Department of Defense

Mission Engineering Guide

Version 2.0

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Office of the Under Secretary of Defense
for Research and Engineering

Mission Capabilities

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Department of Defense

Mission Engineering Guide

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Mission Engineering Guide Change Record

October 2023. The second edition of this publication replaces the *Department of Defense Mission Engineering Guide* (MEG) version 1.0 (November 2020).

The MEG version 2.0 serves as a resource to aid current and prospective practitioners in understanding mission engineering principles, methodology, and attributes. The MEG is not a Department of Defense manual, instruction, or directive; rather, the MEG describes the interdisciplinary process of mission engineering. This extensible and scalable process helps to answer questions related to assessing systems or systems of systems (SoS) within a mission context to inform design and integration of current and emergent capabilities to yield desired mission outcomes.

Since its first publication in November 2020, the MEG has undergone practical review and implementation by a diverse community of mission engineers, both within and outside the Department. In this revision, the essential methodology and fundamental elements of the mission engineering process are preserved. The MEG version 2.0 clarifies and expands upon mission engineering best practices, terminology, activities, and products to ensure both novice and expert practitioners have a clear understanding of the purpose, application, and benefits of the mission engineering process.

This document has been developed in accordance with Department of Defense Directive (DoDD) 5137.02 "Under Secretary of Defense for Research and Engineering (USD(R&E))," which assigns the Under Secretary the role of leading the Department "in mission engineering policy, practices, and tools for analysis of warfighting concepts of operation, functions, systems, and technologies in an end-to-end mission context."[1]

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Mission Engineering Executive Steering Council

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[1] Department of Defense Directive 5137.02 "Under Secretary of Defense for Research and Engineering (USD(R&E))," July 15, 2020

CONTENTS

1.0 INTRODUCTION

1.1 Background

As the Department of Defense works to provide the Joint Force with the necessary capabilities, technologies, and systems to successfully execute missions, practitioners of mission engineering can leverage the process described in this guide to help identify and analyze gaps as well as determine which capabilities, technologies, and systems can improve mission outcomes. Increasingly, the Department is emphasizing a mission-focused approach to operations and support activities to ensure resources are aligned to accomplish organizational goals. Mission engineering is a process that helps the Department better understand and assess impacts to mission outcomes based on changes to systems, threats, operational concepts, environments, and mission architectures. Mission-based, data-driven outputs help to inform acquisition, research and development, and concepts of operation, as well as to "assess the integration and interoperability of the systems of systems (SoS) required to execute critical mission requirements."[2] Using software tools to digitally *engineer a mission*, the Department can deliver quantitative results that will improve the quality and robustness of information for decision making.[3]

The Office of the Secretary of Defense and the military Components use mission engineering to identify military needs and solutions, explore trades across the mission, mature operational concepts, guide requirements and resource planning, inform experimentation, and prototype selection or program decisions.[4] As the technical subelement that enables Mission Integration Management (MIM), the mission engineering process also provides inputs to inform portfolio management decisions.[5]

1.2 Purpose of the Mission Engineering Guide

The *Department of Defense Mission Engineering Guide* (MEG) serves as a key document that provides practitioners and subject enthusiasts a strong overview and understanding of mission engineering. This guide includes a detailed explanation of the interdisciplinary mission engineering process, its key elements, and its associated terminology. The MEG is not a step-by-step handbook on how to implement mission engineering; rather, the MEG outlines a scalable and adaptable methodology that can be tailored to address a variety of questions based on scope, complexity, and time. Specifically, the MEG:

- Describes the mission engineering methodology and its main attributes
- Provides guiding principles for executing mission engineering and developing rigorous analytical products

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[2] Department of Defense Directive 5000.01, Section 1b, "The Defense Acquisition System," September 9, 2020

[3] Author's note: example tools include physics-based and effects-based simulations as well as model-based or enterprise architectures, and other digital modeling software.

[4] Department of Defense Instruction 5000.88, Section 3.3, "Mission Engineering and Concept Development," November 18, 2020

[5] Public Law 114-328, Section 855, "National Defense Authorization Act for Fiscal Year 2017," December 23, 2016

- Advises best practices and considerations when conducting mission engineering
- Informs mission engineering practitioners at different levels of proficiency and from diverse disciplinary backgrounds about the processes used to conduct mission engineering activities
- Defines mission engineering terminology

2.0 Mission Engineering

2.1 Overview

> ***Mission engineering*** *is an interdisciplinary process encompassing the entire technical effort to analyze, design, and integrate current and emerging operational needs and capabilities to achieve desired mission outcomes.*

The mission engineering process decomposes missions into constituent parts to explore and assess relationships and impacts in executing the end-to-end mission. Mission engineering is used to identify and quantify gaps, issues, or opportunities across missions and seeks to address these by assessing the efficacy of potential capability solutions—materiel or non-materiel—that enhance mission outcomes.[6]

Mission engineering results inform decisions on military requirements, acquisition, research, and development as well as enable an early shift from qualitative to quantitative analysis. The methodology evaluates end-to-end mission approaches that include measurable elements amid warfighter-defined, threat-informed operational contexts. Mission engineering can assess a range of potential solutions—materiel and non-materiel—within a mission context to inform systems or SoS design and integration considerations, operational concepts, and trade-offs in Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy (DOTMLPF-P), based on impacts to the mission.

