When and Where to Apply the Family of Architecture-Centric Methods

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Scope of the Presentation

• Architecture products are used throughout the lifecycle, with the primary focus on the left side of the architecture engineering cycle.

• Specific SEI methods are not the emphasis; instead, the emphasis is on developing the products that are associated with the methods and their use in the lifecycle.

• We illustrate these points using examples from DoD programs, but everything that we will discuss has been applied and implemented in non-DoD and commercial programs also.

• For example, the term *acquisition* is used to cover broad activities including the development process and timelines, development products, milestones, and envisioned development organization.
Family of Architecture-Centric Methods

SoS/EA
- MTW
- SoS Architecture Evaluation

System
- APW
- System ATAM

Software
- QAW
- ATAM

- Acquisition/Development Process
- Quality Attribute-Based Requirement Elicitation Methods
- Quality Attribute-Based Architecture Evaluation Methods
SoS Architecture Quality Attribute Specification and Evaluation Approach

- Early elicitation of quality attribute considerations
- Early identification and addressing of architecture challenges
- Early identification and mitigation of architectural risks

SoS Business / Mission Drivers
  - Vignettes
  - Mission Threads
  - SoS Architecture Plans

Mission Thread Workshop
  - Quality Attribute
  - Augmented Mission Threads
  - SoS Architecture Challenges

SoS Architecture Evaluation
  - SoS Architecture Risks
    - Problematic systems identified with the augmented mission threads

System ATAM
  - System & S/W Architecture
  - Sys & S/W Arch Risks

SoS and System Architecture(s) Acquisition / Development
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Ballistic Missile Defense (BMD) OV-1 Example

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Example Ship’s SoS Tier Definition

**Tier Definition**

| Tier 0 – Operational Context | NR-KPP, CDD, and ISP documentation | NA |
| Tier 1 – Ship Platform Context | Describes the system interaction with external entities | NA |
| Tier 2 – Segment and Group Context | Internal to the Ship System | 1-digit |
| Tier 3 – Element Context | Describes major ship system type functionality and interactions with other major system types | 2-digit |
| Tier 4 – Component Context | Describes Ship System functionality and interactions with other systems | 3-digit |
| Tier 5 – Unit Context | Defines the functionality and interaction of the components within a ship subsystem | 4/5-digit |

**Software Work Breakdown Structure (SWBS)**

<table>
<thead>
<tr>
<th>Tier 0</th>
<th>Tier 1</th>
<th>Tier 2</th>
<th>Tier 3</th>
<th>Tier 4</th>
<th>Tier 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-digit</td>
<td>2-digit</td>
<td>3-digit</td>
<td>4/5-digit</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Example Ship’s SoS Tier Definition**

**Tier Definition**

- **Tier 0 – Operational Context**
  - NR-KPP, CDD, and ISP documentation

- **Tier 1 – Ship Platform Context**
  - Describes the system interaction with external entities

- **Tier 2 – Segment and Group Context**
  - Internal to the Ship System
  - Describes major system segments (Mission Systems and Ship Systems) functionality and SWBS Level IV Groups

- **Tier 3 – Element Context**
  - Describes major ship system type functionality and interactions with other major system types
  - 2-digit SWBS level of fidelity (i.e., Power Distribution System interface with Surveillance Systems)

- **Tier 4 – Component Context**
  - Describes Ship System functionality and interactions with other systems
  - 3-digit SWBS level of fidelity (i.e., Seawater Cooling System interface with Emergency Diesel Generator)

- **Tier 5 – Unit Context**
  - Defines the functionality and interaction of the components within a ship subsystem
  - 5-digit SWBS level of fidelity (i.e., interface of Specific System A to Specific System B)
Mission Threads Flow from Vignettes – Example (Non-Augmented)

1. 20 land-based missiles launched – X-minute window
2. Satellite detects missiles; cues CMDR
3. CMDR executes replanning; reassigns Alpha and Beta
4. Satellite sends track/target data – before they cross horizon
5. Ships’ radars are focused on horizon crossing points

