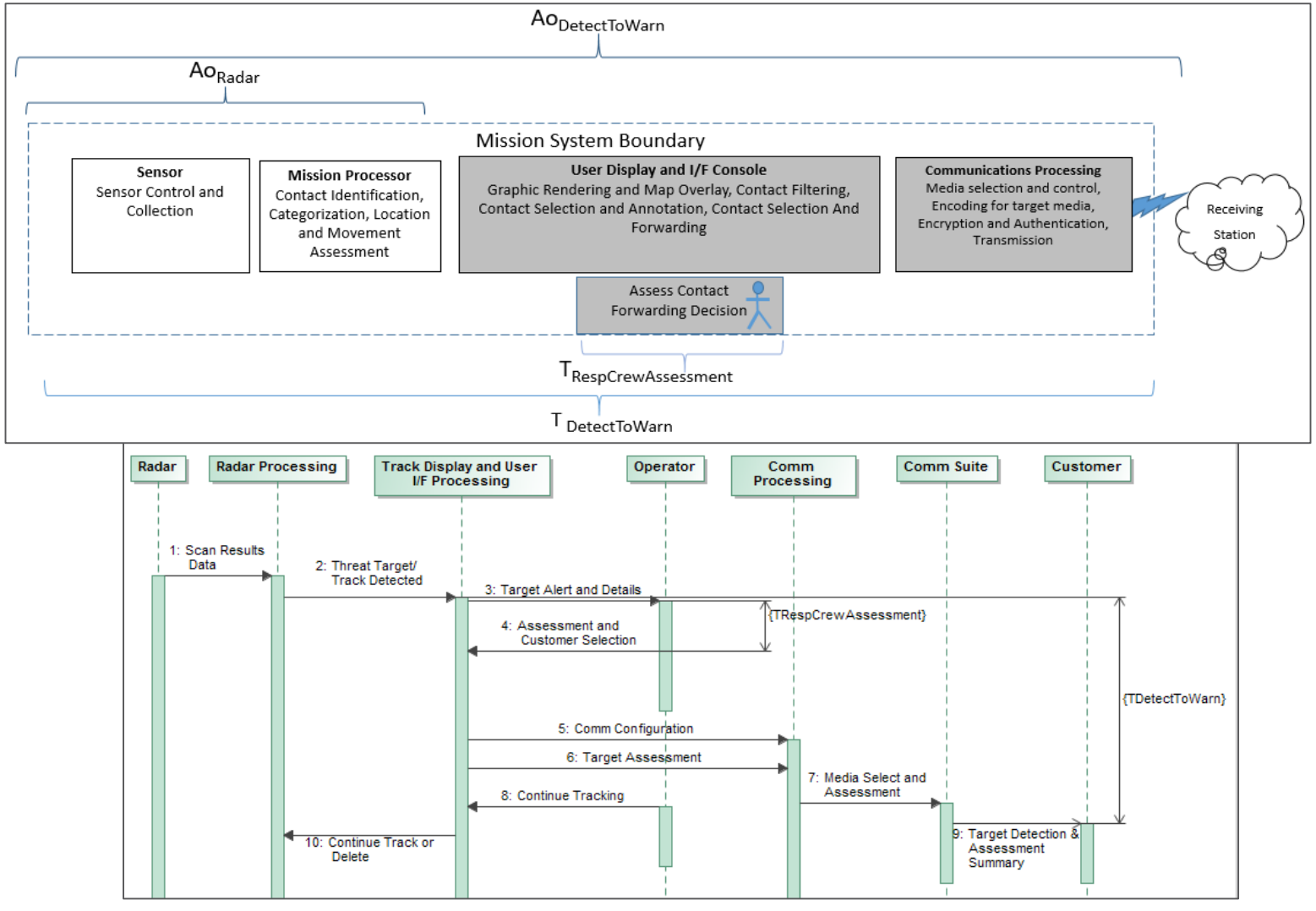




For each mission step the expected actions, outcomes, and assets are assembled

Step 2-2: Develop Base Mission Thread (continued)