Mission engineering has direct application to systems engineering processes by providing a better understanding of characteristics, performance parameters, functions, and features of systems and SoS that have an impact on mission outcomes. The goal of mission engineering is to *engineer missions* by *identifying the right things* (i.e., technologies, systems, SoS, or processes) to achieve the intended mission outcomes and provide mission-based inputs into the systems engineering process to aid the Department in *building things right*.

The results of mission engineering are used for a variety of purposes. For instance, findings can inform technology investments, suggest alternative ways to use current systems, identify mission gaps and preferred approaches to addressing these gaps, and trigger the initiation of a new acquisition to meet capability gaps. Mission engineering results may satisfy the requirements for a Capabilities Based Analysis[7] or provide the starting point for an Analysis of Alternatives.[8] Figure 2-1 illustrates the various consumers of mission engineering products ranging from concepts to capability development to acquisition.

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[6] Author's note: in accordance with CJCSI 5123.01I, "Charter of the Joint Requirements Oversight Council and Implementation of the Joint Capabilities Integration and Development System," October 30, 2021

[7] Office of the Chairman of the Joint Chiefs of Staff, "Manual for the Operation of the Joint Capabilities Integration and Development System," current edition

[8] DoDI 5000.02, "Operation of the Defense Acquisition System," January 7, 2015

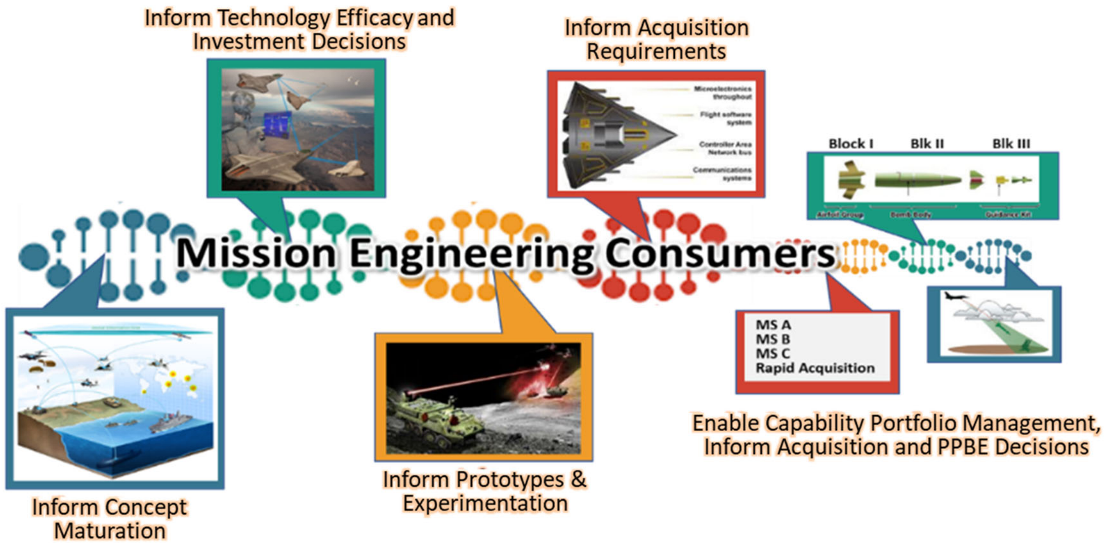

Figure 2-1. Consumers of Mission Engineering Outputs

2.2 Mission Engineering Methodology

Missions are tasks and actions undertaken to achieve a specific objective.[9] The mission engineering process can be scoped based on the complexity of the mission, the functional mission level (i.e., strategic, operational, or tactical), the availability of data, and the decisional needs of the mission engineering activity. The methodology can be adapted according to practitioners' goals: to preemptively identify risks and opportunities for change; to resolve identified issues across a mission; or to explore potential "*what if?*" changes to the mission and its operational environment. The process illustrated in Figure 2-2 is not necessarily a sequence of discrete steps, but it can be performed iteratively as more information is gained throughout the process. This methodology should produce repeatable and traceable results and products that can provide justifiable evidence to advise decision makers, and it should be leveraged to inform subsequent analyses.

