Mission Threads: Bridging Mission and Systems Engineering

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SE Technical Processes and the Acquisition Lifecycle

Continuous application across all phases
SE Processes
Not a sequence of steps

The systems engineering technical and technical management processes are not sequential

They may be
• Iterative
• Recursive
• Concurrent
“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

Mission Engineering- System of Systems (SoS) Focus

- How do all the parts of the “kill chain” – the SoS - work together to accomplish the mission?
- What are the mission level constraints?
- What are the mission environ. factors and effect?
- What are the implications for the SOI?
- What must the SOI contribute? How?

etc.

Systems Engineering - Mission Context Focus
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.

How does the mission “flow” thru the SOI?

What “parts” of the SOI are critical to the mission and require special attention?

How should the mission requirements and their integration into the SOI be managed?

Data sensitivity
CPI/CC
Ao
Resiliency
Timing
TTPs
Logistics ...

This presentation consists of Engility Corporation general capabilities information that does not contain controlled technical data as defined by the International Traffic in Arms (ITAR) Part 120.10 or Export Administration Regulations (EAR) Part 734.7-11.”
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.


“… 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
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)

Premise

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

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

Examine the evolving threads and system in the context of the
• Mission Need
• SOS
• SOI
Step 1: Do the Mission Engineering and Develop Context Mission Threads

Identify and analyze each mission 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 the 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.”

<table>
<thead>
<tr>
<th>Activity</th>
<th>Performing Entity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveillance and warning – threat detection and assessment</td>
<td>Surveillance and warning platform</td>
</tr>
<tr>
<td>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)</td>
<td>Maritime Operations Center (MOC)- Composite/strike warfare commander (STWC/CWC)</td>
</tr>
<tr>
<td>Evaluate and issue Air Tasking Order (ATO)</td>
<td>Air Resource Element Coordinator (AREC) which in our example is the carrier commander or similar</td>
</tr>
<tr>
<td>Manage safe passage, strike and aircraft in operational area</td>
<td>Tactical Air Control Center (TACC)</td>
</tr>
<tr>
<td>Provide target updates to TACC and aircraft</td>
<td>Surveillance and warning platform</td>
</tr>
<tr>
<td>Perform battle damage assessment and report to command element and Air Operations Center (AOC)</td>
<td>Surveillance and warning platform</td>
</tr>
</tbody>
</table>
Step 1: Do the Mission Engineering and Develop Context Mission Threads – Example (continued)

Flow is described as “… a sequence of activities and events … following with an opportunity to detect a threat or element that ought to be attacked, continuing with a commander’s assessment of damage after an attack.”

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<td>Performs threat detection and assessment.</td>
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<td>Strike warfare commander (SWC)</td>
<td>Identifies threat and time sensitivity of threat, identifies as strike target, passes interdiction to Composite Warfare Commander (CWC).</td>
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<td>Maritime Operations Center (MOC)</td>
<td>Composite/strike warfare commander (STWC/CWC), approves target passed to Air Resource Element Coordinator (AREC).</td>
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Target threat and type identification reliability
Expected standoff and sensor range
Location accuracy
Comm interoperability
Data format and sensitivity
Time constraints
End to End Mission Ao
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 accomplished 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 exercised, 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 affect 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.