



Leveraging UAF for Mission Engineering

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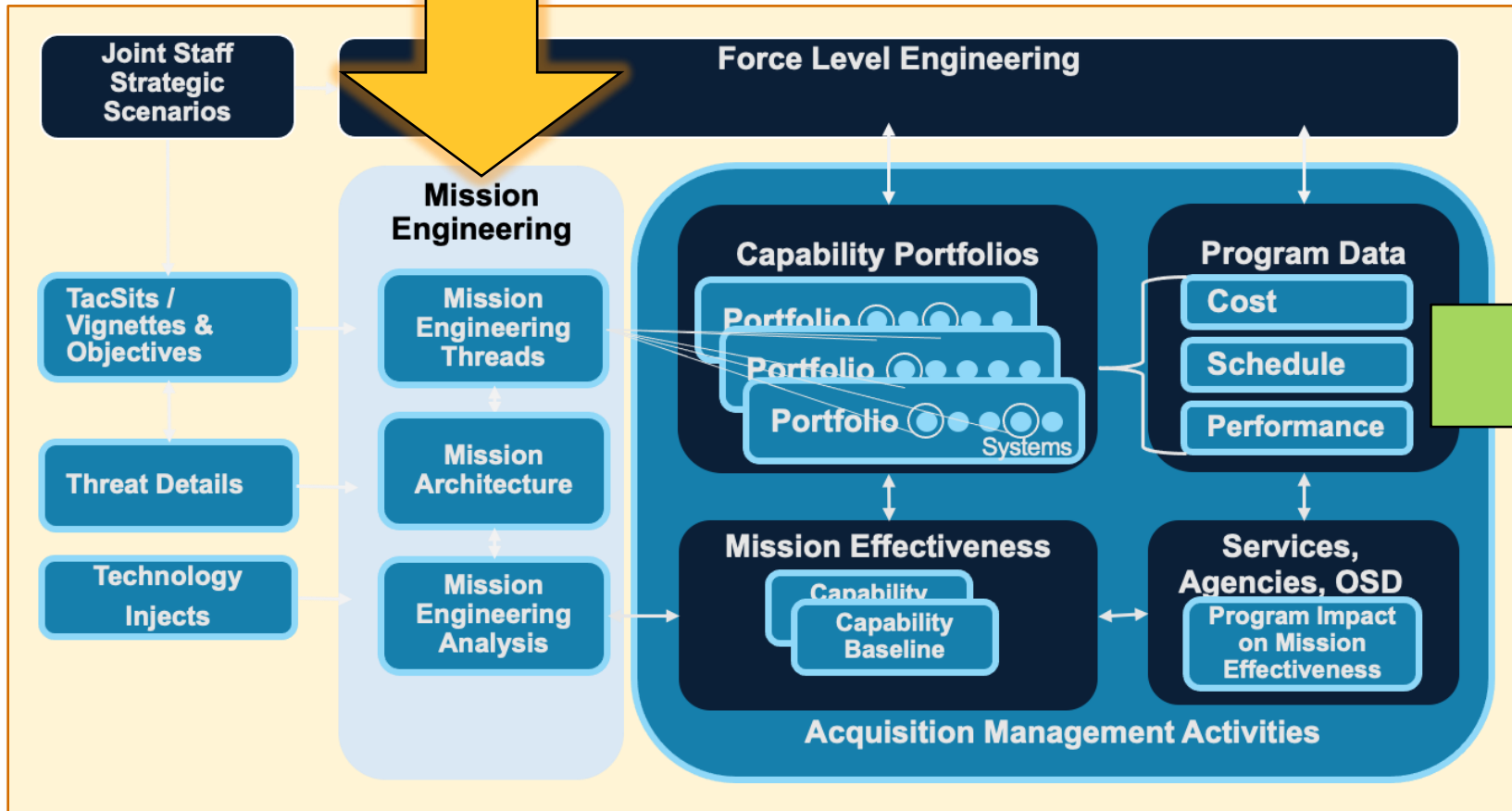
***UAF Summit: Actionable
Architecture in the 21st Century
22 March 2023***

Capability Portfolio Management → Force Level Engineering



However, Mission Architectures provide additional **Mission Effectiveness** metrics by which to assess the impact of Programmatic Risks on the ability to execute Missions

Typical Acquisition analyses and decision making are based on **Cost, Schedule & Performance** metrics



Mission Engineering (ME) Guide

- **The ME Guide provides overarching guidance and information by:**

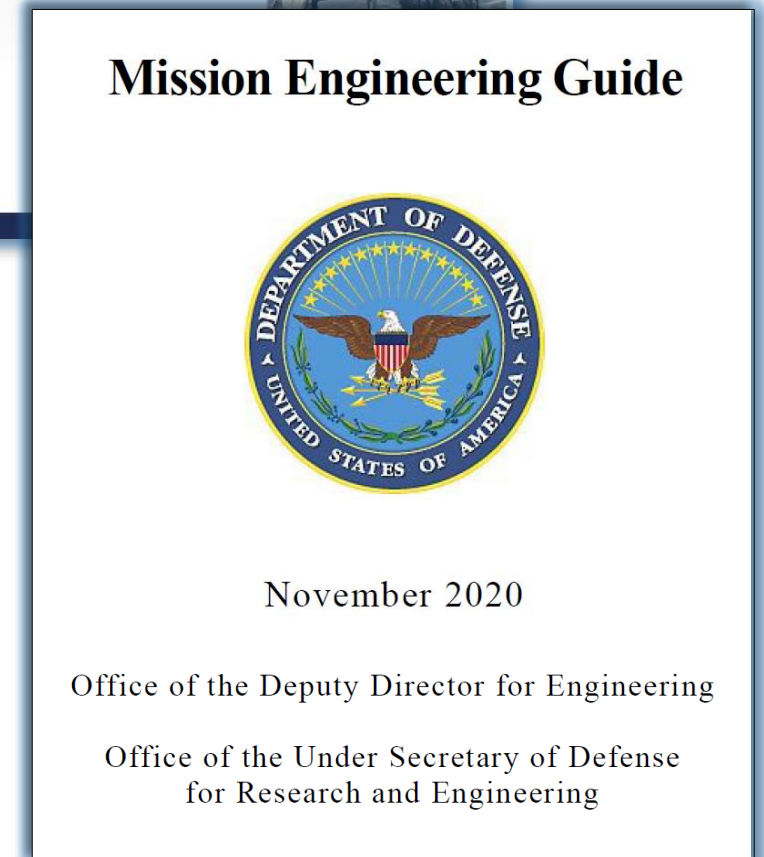
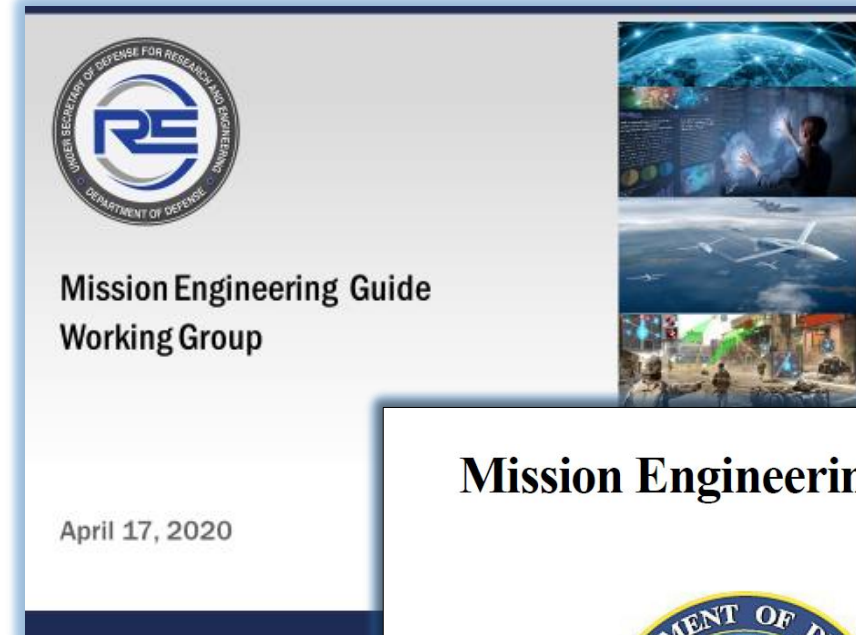
- Elaborating on the benefits of using Mission Engineering
- Explaining what is and what is not Mission Engineering
- Describing ME best practices, principles and attributes
- Establishing a set of common terms and definitions