[9] Department of Defense Dictionary of Military and Associated Terms (formerly Joint Publication 1-02)

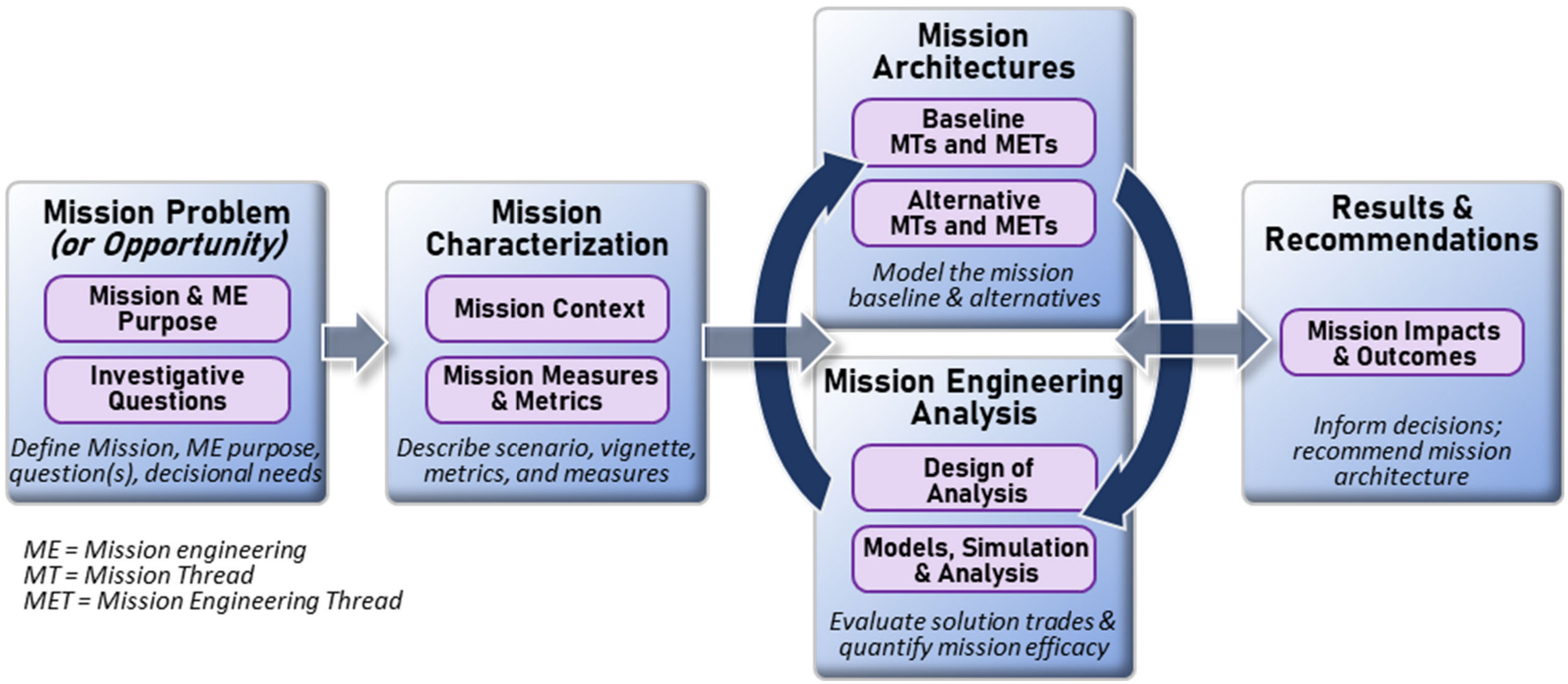

Figure 2-2. The elements of the mission engineering process.

2.3 Considerations

2.3.1 Digital Engineering in Mission Engineering

Digital engineering principles support a continuum that enables consistency and reuse of models and data when applied in the mission engineering process.[10] The use of digital representations and artifacts provides both a technical means to communicate across a diverse set of stakeholders and the means to deliver data-driven, quantitative outputs resulting in better-informed decisions. With the use of digital tools and model-based engineering approaches, mission architectures can be represented as *digital mission models* within a particular scenario. The use of these tools and approaches allows for traceability from mission tasks to solutions. These tools also enable the reuse of products to facilitate updates and changes as needed. Digital linkage and traceability enable strong configuration management of mission engineering inputs and products. In addition, the use of general-purpose modeling languages, overlays, styles, and frameworks—e.g., System Modeling Language (SysML), Business Process Model and Notation (BPMN), Unified Architecture Framework Modeling Language (UAFML), and Unified Modeling Language (UML)—enables common understanding, sharing, and reuse of products across the enterprise.

There are a variety of digital tools that can be used to implement mission engineering depending on the scope, products, and fidelity required. Examples of digital tools include physics-based, behavior-based, and effects-based simulations, as well as model-based or enterprise architecture software. These tools provide a *quantitative*, or computational and logical means, to trace, analyze, and evaluate a variety of factors that impact the end-to-end mission.