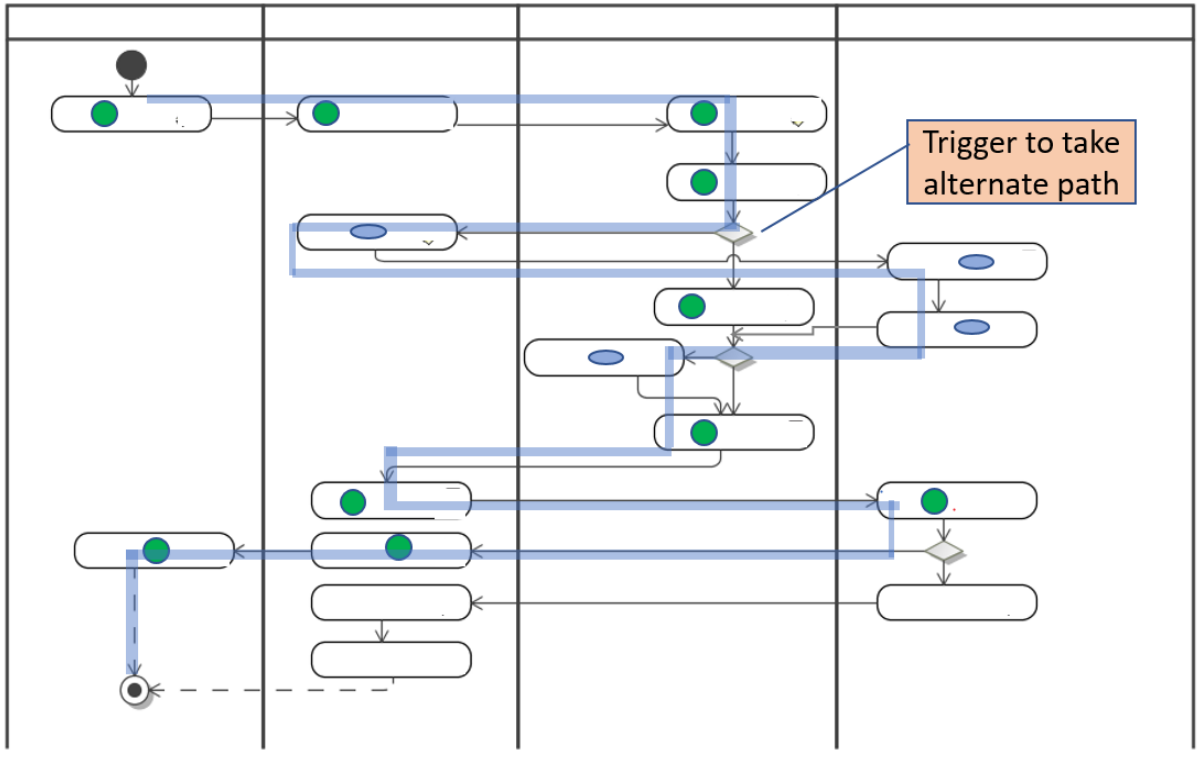
Identify constraints found in JCIDS requirements or discovered during mission engineering that are specific to a mission flow or its elements



Step 3: Develop Scenario Specific Mission Threads from Alternate Mission Flows

Address cases where the main mission path fails or alternate actions are needed to adapt to the mission need

Manifested as alternate paths/excursions from the main mission thread in the activity diagram



For example, special processes

- For certain contact or target types,
- Addressing disruption of communications
- Responding to threat/time sensitive target

Identify additional requirements, constraints, system components and data variants associated with the alternate path.

Step 4: Identify Operational Conditions Affecting the Quality of Mission Thread Execution

Operational realities may effect performance in one or more mission threads, but not lead to alternate paths

The associated constraints or parameters need to be analyzed with respect to their impact on the associated threads and their implications for the SOI.

For example,

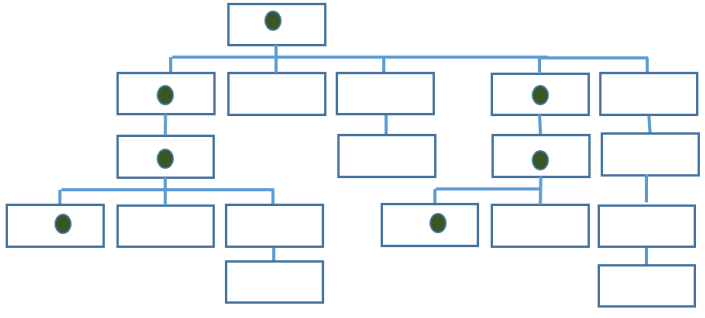
- Nominal or extreme message traffic
- Decreased RF performance
- Responding to threat/time sensitive target
- Special requirements that apply to the thread or elements in the thread

Step 5: Elaborate and Refine Mission Threads to Examine How Lower-Level Elements Support the Mission