- **Intended Uses**

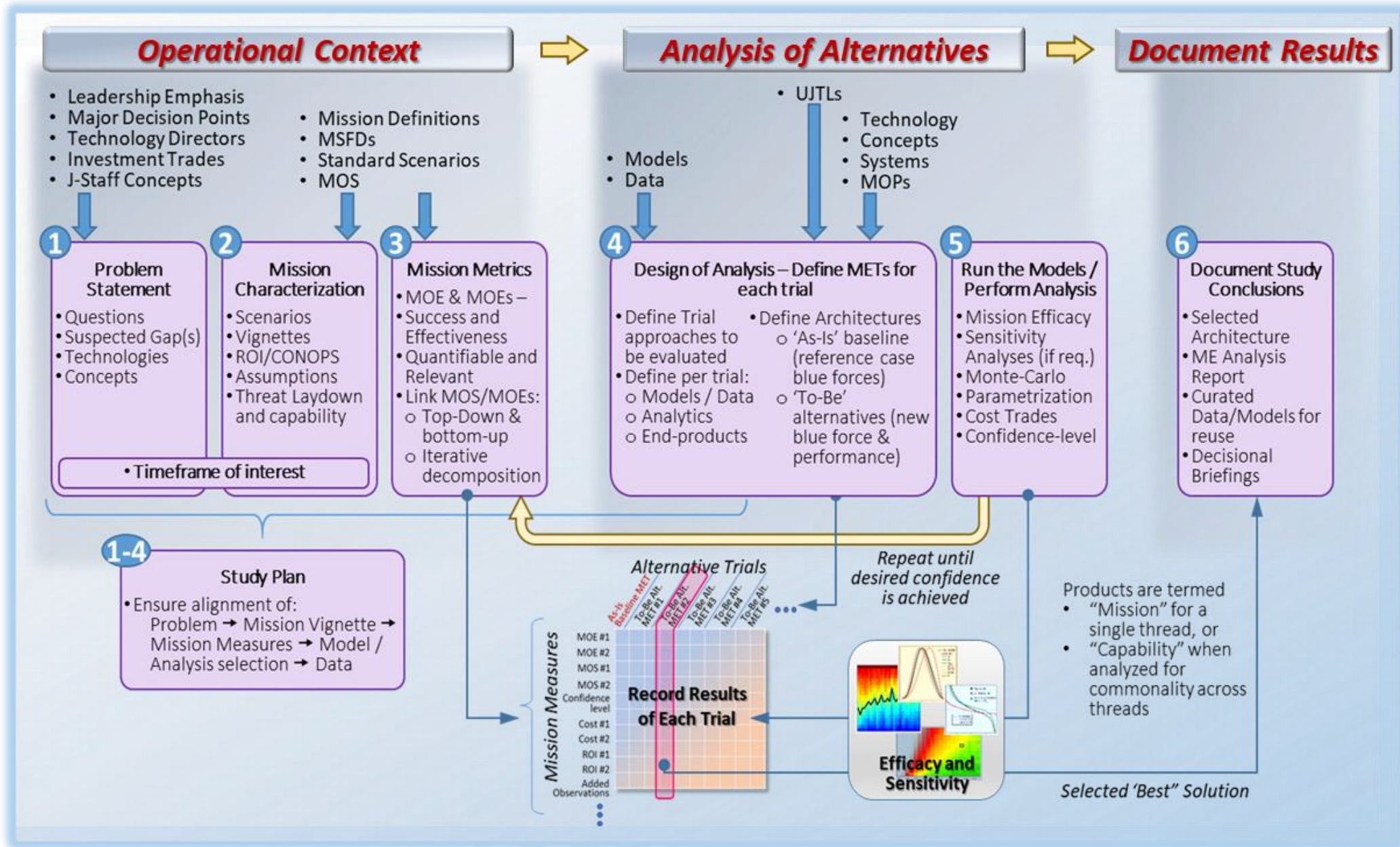
- Align modernization investments with warfighter-defined mission capability gaps and shortfalls
- Conduct Mission Engineering analysis in support of acquisition, operations and portfolio management

- **ME Guide Development**

- Leveraged inputs from various sources to ensure community agreement of concepts, lexicon, and processes
- Working group consisted of representatives from Army, Navy, Air Force, Joint Staff, OUSD(A&S), MDA, CAPE, CIO/CDO



Provides a 6-Step Process for Executing ME Studies





Step 4 – Design of Analysis

Analyzing the Alternatives

4a

Design of Analysis – Define the trials to be evaluated

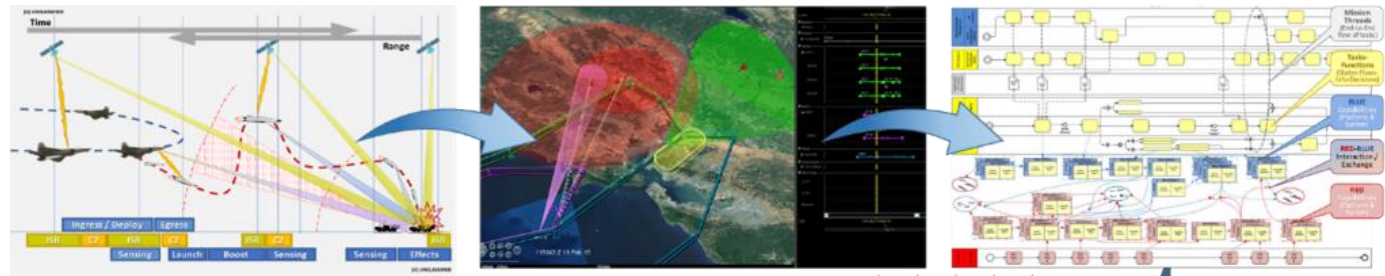
- Define Approaches
 - 'As-Is' baseline (reference case blue forces)
 - 'To-Be' alternatives (new blue force & performance)

4b

Design of Analysis – Define the trials to be analyzed

- Approach = Trial in a run matrix
- Approach best described by Mission Thread
- Define per trial:
 - Models / Data
 - Analytics
 - End-products

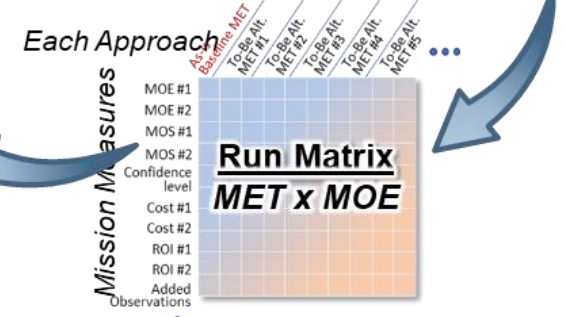
- Step 4a – Define the approaches (Current & Future)**
 - Define **Mission Threads (MTs)** for “As-Is” and “To-Be” baseline approach
 - Define multiple “To-Be” alternative approaches that will be investigated
 - Define **Mission Engineering Threads (METs)** - “flow” of the mission
- Step 4b – Define each trial and necessary resources**
 - Create run matrix: Approach (MET) x MOE
 - Collect the needed data to enable analytics/modeling
 - Create execution plan for each entry in the run matrix