…

N. Engagement cycle is started on each ship
N+1. Aircraft are detected heading for fleet
N+2. SA detects missile launches; tells CMDR
N+3. CMDR does replanning; UAVs are redirected
N+4. FCQ tracks are developed from UAV inputs
Mission Thread
(augmented via the Mission Thread Workshop)

- Developed from SMEs
- Architecture & Engineering Challenges Derived from Thread Augmentation

<table>
<thead>
<tr>
<th>Steps</th>
<th>Quality Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>availability</td>
</tr>
<tr>
<td>2</td>
<td>maintainability</td>
</tr>
<tr>
<td>3</td>
<td>...</td>
</tr>
<tr>
<td>4</td>
<td>...</td>
</tr>
<tr>
<td>n</td>
<td>...</td>
</tr>
</tbody>
</table>

Thread
- Vignette
- Nodes and Actors
- Assumptions

Use Cases (OV6 and SV6)
- OV1
- OV2

Augmentations
- ...
Conceptual Flow of the MTW

SoS Drivers and Capabilities → Mission Threads and Vignettes → SoS Quality Attributes → Quality Attribute Augmentation (with stakeholders)

 Legacy Systems

Views: Operational Development Sustainment

SoS Architecture Plan

SoS Challenges

Mission Threads Augmented with Quality Attribute, Capability Engineering Considerations

Architectural Issues

Engineering Issues

Capability Issues

Qualitative Analysis of Augmented Mission Threads (w/o stakeholders)
Legacy System Architecture Evaluation – Early

- Early elicitation of quality attribute considerations
- Early identification and addressing of architecture challenges (e.g., architecture evaluation of candidate legacy system)
- Early identification and mitigation of architectural risks
Conceptual Flow of System ATAM

- Business Drivers
- Quality Attributes
- QA Scenarios (based on augmented mission threads and use cases)
- Qualitative Analysis (with stakeholders)
- Architecture Challenges
- Architecture Decisions
- Tradeoffs
- Sensitivity Points
- Non-Risks
- Risks
- System and Software Risk Themes
Is a System ATAM Variant Appropriate for a Defensive Engagement System?

Comments from augmented mission thread:

• The Defensive Engagement System may not be able to support the deconfliction timeline for 5 incoming missiles.
• The Defensive Engagement System may not have the capability to acknowledge Beta’s acceptance of its assignment of 2 missiles.
• Is the Defensive Engagement System capable of sending track updates to the interceptor missiles that Beta had launched within the intercept timeline?

In Phase 0, the System ATAM lead meets with SoS and appropriate system architects to discuss what is in and out of scope concerning the system under analysis and if appropriate documentation exists. Agree on scenarios based on the augmented mission thread, with the understanding that additional scenarios can be added during Phase 2 of the System ATAM.
Examples of Scenarios

Scenarios address both system and software aspects:

- **Use case scenario**
  
  The Defensive Engagement System (DES) is able to support deconfliction of 7 incoming missiles using own-ship and external information within XX seconds.

- **Growth scenario**
  
  An upgraded DES is able to reduce the confliction time by 40% of 7 incoming missiles with no loss of existing functionality.

- **Exploratory scenario**
  
  The DES is able to operate at up to 80% of its time budget for deconfliction of 7 incoming missiles with 8 coalition UAVs and 3 coalition helicopters operating in its vicinity.
ATAM Phase 2 Specifics

Stakeholders will consist of

- System Architects of associated systems relevant to the system under evaluation
- SoS Architects who know the total system and how the system under evaluation is envisioned to fit in
- Relevant stakeholders of the system under evaluation in the areas of requirements, development, T&E, sustainment, and M&S

ATAM evaluators will look to identify/expose potential system and software architecture risks, with the help of the stakeholders. Subject-matter experts may be used on the evaluation team, if necessary.
Walk-through of a scenario derived from augmented MT

The Defensive Engagement System (DES) is able to support deconfliction of 7 incoming missiles using own-ship and external information within XX seconds.