2.3.2 Robustness and Transparency Across the Mission Engineering Process

The mission engineering methodology is designed to explore multiple options for addressing mission challenges or seizing opportunities for technology integration across a mission. The methodology provides a means to compare the effectiveness of alternative mission approaches or sensitivities around a range of uncertainties to explore the mission space and provide options for trading capabilities or balancing investments.

To lend transparency to the mission engineering process, practitioners should document assumptions, constraints, sources of data used, and other factors that drive the results of analysis. Increased visibility of data, methods, inputs, and factors influencing the design of analysis enables stakeholders and decision makers to obtain a better understanding of, and confidence in, the outputs and findings of the activity.

Together, the robustness and transparency of the mission engineering methodology enable practitioners to obtain a better understanding of each other's work and increase credibility of the results.

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[10] Department of Defense Chief Technology Officer website, "Digital Engineering," https://ac.cto.mil/digital_engineering/

2.3.3 Reuse—Curation of Data and Products

Without relevant and trustworthy sources of data, completing the mission engineering process may not even be possible. Based on the complexity and scope of the mission, large datasets may be needed to characterize the mission and develop the required models for mission engineering—the development of mission architectures and the execution of mission engineering analysis. The datasets that support mission engineering analysis include details on the mission and concepts of operation, operational environment and geographic region, *red*- and *blue*-force structures and orders of battle, and systems or SoS parameters and concepts of employment. A record of other completed analyses (e.g., engineering-level analyses) that address similar or related topics is valuable. Practitioners should cast as wide a net as possible across the Department of Defense, other U.S. Government partners, academia, industry, and the national laboratories for relevant source data. The collection and storage of data will be an iterative process throughout mission engineering as more information will be required for different activities and alternative mission approaches under assessment. Data sources should be credible to ensure validity of the products developed and that results of appropriate fidelity―i.e., accuracy, precision, and statistical confidence―are obtained. In the event the necessary datasets are not available, reasonable assumptions may be required.

Practitioners should consider the following factors when developing datasets for mission engineering:

- Timeliness—*When were the data last updated?*
- Lineage—*What is the source of the data? Is the source authoritative?*
- Fidelity—*What is the degree of confidence in the quality of the data?*
- Validity—*Are the data complete? How do the data match agreed-upon definitions?*
- Linkage—*How were the data generated, converted, or collected? With what mission engineering activity were the data associated?*
- Storage—*How would one catalogue and retrieve the data? With what other datasets are they topically associated?*

Mission engineering adds value to the Department's engineering, acquisition, and operational enterprises by facilitating the preservation and maintenance—i.e., the curation[11]—of data products from current and prior mission engineering activities. Product curation refers to capturing not only the results and recommendations of a particular analysis, but also to the recording of assumptions, constraints, sources, models, and data collected. Curation of these elements helps to serve as a starting point from which subsequent mission engineering activities can be developed.

[11] Office of the Undersecretary of Defense for Research and Engineering, "Department of Defense Digital Engineering Strategy," June 2018

While some general rules and best practices apply, the practitioner will have to make informed decisions regarding which data assets are appropriate for reuse.

When data is retained, practitioners should clearly describe the context of the initial use of the data. Doing so will provide future users with sufficient information to assess whether reuse of the data is appropriate in a new context.

Practitioners should consider compiling a library of models and datasets that are developed and used throughout the mission engineering activity and should document the source of data. As new information is developed and collected, the data within the models can be updated to reflect changes in threat, concepts of operation (CONOPS), and system performance data. The datasets can be generated and collected from wargames, exercises, developmental and operational tests, experimentation, and demonstrations. For example, data and results from experimentation provide valuable information on whether the potential DOTMLPF-P solutions are implementable or have the claimed performance within a relevant live (physical), virtual, or constructive venue. Over time, properly curated datasets will yield an increase in the fidelity of the models and results obtained from the mission engineering activities.

3.0 MISSION PROBLEM OR OPPORTUNITY

To be effective, the mission engineering process requires thorough planning that focuses on formulating and agreeing to a well-defined scope for the mission engineering effort. Advanced planning ensures that the options, parameters, and constraints determined throughout the mission engineering process stay aligned and can be traced back to the intent of the effort. In addition, a well-structured plan ensures long-lead-time elements are initiated immediately, and that the overall implementation and execution of the mission engineering activities are focused and successful.

Therefore, mission engineering begins with defining a clear understanding of its intended purpose, which, in turn, is informed by a clear understanding of the mission under investigation, its contextual setting, and its timeframe. Practitioners should capture the purpose in a statement that synopsizes the mission gaps, problems, or opportunities that drive the effort. This statement of purpose will inform a set of well-articulated questions that further bound and scope the focus of the mission engineering activity.