Analysis Execution Tables

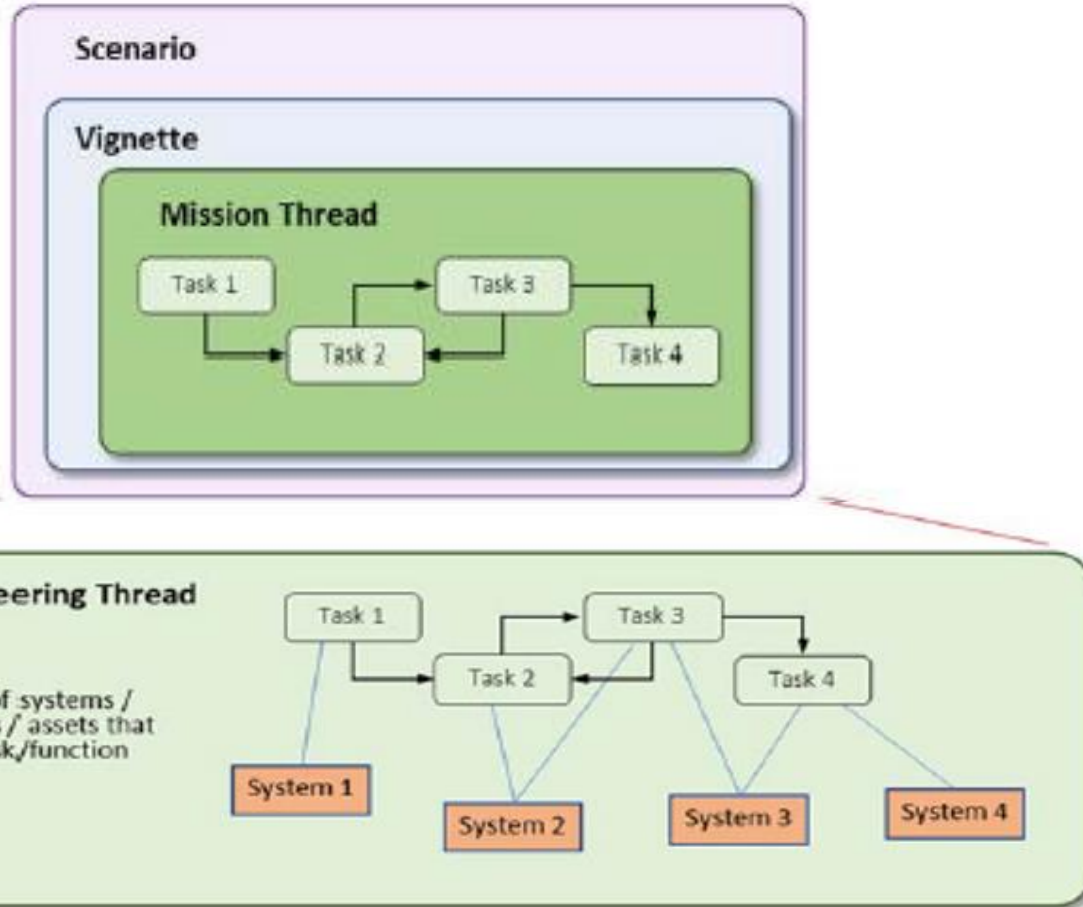
- Resources**
- Models**
- Data**

| Approach | | Threat Vector | | | | | |
|---------------------------------|---|---------------|---|--------------|--------------|--------------|---|
| | | Baseline | Alt Vector 1 | Alt Vector 2 | Alt Vector 3 | Alt Vector 4 | |
| To-Be Layered H&B Defense | 1 | Clear | x | x | x | x | x |
| | 2 | Clear | x | | | | |
| | 3 | Clear | x | | | | |
| To-Be Combined H&B + KE Defense | 1 | Clear | Outside of current scope (insufficient time to run, candidate for future study) | | | | |





Mission Threads & Mission Engineering Threads



Mission Thread (MTs)

- The tasks to be executed to conduct or carry out the mission to satisfy a defined objective
- Threads define the task execution sequence in a chain of events of how systems, people, data, methods, tactics, timing, and interfaces will interact to complete necessary tasks against threats and other variables to achieve mission objective(s).

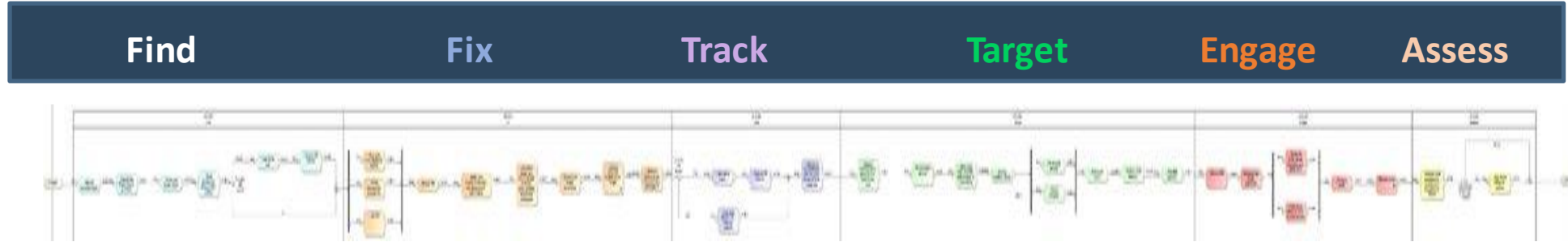
Mission Engineering Threads (METs)

- As details associated with specific systems, technologies, or people are added, the generic MTs become METs.

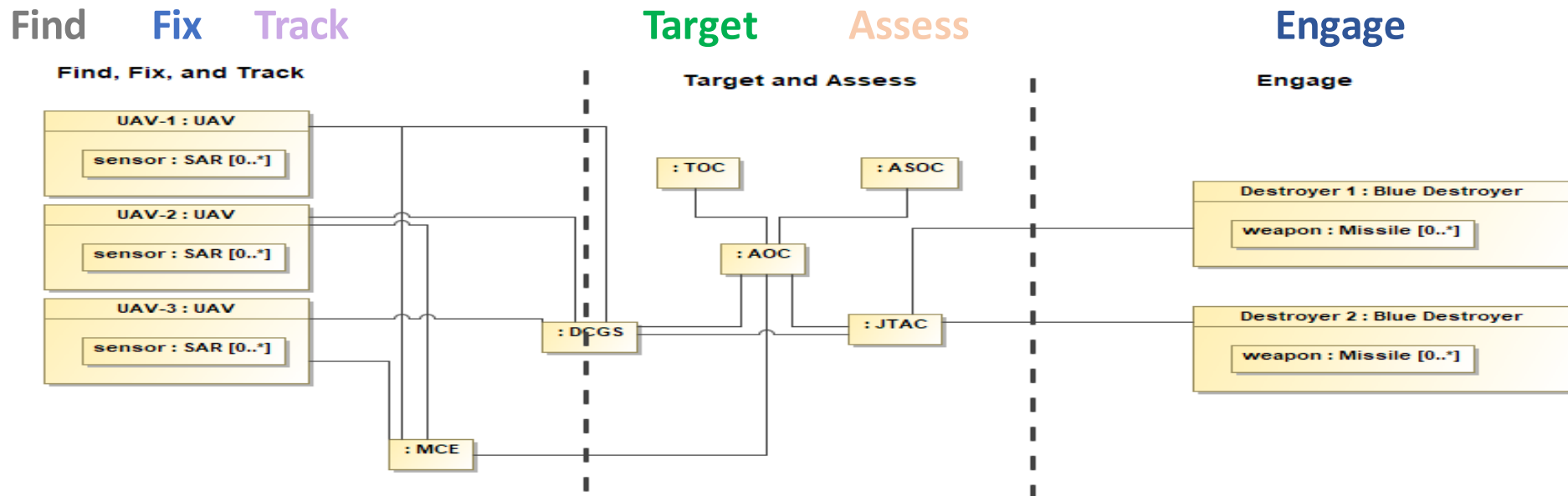


Key Mission Engineering Views in the Mission Architecture

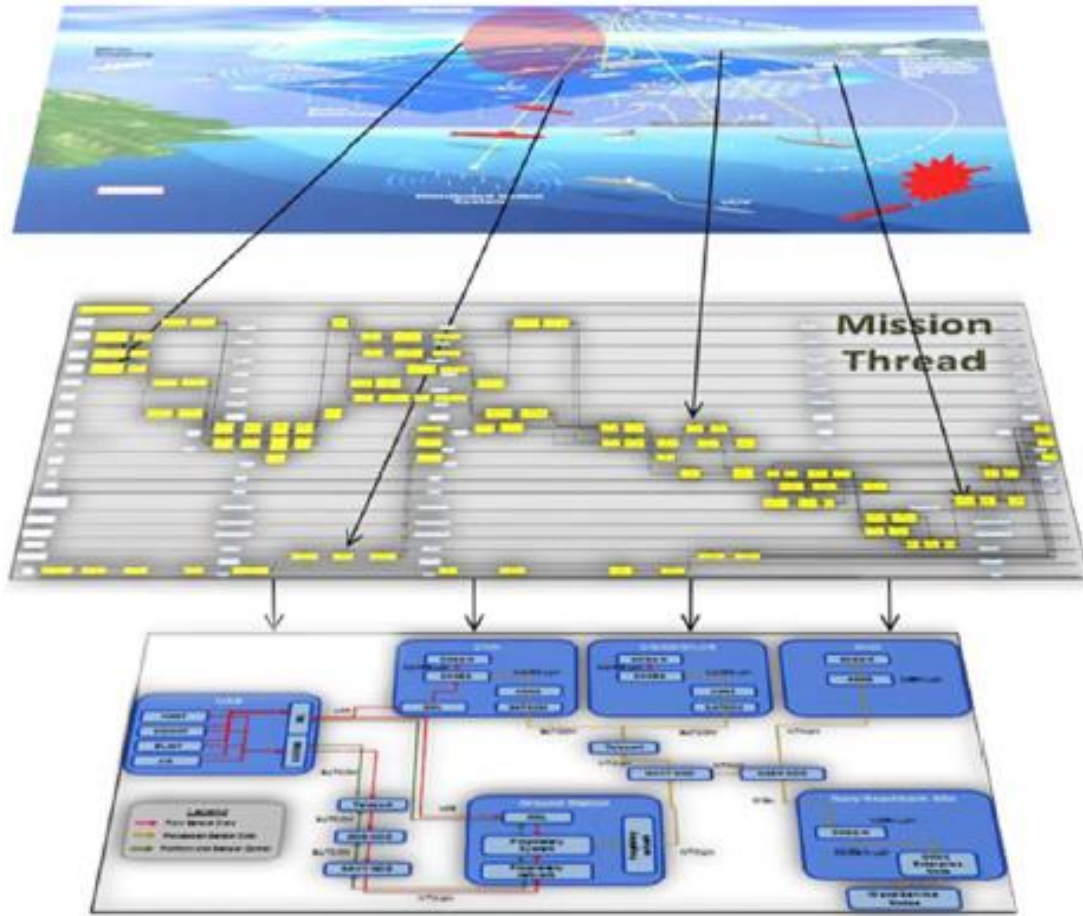
- **Mission Thread (MT):** An end-to-end sequence of tasks, activities and events to execute a mission