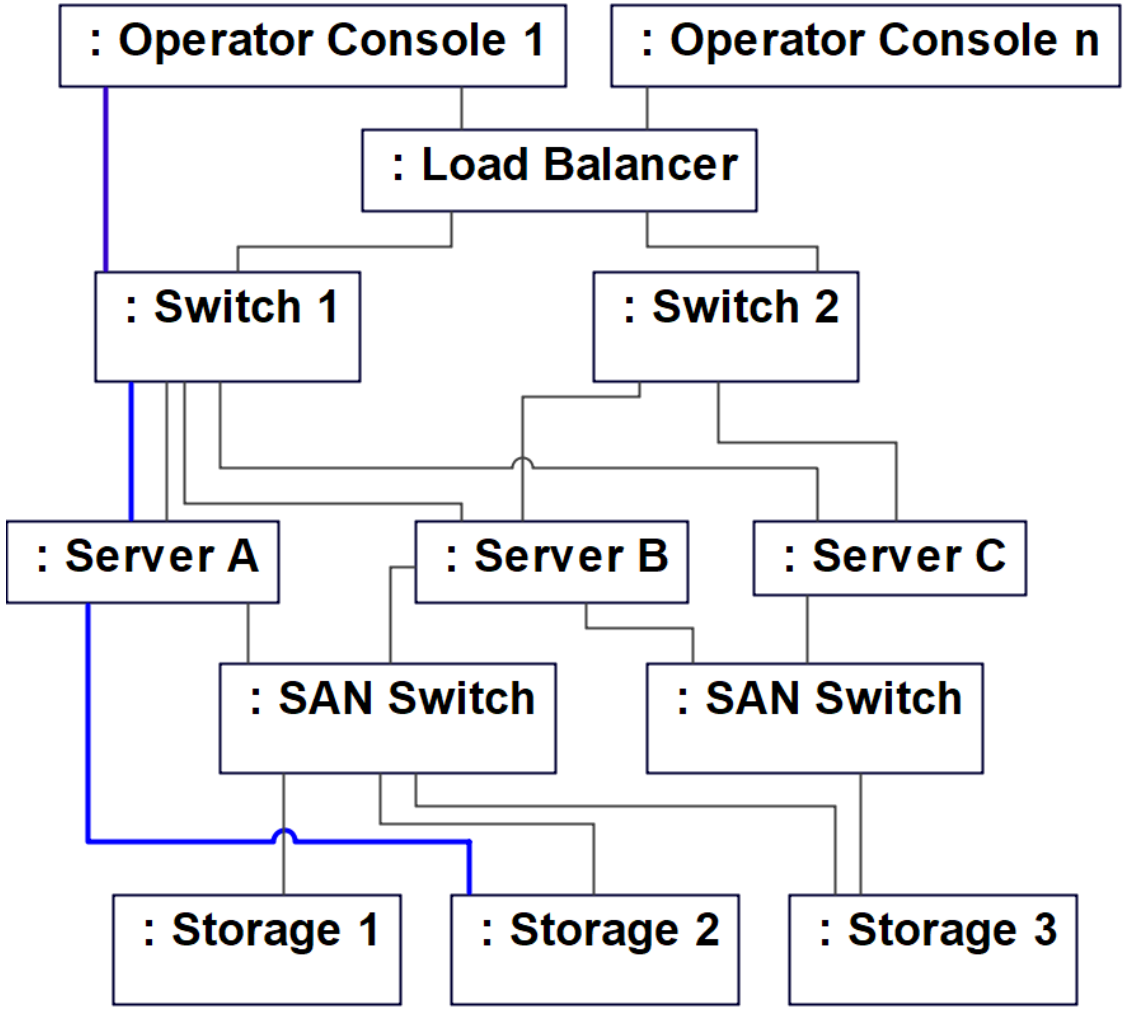
As the system matures and the configuration details become known, each mission thread is elaborated to show which lower level system components provide the capability described in higher level threads

- Facilitates evaluating allocated requirements and constraints (e.g. timing, availability, security…) in the context of the supported mission
- Minimizes the risk of unforeseen impacts of design and implementation changes and upgrades by identifying system elements shared by multiple missions
- Supports identification of critical functionality and system elements in a single thread or shared between multiple threads