- System architect identifies that currently DES can support 3 incoming missiles with 25% spare capacity given the existing hardware.
- The architect also states that the system has a monolithic software architecture, which is tightly coupled to the hardware.
- The architect identifies that upgraded hardware is available for the system, which will improve performance, but the software will need to be redesigned to support it.
Focus on SoS Architecture Evaluation

Early identification and mitigation of architectural risks
Conceptual Flow of SoS Architecture Evaluation

Series of MTWs → SoS and System Architecture → QA-augmented mission threads and SoS Challenges → Architecture Approaches → Architecture Decisions → Qualitative Analysis (with stakeholders)

SoS and System Risk Themes
- Architecture Risks
- Engineering Risks
- Capability Risks
Focus on QAW

SoS Business / Mission Drivers
Warfare Vignettes
Mission Threads
SoS Architecture Plans
Mission Thread Workshop
Augmented Mission Threads
SoS Architecture Challenges
QAW
System ATAM on candidate legacy system
SoS Architecture Evaluation
Sys Arch Risks
SoS Architecture System Architectures
SoS Architecture Risks
Problematic systems identified with the augmented mission threads
SoS and System Architecture(s) Acquisition / Development
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Conceptual Flow of the QAW

- **Business Drivers**
- **Software Architecture Plans**
- **Quality Attributes**
  - Quality Attribute Scenario elicitation, prioritization, refinement (with stakeholders)
- **Prioritized Quality Attribute Scenarios**
- **Qualitative Analysis of Refined Scenarios (w/o stakeholders)**
- **Refined QA Scenarios**
  - (subset of scenarios, in priority order)
- **Architecture Challenges**
  - impacts
distilled into
Focus on ATAM

SoS Business / Mission Drivers

Warfare Vignettes
Mission Threads
SoS Architecture Plans

Mission Thread Workshop

Augmented Mission Threads
SoS Architecture Challenges

Sw Architecture

Sw Risks

ATAM

System ATAM on candidate legacy system

Sys Arch Risks

SoS Architecture Evaluation

SoS Architecture Risks

Problematic systems identified with the augmented mission threads

SoS and System Architecture(s) Acquisition / Development

SoS and System Architecture(s) Acquisition / Development
Conceptual Flow of the ATAM

Business Drivers → Quality Attributes → Scenarios

Software Architecture → Architectural Approaches → Architectural Decisions

impacts → Software Risk Themes

distilled into → Tradeoffs, Sensitivity Points, Non-Risks, Risks

Qualitative Analysis of Refined Scenarios
Acquisition/Development Aspects
Responsibilities of an Acquisition Organization

Diagram showing the flow of responsibilities from Pre-Contract Work through Contract Performance Phase to Test and Acceptance and Operational Deployment. Key responsibilities include:

- **Government performs**:
  - Management Oversight and Technical Monitoring
  - Post-Delivery Work

- **Supplier performs**:
  - Contract Performance Phase

- **Acquisition Planning and RFP/Contract Preparation**

Activity Legend:
- Government Responsibility
- Contractor Responsibility

Pre-Contract Work to End of Acquisition timeline.
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Representation of Contract Performance Phase

Government performs

Pre-Contract Work

Management Oversight and Technical Monitoring

Ongoing Interaction

Government performs

Post-Delivery Work

Contract Performance Phase

Test and Acceptance and Operational Deployment

Pre-Contract Work

Contractor Responsibilities

Requirements Elaboration

Architectural Design

Detailed Design

Implementation

Test and Integration

Technical Planning, Configuration Management, and Risk Management

-- Representative System and Software Development Activities --
Artifacts Impacted by Architecture-Centric Methods

- Request for Proposal (RFP)/source selection
- Integrated Master Schedule (IMS)
- System Engineering Plan
- Test & Evaluation Plan
- Acquisition Milestones
- Requirements
- Architecture vision
- Context
- "As is" and "To be"
- Module
- Allocation
- Component-and-connector
- Objectives
- Business and technical drivers
- Quality attributes
- Work flows/scenarios/mission threads/high-level use cases
- Key performance parameters
- Concepts of operations

Acquisition

Architecture

Visual Representation

Specifications

Processes

Risk

Architecture Guidelines and Principles document
- Architecture compliance
- Modeling and simulation
- Architecture Evaluations

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