- **Mission Engineering Thread (MET):** Mission threads that include technical details of the capabilities and systems required and utilized to execute the tasks and activities for a mission



Mission Architecture



- A **Mission Architecture** is a conceptual modeling of concepts, approaches, and systems of systems
 - that enables details of the process flow, timing, interactions, data, capabilities, and performance ...
 - to be examined in relation to the other processes, entities, and systems ...
 - that contribute to achieving the mission objectives
- A **Mission Architecture** can ...
 - address an overall campaign of many concurrent processes and entities or ...
 - will narrowly focus on just one entity and flow
- A **Mission Architecture** should be represented by a series of tailored “views” that will illustrate and highlight specific and relevant details



Mission Architecture Models

Operational Activities

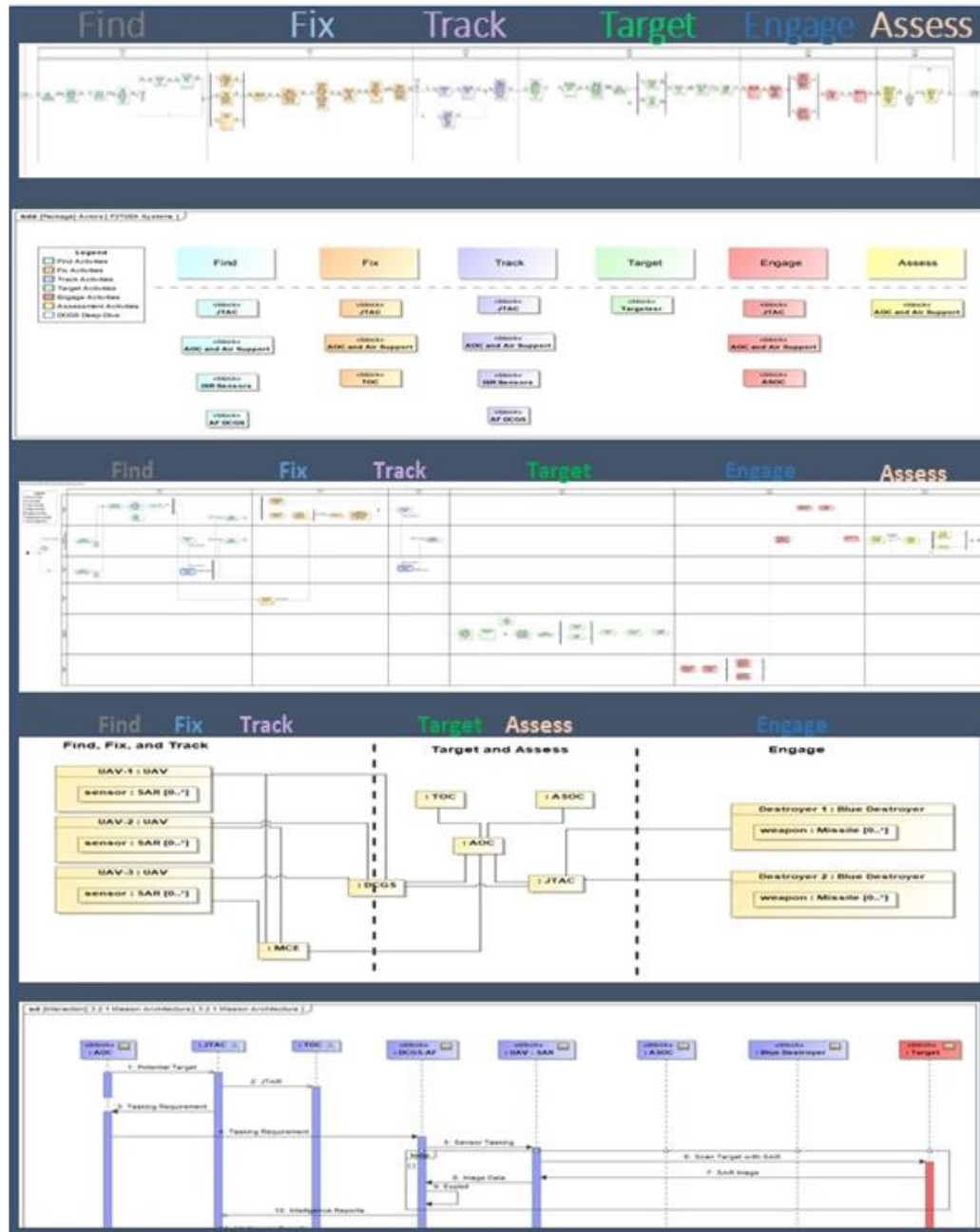
Systems supporting Activities

Organizations executing Activities

End-to-end flow between Systems

Sequence of Operational Activity actions

Baseline MT and MET Models



Mission Engineering Views in UAF

| UAF UNIFIED ARCHITECTURE FRAMEWORK™ | Motivation Mv | Taxonomy Tx | Structure Sr | Connectivity Cn | Processes Pr | States St | Sequences Sq | Information If | Parameters Pm | Constraints Ct | Roadmap Rm | Traceability Tr | |
|--|----------------------------------|----------------------------------|--------------------------------------|---|--|------------------------------|---|---|---|---|---|---|---------------------------------|
| Architecture Management Am | Architecture Principles Am-Mv | Architecture Extensions Am-Tx | Architecture Views Am-Sr | Architectural References Am-Cn | Architecture Development Method Am-Pr | - | - | Dictionary Am-If | Architecture Parameters Am-Pm | Architecture Constraints Am-Ct | Architecture Roadmap Am-Rm | Architecture Traceability Am-Tr | |
| Summary & Overview Sm-Ov | | | | | | | | | | | | | |
| Strategic St | Strategic Motivation St-Mv | Strategic Taxonomy St-Tx | Strategic Structure St-Sr | Strategic Connectivity St-Cn | Strategic Processes St-Pr | Strategic States St-St | - | Strategic Information St-If | MOE's Environment & MOP's Elements and Measures Me-Pm and Risks Rk-Pm | Strategic Constraints St-Ct | Strategic Roadmaps: Deployment, Phasing St-Rm-D, -P | Strategic Traceability St-Tr | |
| Operational Op | Requirements Rq-Mv | Operational Taxonomy Op-Tx | Operational Structure Op-Sr | Operational Connectivity Op-Cn | Operational Processes Op-Pr | Operational States Op-St | Operational Sequences Op-Sq | Operational Information Model Op-If | | Operational Constraints Op-Ct | - | Operational Traceability Op-Tr | |
| Services Sv | | Services Taxonomy Sv-Tx | Services Structure Sv-Sr | Services Connectivity Sv-Cn | Services Processes Sv-Pr | Services States Sv-St | Services Sequences Sv-Sq | | | Services Information Model Sv-If | Services Constraints Sv-Ct | - | Services Traceability Sv-Tr |
| Personnel Ps | | Personnel Taxonomy Ps-Tx | Personnel Structure Ps-Sr | Personnel Connectivity Ps-Cn | Personnel Processes Ps-Pr | Personnel States Ps-St | Personnel Sequences Ps-Sq | | | Personnel Information Model Ps-If | Personnel Constraints Ps-Ct | Personnel Roadmaps: Evolution, Forecast Ps-Rm-D, -F | Personnel Traceability Ps-Tr |
| Resources Rs | Resources Taxonomy Rs-Tx | Resources Structure Rs-Sr | Resources Connectivity Rs-Cn | Resources Processes Rs-Pr | Resources States Rs-St | Resources Sequences Rs-Sq | Resources Information Model Rs-If | Resources Constraints Rs-Ct | | Resources Roadmaps: Evolution, Forecast Rs-Rm-D, -F | Resources Traceability Rs-Tr | | |
| Security Sc | Security Controls Sc-Mv | Security Taxonomy Sc-Tx | Security Structure Sc-Sr | Security Connectivity Sc-Cn | Security Processes Sc-Pr | - | - | Security Information Model Sc-If | | Security Constraints Sc-Ct | - | Security Traceability Sc-Tr | |
| Projects Pj | - | Projects Taxonomy Pj-Tx | Projects Structure Pj-Sr | Projects Connectivity Pj-Cn | Projects Processes Pj-Pr | - | - | Projects Information Model Pj-If | | Projects Constraints Pj-Ct | - | Projects Traceability Pj-Tr | |
| Standards Sd | - | Standards Taxonomy Sd-Tx | Standards Structure Sd-Sr | - | - | - | - | Standards Information Model Sd-If | | Standards Constraints Sd-Ct | - | Standards Roadmap Sd-Rm | Standards Traceability Sd-Tr |
| Actual Resources Ar | - | - | Actual Resources Structure, Ar-Sr | Actual Resources Connectivity, Ar-Cn | Simulation | | | - | | - | Parametric Execution/ Evaluation | - | - |