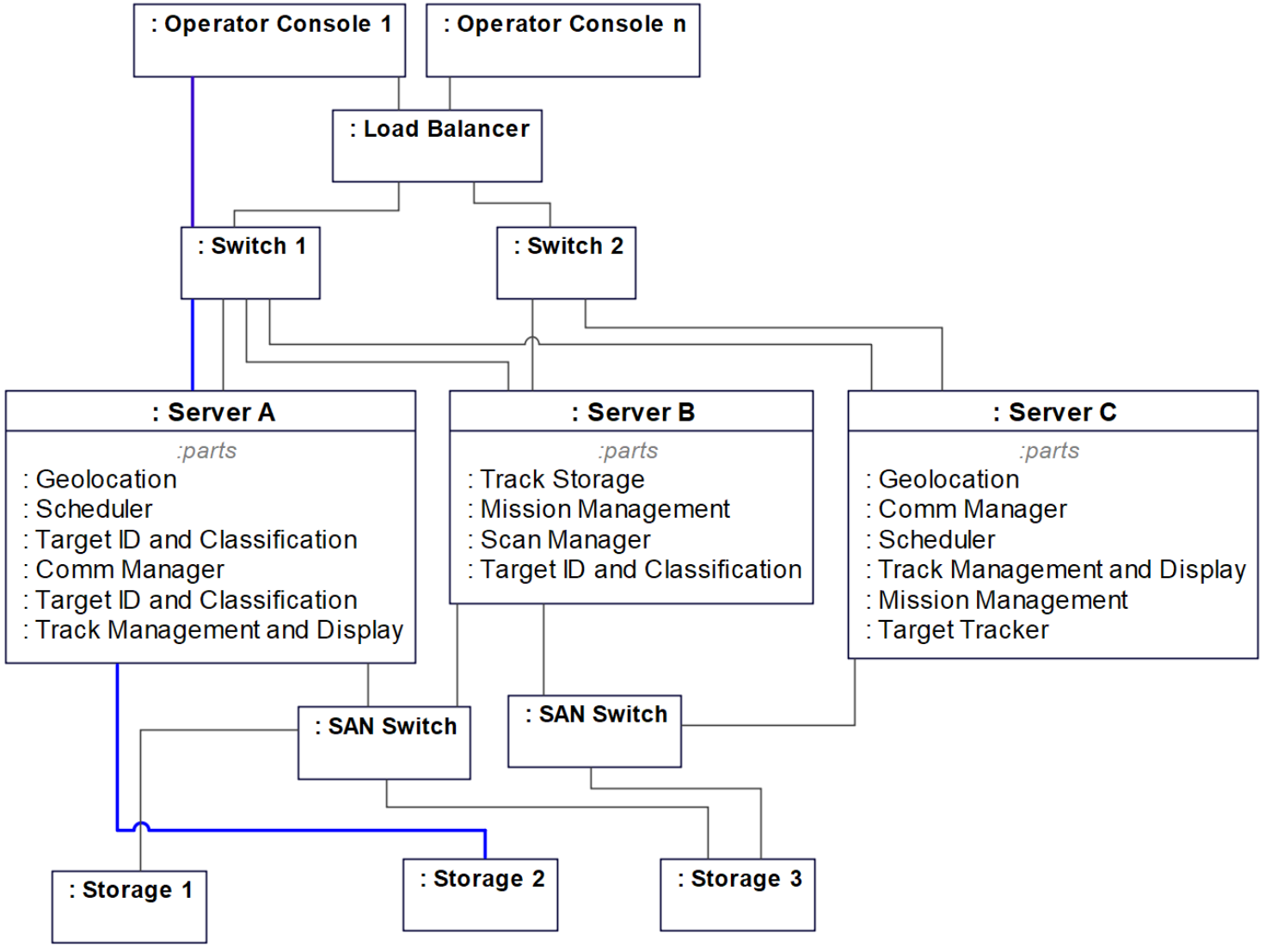
(system reliability, maintainability, and availability (RMA) analysis, system safety analysis, and the criticality and system resiliency analysis required to support trusted networks and cyber security).