3.1 Identify Mission and Mission Engineering Purpose

Mission engineering starts by identifying two foundational elements: *what is the mission?* and *what is to be investigated about that mission?* These elements are crucial to scoping the mission engineering activities that follow.

> *The purpose and questions bounding the mission engineering activity should clearly articulate assumptions, gaps, problems, or opportunities.*

The mission engineering purpose—i.e., *what is to be investigated?*—can take one of four forms:

- Identify potential gaps and quantify shortfalls in the ability to achieve desired mission outcomes
- Explore mission cause-and-effect relationships, or sensitivity analysis, to gain deeper understanding of the factors affecting mission outcomes
- Evaluate trade space of potential solutions to address known gaps within the mission
- Investigate mission impact of new opportunities, which can include changes to or the integration of new technologies, capabilities, or concepts of operations

From the beginning, it’s important to have a clear understanding of what goal or decision will be informed as this will drive subsequent choices throughout the process. Understanding the decisional needs focuses the effort to address the *so what?* of the mission engineering investigation. These decisions guide the specific questions for the activity as well as the degree of fidelity and level of analytic rigor needed from the results, findings, and conclusions.

Table 3-1. Example purpose statements and questions to scope the problem or opportunity.

Example 1: Identify capability gaps: In a year 2040 Base Defense Scenario focused on the Western Islands region, the Joint Force will be executing a base defense mission and needs to achieve mission objectives (in this example, the purpose is to uncover mission capability shortfalls). • Based on the current expected asset availability and munitions inventory, will Joint Force be able to achieve its mission objectives? • If not, why? What are the limiting factors or gaps preventing the Joint Force from achieving its mission objectives?
Example 2: Explore cause and effect: In a year 2040 Base Defense Scenario focused on the Western Islands region, evaluate the Joint Force's ability to execute a base defense mission if 25 percent of the *blue* mission assets are not available (i.e., purpose is to inquire how well the Joint Force will meet mission objectives). • How does the mission outcomes change when blue assets are reduced by 25 percent? • What is the sensitivity to attrition of *red* as the number of *blue* assets change (decrease or increase)? • Will changing the number of *blue* assets increase total survivability of *blue* assets? Is there a change to the total number of weapons or munitions expended?
Example 3: Trade solutions to gaps: In a year 2040 Base Defense Scenario focused on the Western Islands region, the Joint Force lacks Position, Navigation, and Timing (PNT) capability to perform base defense missions in contested environments (in this example, the purpose is to evaluate potential solutions that close gaps and improve mission outcomes). • How is base defense mission success impacted by using alternate PNT technologies? • What is the performance of alternate PNT technologies in adverse environmental conditions?
Example 4: Investigate opportunities: In a year 2040 Base Defense Scenario focused on the Western Islands region, a new capability will be fielded to support base defense mission (in this example, the purpose is to assess impacts of mission when integrating the new capability). • Is the Joint Force more effective in achieving its objectives by utilizing this capability compared to the baseline mission approach (the agreed upon starting point for how the mission will be executed to address the mission engineering effort; driven by the mission, scenario, and epoch)? • Is mission success achieved with reduced weapon expenditure? Is survivability of platforms increased? • Are additional capabilities or technologies (i.e., enablers) required to employ this capability solution?

3.2 Determine Investigative Questions

The purpose statement is amplified by posing one or more key questions that narrow the scope of the mission engineering effort. Subsequent activities in the mission engineering methodology trace back to answering these questions. The questions should drive analytic outputs to address the purpose of the activity—i.e., inform the decisions, trades, and designs. The questions should guide the selection of alternative mission approaches to be used in the design of analysis and point the way toward the development of key measures and metrics. As such, these questions should further refine the fidelity—i.e., the accuracy, precision, and confidence of the analytic outputs and data inputs. Table 3-1 offers examples of investigative questions aligned with purpose statements.

3.3 Identify and Engage with Stakeholders

Stakeholders help focus the mission engineering activity on the level of confidence needed to address its purpose—informing data collection, model fidelity, and the design of analysis.

As the purpose of the mission engineering effort is developed, practitioners should identify the key stakeholders who will support the activities. Stakeholders can be those who are informed by and those who will use the mission engineering results to support their efforts or make informed decisions. Stakeholders can include end-users, sponsors, leaders, and decision makers.

The identification of new mission capabilities can require the development and alignment of critical skill sets, subject matter expertise, and personnel resources. Leaders and practitioners across the enterprise should recognize these needs and coordinate their fulfillment as early as possible. Effective stakeholder engagement can lead to the identification of subject matter experts who can support mission engineering efforts with data, information, and the verification and validation of assumptions.