Capabilities & Threats

Mission Threads

Mission Engineering Threads

Roadmaps

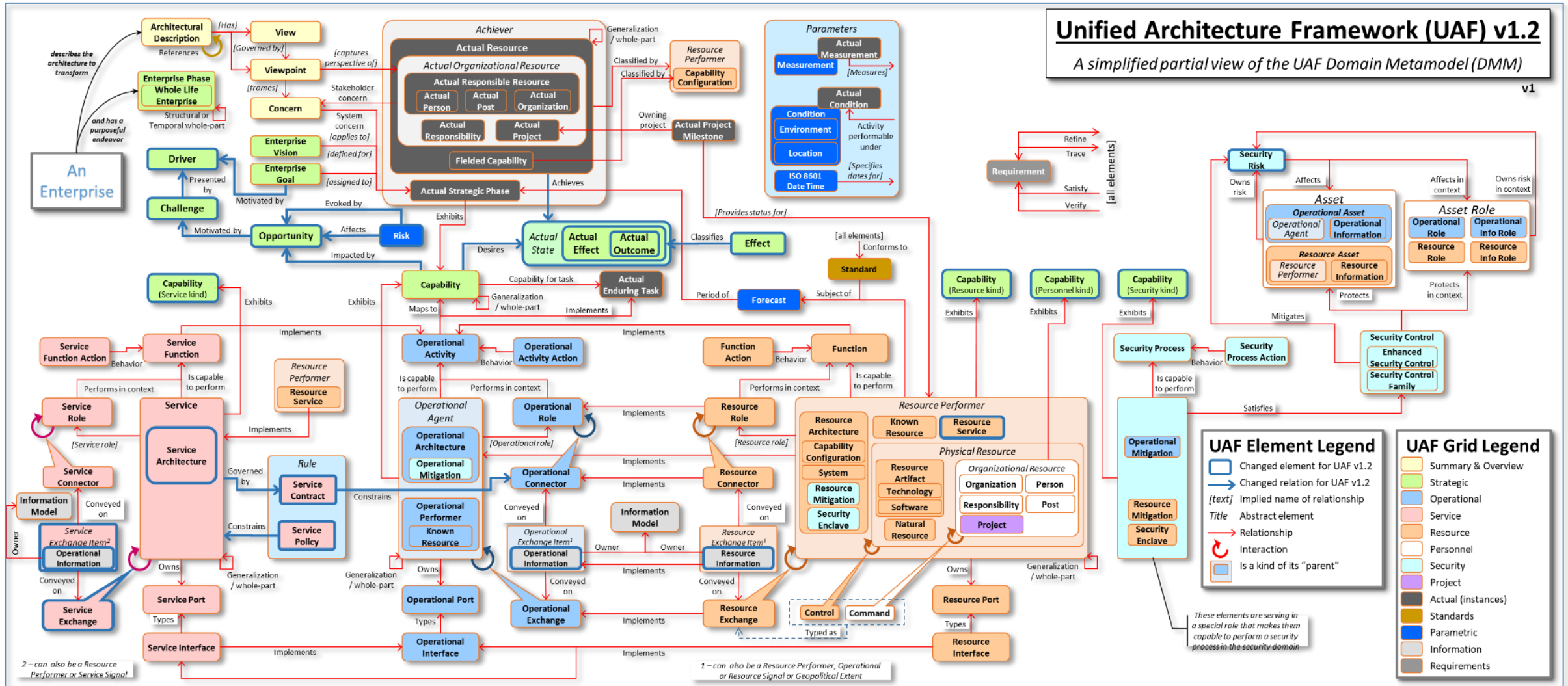
Services

Personnel

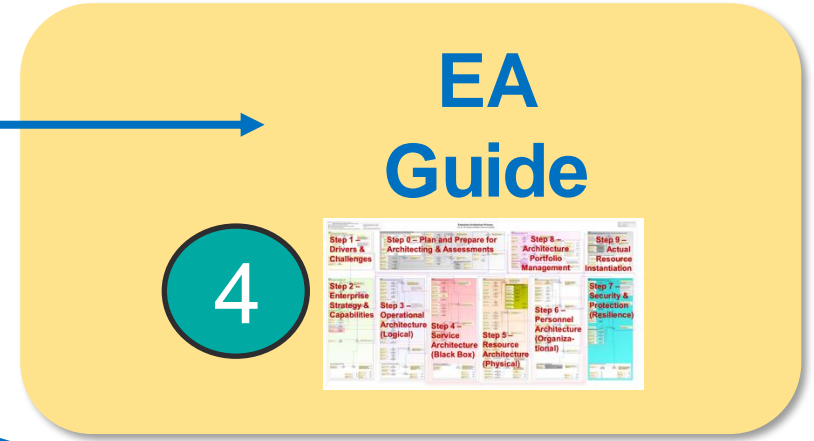
Security

Projects

UAF Conceptual Schema (i.e. an Enterprise Ontology!)



EA Guide for UAF



4



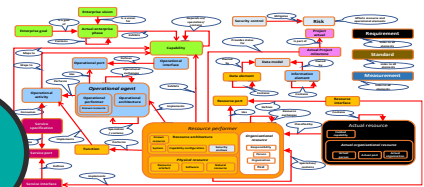
View Specifications organized in Viewpoints and Aspects (Grid)

1

| | Business | Structure & Connectivity | Behavior | Information | Parameters | Constraints | Realized | Traceability |
|-----------------------|----------|--------------------------|----------|-------------|------------|-------------|----------|--------------|
| Strategic | | | | | | | | |
| Operational | | | | | | | | |
| Services | | | | | | | | |
| Personnel & Resources | | | | | | | | |
| Security | | | | | | | | |
| Projects | | | | | | | | |
| Needs | | | | | | | | |
| Requirements | | | | | | | | |

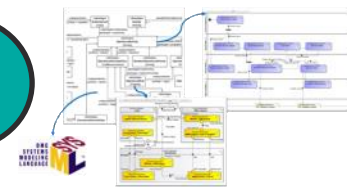
UAF Domain MetaModel (DMM)

2



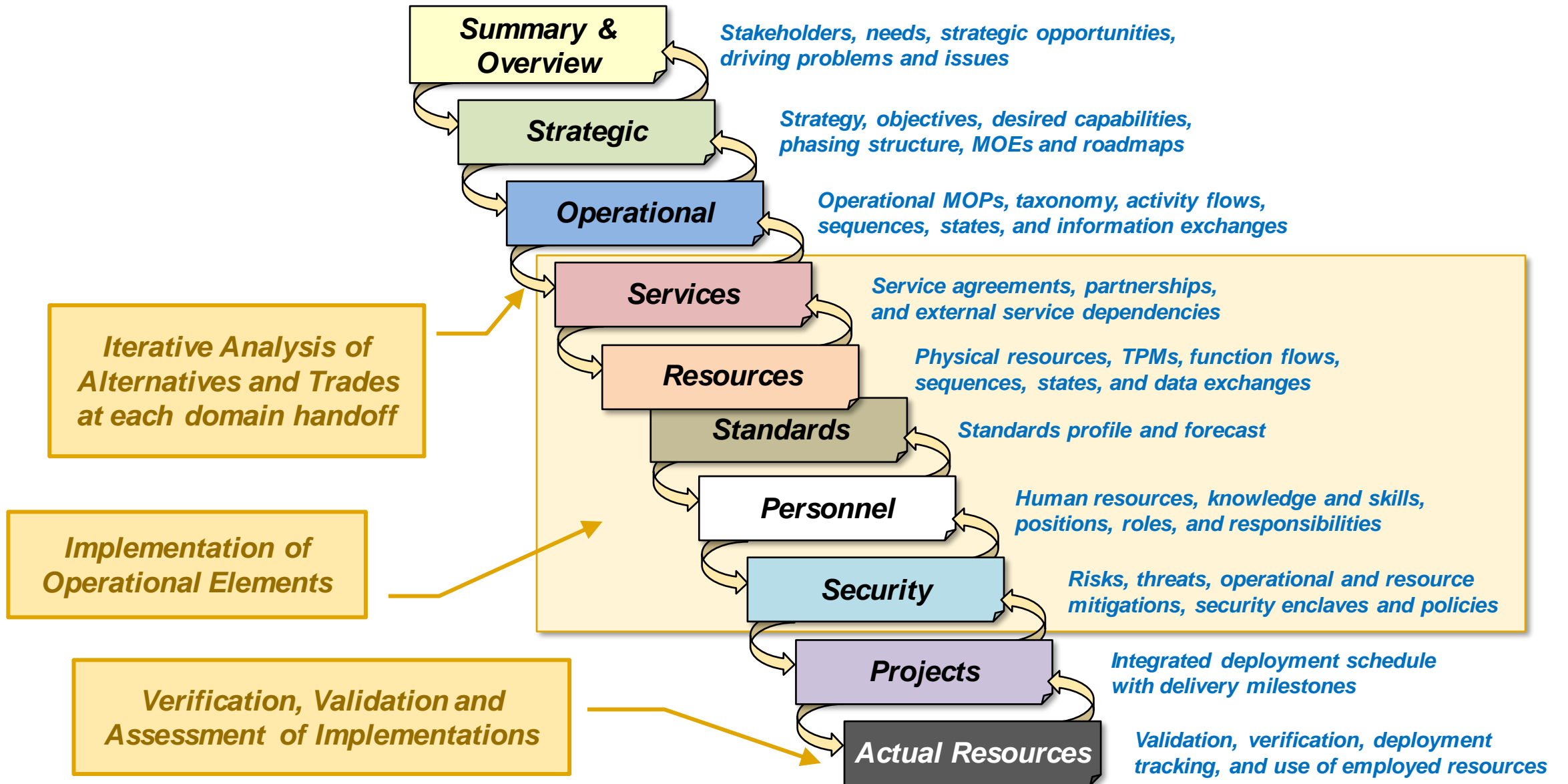
UAF Modeling Language* (UAFML) based on SysML