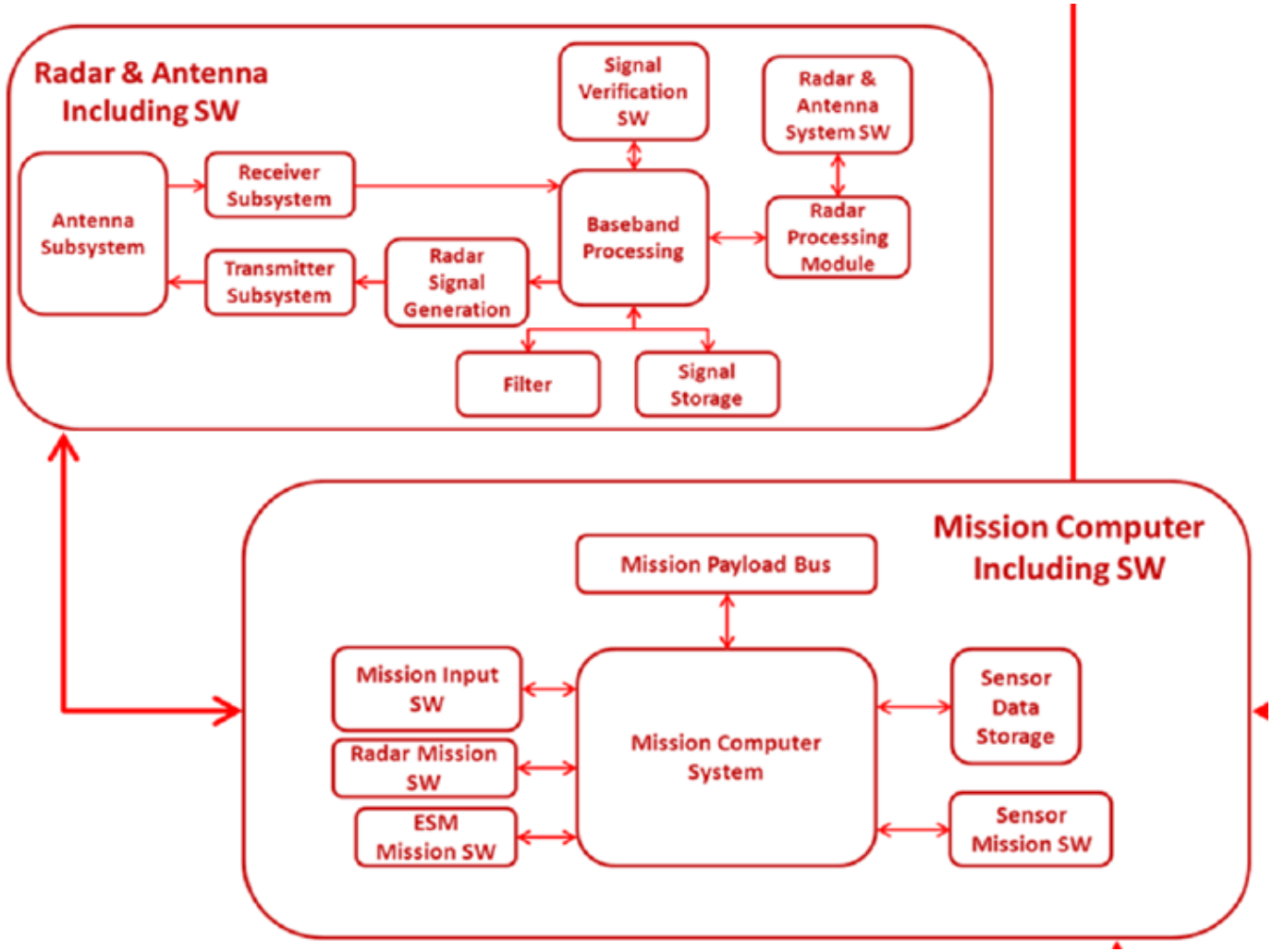
Step 5: Elaborate and Refine Mission Threads to Examine How Lower-Level Elements Support the Mission – Example



Step 5: Elaborate and Refine Mission Threads to Examine How Lower-Level Elements Support the Mission – Example (continued)



Step 5: Elaborate and Refine Mission Threads to Examine How *EVEN* Lower-Level Elements Support the Mission – Example



Systems Engineering Requirements Analysis and Trade-off for Trusted Systems and Networks Tutorial: Notional Architecture Handout
Melinda Reed, DASD(SE)
Paul Popick, Johns Hopkins University Applied Physics Lab, March 2013

Conclusion

Mission Threads

- Developed across the SoS for each mission early in the development or modification program
- Extended and focused on the SOI
- Elaborated to lower system level as the development progressed

Provide a means for maintaining a mission focus and traceability to the mission throughout the engineering and acquisition lifecycle

Thus reducing the risks associated with compliance, security, and operational suitability.

AND IT REALLY HELPS WHEN IT COMES TIME TO TEST…

Take Away

Beyond [the standard] list of system engineering activities, there are ***critically important attributes*** *of the process* that ***go beyond the technical work per se***. These include the following:

Adopting explicit, mission-driven outcomes to inform the system engineering trade-offs ….including ***the engineering and integration of end-to-end mission threads***.

"C4ISR for Future Naval Strike Groups," Committee on C4ISR for Future Naval Strike Groups, National Research Council, National Research Council in their recommendations for improving performance in the networked environment (p. 90).