4.0 MISSION CHARACTERIZATION

The statement of purpose and investigative questions are placed in a specific mission context for analysis. *Missions* are purpose-specified tasks and actions to achieve specific objectives.[12] Example sources of missions include Joint Warfighting Concepts, CONOPS, and operational plans. Mission context is very important; the context provides critical variables that can influence mission outcomes and decisions. These variables that characterize the mission include objectives, factors associated with operations, and the conditions of the environment. The mission context should also include enough information from which to derive mission measures and metrics that address the investigative questions in the statement of purpose. Additionally, the mission context should help evaluate the extent to which executing the mission successfully achieves the desired outcomes and end-state.

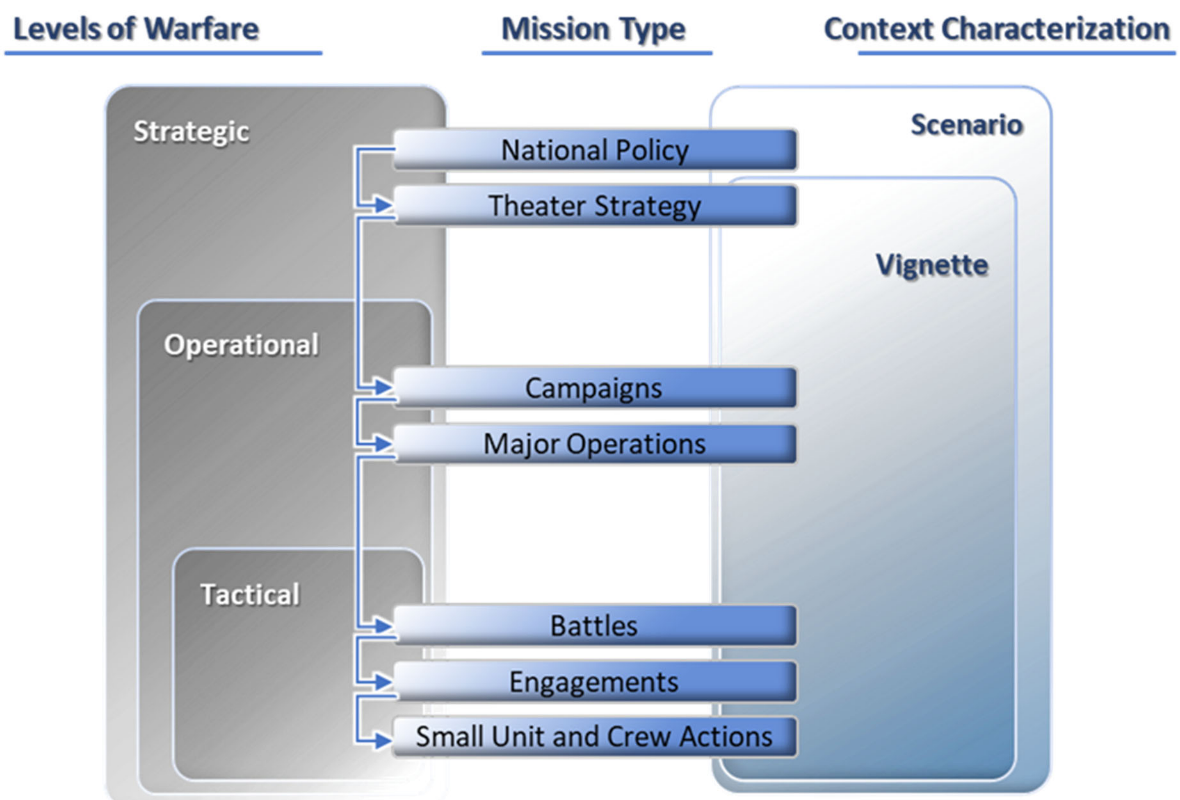

Figure 4-1. Generalized hierarchical and overlapping relationships between levels of warfare, mission type, and context characterization.

[12] Department of Defense Dictionary of Military and Associated Terms (formerly Joint Publication 1-02)

The Doctrine for the Armed Forces defines the three levels of warfare as

> Strategic, operational, and tactical—[that] link tactical actions to achievement of national objectives. There are no finite limits or boundaries between these levels, but they help commanders design and synchronize operations, allocate resources, and assign tasks to appropriate command. The strategic, operational, or tactical purpose of employment depends on the nature of the objective, mission, or task.[13]

With a tendency to overlap, these levels are generally aligned to the context of both the objective and mission, which are defined by scenarios and vignettes. See Figure 4-1.