3



* Formerly called the "UAF Profile (UAFP)"

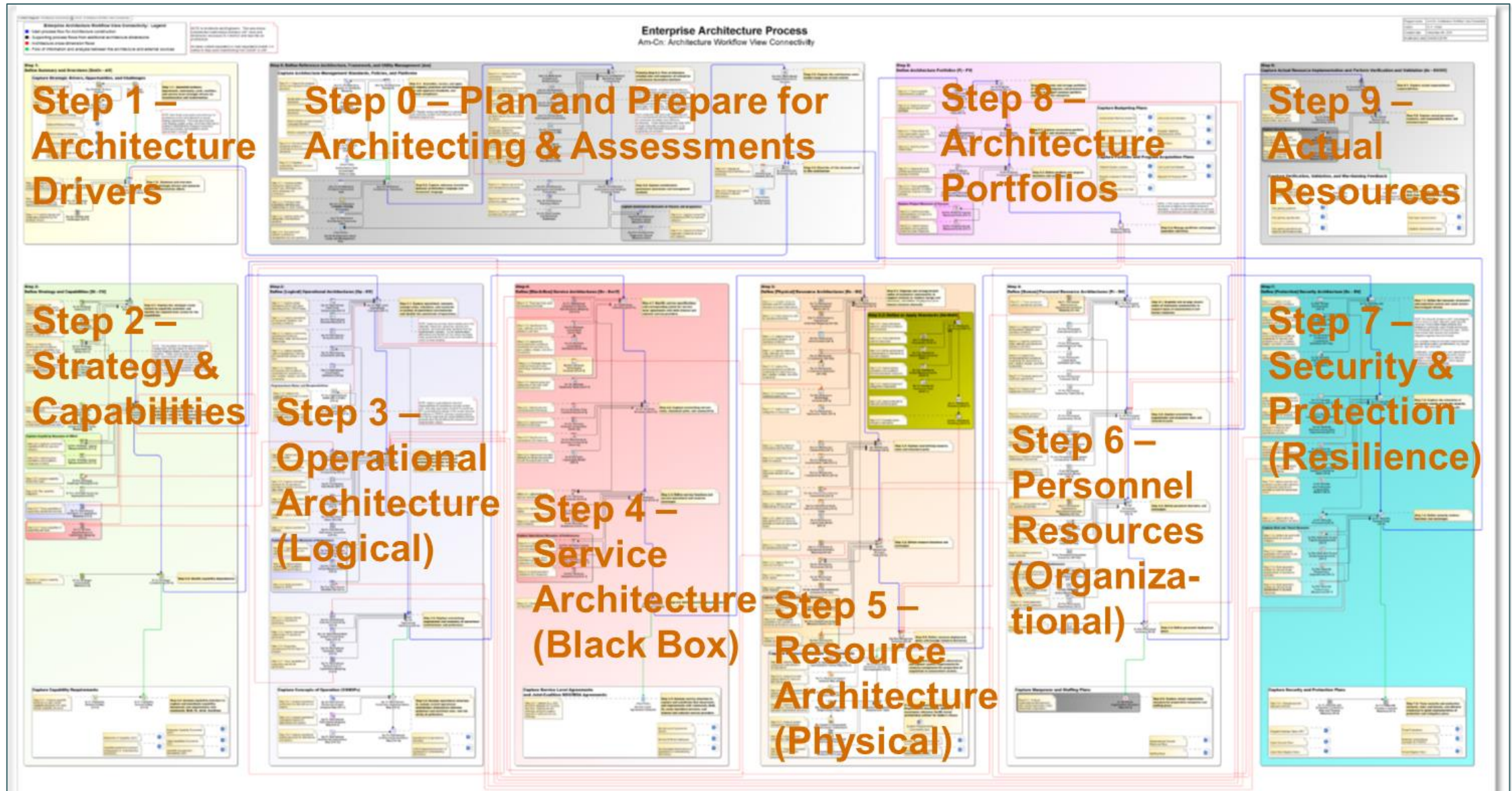
Mission Engineering Focuses on an Operational Architecture that is Implemented by a Resources Architecture





Modeling Workflow in the EA Guide for UAF

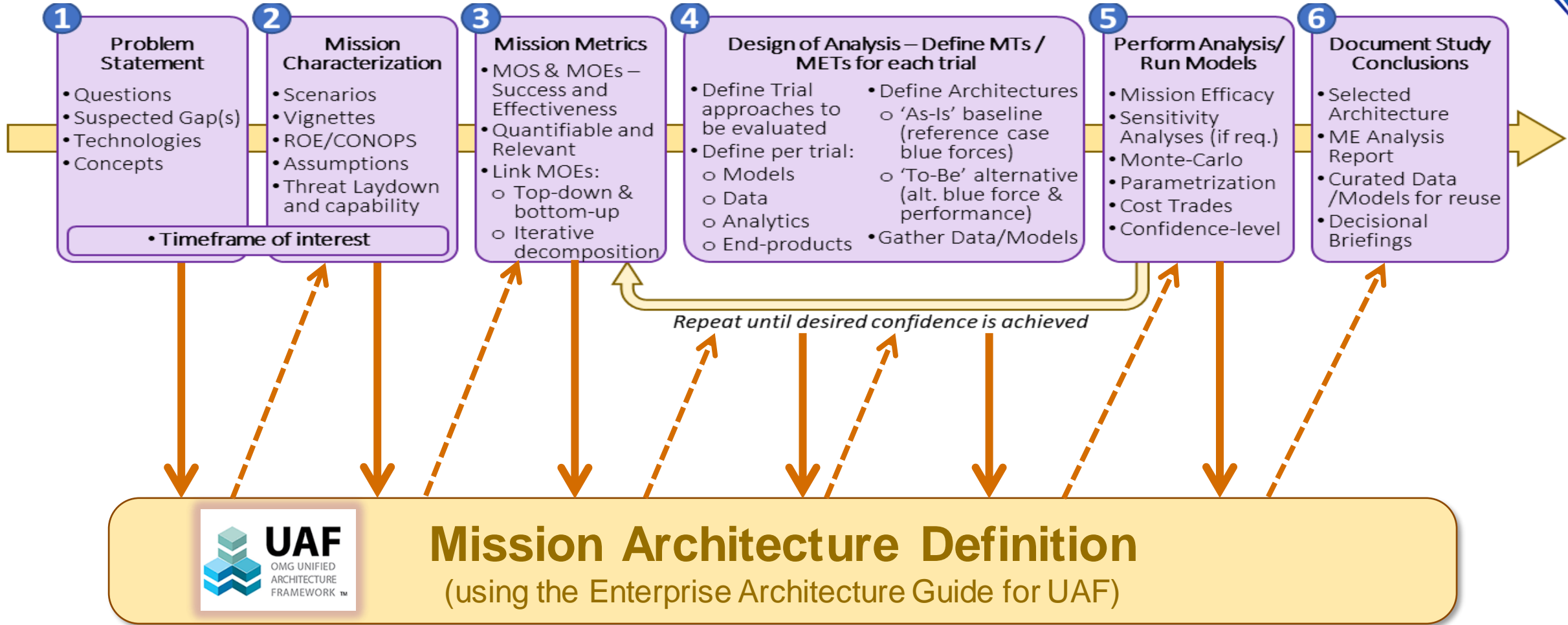
Provides a structured approach for modeling a Mission Architecture





ME Process and Mission Architecture Definition

UAF is a useful framework to guide definition of the Mission Architecture



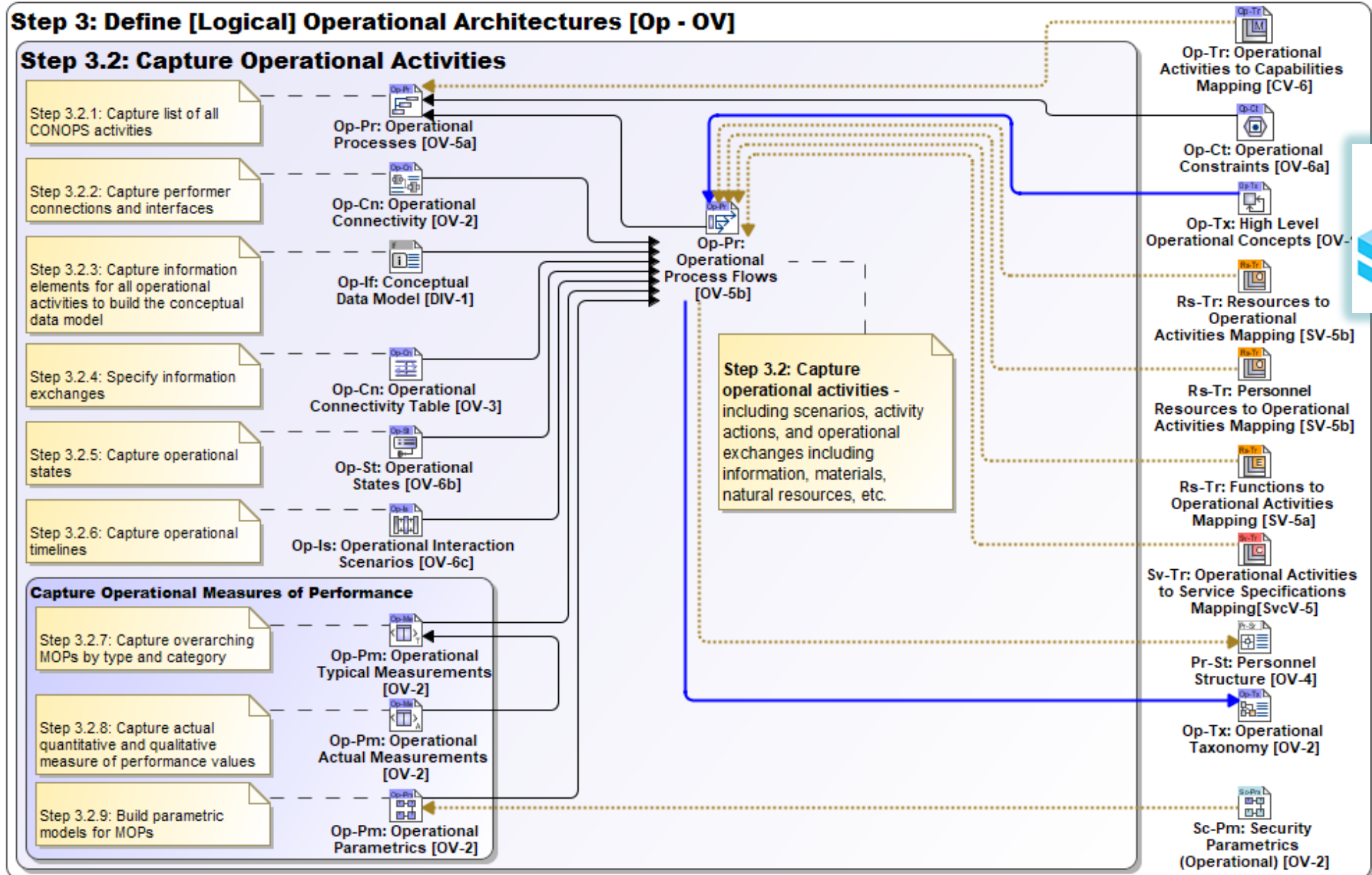
UAF provides a pre-defined and standardized ontology for modeling an Enterprise and its Mission Operations

Mission Engineering Steps



- 1. Problem Statement**
 - 1.1. Articulate Purpose of Study
 - 1.2. Develop Questions of Interest to be Answered
 - 1.3. Articulate Mission or Technology Area of Concern
- 2. Mission Characterization**
 - 2.1. Define the Mission
 - 2.1.1. Link commander's intent with Operational Purpose Documents
 - 2.1.2. Define the Time Frame
 - 2.1.3. Define Scenarios
 - 2.1.4. Define Vignettes
 - 2.2. Define the Operational Environment
 - 2.2.1. Link to Defense Planning Scenarios
 - 2.2.2. Define Geographic Area
 - 2.2.3. Define the Conflict
 - 2.2.4. Define the Threat Laydown
 - 2.2.5. Define Red and Blue Forces
 - 2.2.6. Define the Order of Battle
 - 2.2.7. Define Rules of Engagement
 - 2.3. Define Operational Assumptions and Constraints
 - 2.3.1. Define Environmental Constraints
 - 2.3.2. Define Resource Constraints
 - 2.3.3. Define Force Constraints
 - 2.3.4. Define Technical Constraints
 - 2.3.5. Define Technology Roadmaps
- 3. Mission Metrics**
 - 3.1. Define Measures of Success (MOSs)
 - 3.2. Define Measures of Effectiveness (MOEs)
 - 3.2.1. Derive MOEs from the Mission Statement and Problem Statement
 - 3.2.2. Derive MOEs from the Constituent Approaches and Systems Proposed
 - 3.3. Define Measures of Performance (MOPs)
 - 3.4. Establish Metric Traceability
 - 3.4.1. Trace MOEs to MOSs
 - 3.4.2. Trace MOPs to MOEs
- 4. Design of Analysis – Define MTs/METs**
 - 4.1. Define Mission Architectures
 - 4.1.1. Define the “As-Is” Architecture
 - 4.1.2. Define “To-Be” Architectures
 - 4.2. Define Mission Approach
 - 4.2.1. Define Mission Threads (As-Is and To-Be)
 - 4.2.2. Define ME Threads (As-Is and To-Be)
 - 4.3. Define and Gather Supporting Analytical Models, Data, and Analytics
 - 4.3.1. Model Development
 - 4.3.2. Model Management
- 5. Perform Analysis/ Run Models**
 - 5.1. Identify Appropriate Analysis
 - 5.1.1. Identify Sensitivity Analysis to be performed
 - 5.1.2. Address if optimization and/or parameterization needs to be performed
 - 5.1.3. Determine most applicable analytical methods
 - 5.1.4. Identify and understand error and uncertainty propagation across the system of models
 - 5.2. Conduct Analysis
 - 5.2.1. Determine Confidence Levels
 - 5.2.2. Compute Metrics
 - 5.2.3. Answer Questions
 - 5.2.4. Identify Capability Gaps
- 6. Document Study Conclusions**
 - 6.1. Prepare Analysis Report/ Give Decision Briefings
 - 6.1.1. Discuss the Problem
 - 6.1.2. Define the Study
 - 6.1.3. Address issues or Uncertainties
 - 6.1.4. Describe Conclusions
 - 6.1.5. Make Recommendations for Further Studies and for Leadership Actions
 - 6.2. Identify a Reference Architecture
 - 6.3. Curate Data Models and Architectures


































UAF Workflow: Step 3.2 – Capture Operational Activities





Mapping from **ME Step 4** (Design of Analysis) to **UAF Step 3** (Operational Architecture)