4.1 Develop Mission Context

The mission context is the background setting, conditions, timeframe, operational strategies, and objectives of the mission that are specific to the focus of the mission engineering effort and to answering the key questions. The collection of this information is known as the *scenario*, which is derived from a campaign. The scenario captures the specific description and intent of the mission, i.e., its objectives and CONOPS, along with its associated *epoch* and the relevant operational and environmental conditions. Conditions are descriptive variables of the environment and military operation that affect the execution of tasks in the context of the assigned mission. Conditions can be categorized by the following:

- Physical environment (e.g., sea state, terrain, or weather)
- Operational environment (e.g., the conditions, circumstances, and influences that affect employment of capabilities and bear on the decisions of the commander)
- Functional elements and their relationships (e.g., forces assigned, threats, command and control, and timing of action)
- Informational environment

These sets of conditions can affect execution and mission outcomes. Scenarios can be decomposed into smaller subsets of factors, which are referred to as *vignettes*. Vignettes are more narrowly framed to concentrate on the most important aspects—the phase or segment—of the scenario related to addressing the investigative questions. The Defense Planning Scenarios and the Joint Force Operating Scenarios serve as example source documents that can be leveraged to inform the development of scenarios and vignettes.

The following are some general considerations when characterizing the mission:

What is the purpose of the mission? The mission objectives describe the commander's intent and the conditions, situations, and events that constitute success. The purpose of the mission is often hierarchical—starting with a strategic goal, segmented into operational objectives, and then refined into the tactical effects of a given scenario or vignette.

When does the mission occur (i.e., in what epoch or timeframe)? The timeframe of the mission is important to understand the force laydown—the capabilities, technologies, or systems to be fielded, deployed, and available—and the operational plans and policy implications.

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[13] Joint Publication 1, "Doctrine of the Armed forces of the United States," March 25, 2013

Where is the mission happening? What geographic and geopolitical settings are relevant to the mission? The location of the mission describes not only where the mission takes place (e.g., theater, area of operations), but also what geopolitical considerations are relevant to its execution.

Who is involved (i.e., combatants and noncombatants; friendly, hostile, and neutral forces)? The description of available forces should include *blue* (U.S.), *green* (allies), *white* (noncombatants or neutral), and *red* (adversary) forces as well as orders of battle.

How is the mission executed? The sequence of operational events that will take place to execute the end-to-end mission (i.e., mission approaches).

Figure 4-2 shows a framework for organizing key elements of the mission context, including the relationships among characterizing elements, objectives, environments, assumptions, and constraints that impact mission approaches and systems to be modeled. Practitioners should document assumptions, constraints, and other limitations that bound the mission context.

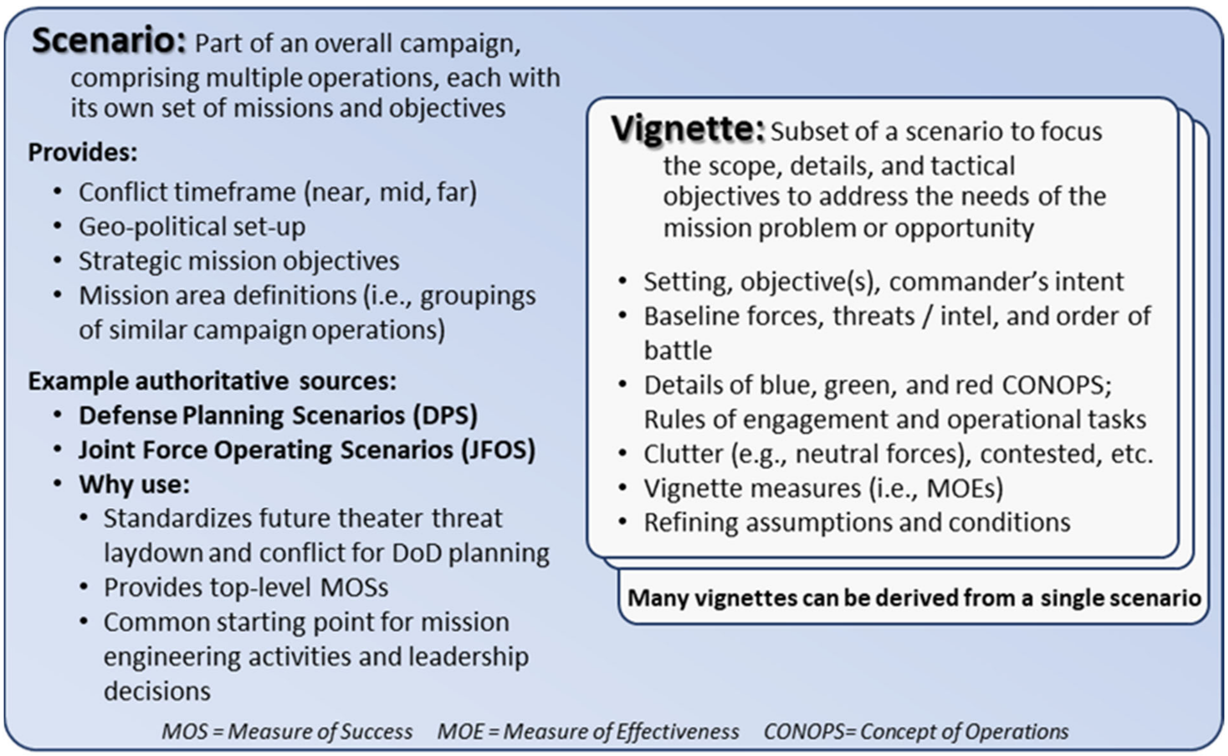


Figure 4-2. Overview of Mission Characterization.