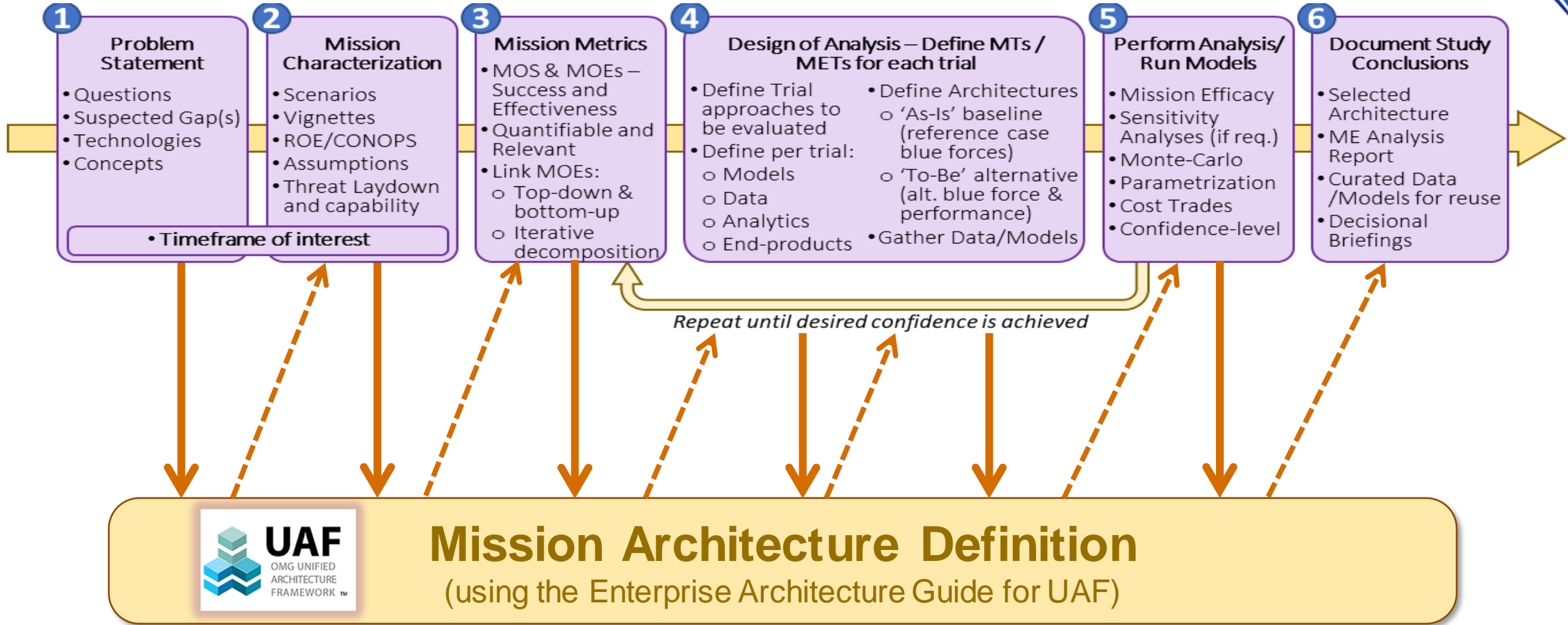
| | UAF Step 3: Define [Logical] Operational Architectures | | | | | | | | | | | | | | | | |
|---|---|--|---|---|---|---|---|--|---|---|---|---|---|--|---|---|---|
| | Step 3.1: Capture Operational Concepts | | | | | | | | | | | | | | | | |
| | Step 3.1.1: Capture simple operational sketches with users | | | | | | | | | | | | | | | | |
| | Step 3.1.2: Capture operational environments, regions, | | | | | | | | | | | | | | | | |
| | Step 3.1.3: Capture overarching operational architecture | | | | | | | | | | | | | | | | |
| | Step 3.1.4: Capture operational rules of engagement, | | | | | | | | | | | | | | | | |
| | Step 3.1.5: Capture the environment and conditional | | | | | | | | | | | | | | | | |
| | Step 3.1.6: Capture the Organizations Involved in the Overall | | | | | | | | | | | | | | | | |
| | Step 3.1.7: Capture the responsibilities of the organizations | | | | | | | | | | | | | | | | |
| | Step 3.2: Capture operational behaviors | | | | | | | | | | | | | | | | |
| | Step 3.2.1: Capture definition of all CONOPS activities | | | | | | | | | | | | | | | | |
| | Step 3.2.2: Capture performer connections and interfaces | | | | | | | | | | | | | | | | |
| | Step 3.2.3: Capture information elements for all operational | | | | | | | | | | | | | | | | |
| | Step 3.2.4: Specify information exchanges | | | | | | | | | | | | | | | | |
| | Step 3.2.5: Capture operational state machines | | | | | | | | | | | | | | | | |
| | Step 3.2.6: Capture operational timelines | | | | | | | | | | | | | | | | |
| | Step 3.2.7: Capture typical MOPs by type and category | | | | | | | | | | | | | | | | |
| | Step 3.3: Capture operational taxonomy | | | | | | | | | | | | | | | | |
| | Step 3.3.1: Capture internal structure of operational | | | | | | | | | | | | | | | | |
| | Step 3.3.2: Capture role-based relationships of operational | | | | | | | | | | | | | | | | |
| | Step 3.3.3: Supporting operational performer table for | | | | | | | | | | | | | | | | |
| | Step 3.3.4: Trace capabilities to supporting operational | | | | | | | | | | | | | | | | |
| | Step 3.4: Analyze operational structure | | | | | | | | | | | | | | | | |
| | Step 3.4.1: Analyze operational performers for alternatives | | | | | | | | | | | | | | | | |
| | Step 3.4.2: Analyze operational role-based impacts for | | | | | | | | | | | | | | | | |
| | Step 3.4.3: Define risk assessments by type and category | | | | | | | | | | | | | | | | |
| | Step 3.4.4: Capture actual quantitative and qualitative | | | | | | | | | | | | | | | | |
| | Step 3.4.5: Build parametric models for MOPs | | | | | | | | | | | | | | | | |
| | Step 3.4.6: Capture operational requirements | | | | | | | | | | | | | | | | |
| | Step 3.4.7: Capture operational activity implementations to | | | | | | | | | | | | | | | | |
| | Step 3.4.8: Capture operational activity structure for | | | | | | | | | | | | | | | | |
| Mission Engineering Step 4: Design of Analysis - Define MTs/METs | | | | | | | | | | | | | | | | | |
| 4.1 - Define Mission Architectures | | | | | | | | | | | | | | | | | |
| 4.1.1 Define the "As-Is" Architecture | | | X | X | | X | X | | X | | X | X | | | X | X | |
| 4.1.2 Define "To-Be" Architectures | | | X | X | | X | X | | X | | X | X | | | X | X | |
| 4.2 - Define Mission Approach | | | | | | | | | | | | | | | | | |
| 4.2.1 Define Mission Threads (As-Is and To-Be) | | | | X | X | | | | X | | | | X | | | | X |
| 4.2.2 Define ME Threads (As-Is and To-Be) | | | | X | X | | | | X | X | | | X | | | | X |
| 4.3 - Define and Gather Supporting Analytical Models, Data & Analytics | | | | | | | | | | | | | | | | | |
| 4.3.1 Model Development | | | | | | | | | | | | | | | | X | X |
| 4.3.2 Model Management | | | | | | | | | | | | | | | | | |

| # | ME Step | UAF Views | EA Steps |
|---|--|--|---|
| 1 | 4. Design of Analysis - Define MTs/METs | UAF | EA Workflow |
| 2 | 4.1 Define Mission Architectures | Views | Steps |
| 3 | 4.1.1 Define the "As-Is" Architecture ME Steps |  Op-Ct: Operational Constraints: Definition [OV-6a]  Op-Ct: Operational Constraints [OV-6a]  En-Pm: Environment: Operational [N/A]  Op-Tx: Operational Taxonomy: High Level Operation...  Op-Sr: Operational Structure: Internal Structure [OV-...]  Op-Sq: Operational Sequences [OV-6c]  Op-St: Operational States [OV-6b]  Op-Cn: Operational Connectivity [OV-2]  Op-Pr: Operational Processes [OV-5a]  Op-Sr: Operational Structure [OV-2]  Op-Tx: Operational Taxonomy [OV-2]  Op-Tx: Operational Taxonomy: Table [OV-2]  Op-Tx: Operational Taxonomy: Concept of Operation |  Step 3.2.6: Capture operational timelines  Step 3.2.5: Capture operational states  Step 3.2.2: Capture performer connections and inte...  Step 3.2.1: Capture list of all CONOPS activities  +step 3.2.5: Capture operational state machines  +step 3.3.2: Capture role-based relationships of operation...  +step 3.2.4: Specify information exchanges  +step 3.1.7: Capture the responsibilities of the organizati... |
| 4 | 4.1.2 Define "To-Be" Architectures |  Op-Tx: Operational Taxonomy: High Level Operation...  Op-Sr: Operational Structure: Internal Structure [OV-...]  Op-Sq: Operational Sequences [OV-6c]  Op-St: Operational States [OV-6b]  Op-Cn: Operational Connectivity [OV-2]  Op-Sr: Operational Structure [OV-2] |  Step 3.2.6: Capture operational timelines  Step 3.2.5: Capture operational states  Step 3.2.2: Capture performer connections and inte...  Step 3.2.1: Capture list of all CONOPS activities  +step 3.2.5: Capture operational state machines  +step 3.4.2: Analyze operational role-based impacts for a... |



ME Process and Mission Architecture Definition

UAF is a useful framework to guide definition of the Mission Architecture



UAF provides a pre-defined and standardized ontology for modeling an Enterprise and its Mission Operations



Summary – Leveraging UAF for Mission Engineering

UAF provides a well-structured approach for defining the Mission Architecture

- **UAF is designed for modeling an Enterprise and its Missions**
 - *Provides a standardized ontology for enterprise and mission modeling*
 - *Strategic Viewpoint addresses Drivers, Challenges, Opportunities, Enterprise Objectives and Capabilities*
 - *Operational Viewpoint defines Operational Performers and their Activities, Mission Threads and Measures*
 - *Resources Viewpoint identifies Resource Performers (systems, technologies, platforms, etc) and associated Functionality of those Resources, along with relevant Organizational elements (humans, organizations, etc)*
- **Mission Architecture and Mission Threads**
 - *Mission Thread models are key to conducting effective Modeling & Simulation runs for mission impact analysis*
 - *Mission Architecture models are starting to use UAF to more completely capture the enterprise way ahead*
 - *Mission Engineering can leverage pre-existing UAF and SysML models and model libraries*
- **UAF helps to improve our understanding of the Mission Operations and its Realization Tradeoffs**
 - *Enterprise ontology in UAF clearly distinguishes different concepts in the realm of Missions and Systems of Systems*
 - *Easier to understand and assess impacts of Mission execution on other parts of the Enterprise and downstream*
 - *Multi-layer UAF grid encourages “separation of concerns” between different layers of abstraction*

Unified Architecture Framework can facilitate more advanced enterprise and mission modeling