4.2 Define Mission Measures and Metrics

Mission measures and metrics are the means to assess the end-state or goals of a given mission approach and evaluate the elements contributing to mission outcomes. Measures and metrics are selected from repeatable and unambiguous objective values and threshold values, which most directly inform the investigative questions and decisions to be addressed by the purpose statement.

Measures of Success (*MOS*s)—measurable attributes or target values for success within the overall mission in an operational environment that are typically driven by the mission objectives of the *blue* force.

Measures of Effectiveness (*MOE*s)—measurable military effects or target values for success that come from executing tasks and activities to achieve the MOS.

Measures of Performance *(MOPs)*—measurable performance characteristics or target parameters of systems or actors used to carry out the mission tasks or military effect.

Example MOSs, MOEs, and MOPs

In a Joint Force mission to stop a major enemy ground offensive, the success of the mission (defined by ***MOSs****) could be assessed by measuring the area of the battlespace still under friendly control. If the area remains unchanged, then the enemy's offensive has been stopped, and the mission has been a success.*

A Joint Force Air Component Commander (JFACC) might assess mission effectiveness (defined by ***MOEs****) by measuring how many of the targeted enemy forces contacted friendly forces in coherent platoon-size or larger formations. If that number is small, protecting friendly troops and effectively blunting the enemy offensive, [then] the JFACC may conclude that the* blue *forces' efforts were effective—and that they did the right thing.*

The JFACC might assess [blue] force performance (defined by ***MOPs****) by measuring the number of interdiction sorties successfully flown against enemy follow-on forces. If* blue *forces flew the planned number of sorties or more without loss, the JFACC can assess that* blue *forces are doing things right.*[14]

For the purposes of mission engineering, there is a hierarchy of measures and metrics which provides a logical decomposition of the ends and means to accomplish the overall mission objective and its related tasks. Typically, there is an overall operational objective to be evaluated to determine whether a mission is deemed successful or not. Measures of success help quantify this objective, support the purpose statement, and answer the investigative questions. These measures should help to quantify impacts to the mission outcomes or end-state. Measures of success could be derived from source documents describing specific missions and scenarios, such as the Defense Planning Scenario. An example MOS is *the Joint Force shall defeat 70 percent of the adversary fleet in less than five days*.

One or more MOEs help to characterize the MOS. Measures of effectiveness provide a means to assess and evaluate various actors in the execution of their tasks. Changes to MOEs (e.g., improving a given capability) can result in observations and help build understanding of the sensitivity correlating to the MOS. An example MOE is *the number of red assets destroyed* and *the number of targets tracked*.

[14] Air Force Doctrine Publication 3-0, "Operations and Planning," p. 89, November 4, 2016

The attributes that characterize the specific performance of each actor—i.e., capabilities, technologies, systems, and personnel in the mission approach—represent one or more MOPs. Measures of performance are typically measurable data points that are collected and serve as inputs to support the development and execution of the mission engineering activities. As MOPs are tracked, there may be correlating changes to the MOEs and MOSs. Example MOPs include *missile speed, range, maneuverability, warhead size, lethality, and survivability*.

Measures and metrics should be selected and scoped to the statement of purpose. Measures and metrics will evolve as factors across the mission becomes more fully understood and as various potential solutions are investigated. Relevant measures and metrics emerge after identifying: 1) the purpose statement, investigative questions, and decisional needs; 2) the mission and its objectives; and 3) the mission approach's tasks and assigned actors. A high-quality MOS aligns to the mission of interest and investigative questions associated with the purpose statement. The MOEs and MOPs are defined and collected, as needed, in direct contribution to the MOS. The MOEs and MOPs help to explain whether the MOS is being achieved and the factors contributing to its achievement.

The data and observations gained from obtaining the selected measures and metrics should be preserved for future analysis, potentially to inform revised baseline mission approaches or to help accelerate follow-on efforts given what has been previously learned. High-quality measures and metrics have the following characteristics:

- Consistent and repeatable—to grade across subsequent iterations, trades, and alternative mission approaches
- Relevant and necessary—addresses the purpose statement
- Solution agnostic—unbiased toward a specific mission approach or solution
- Measurable—represents a scale, either directly observed or derived

Figure 4-3 illustrates the linkage of measures and metrics from the system level to the mission objectives. The MOEs and MOPs connect through the mission architecture—from tasks to systems, up to the MOSs. This balance ensures the use of valid measures and metrics in the analysis.

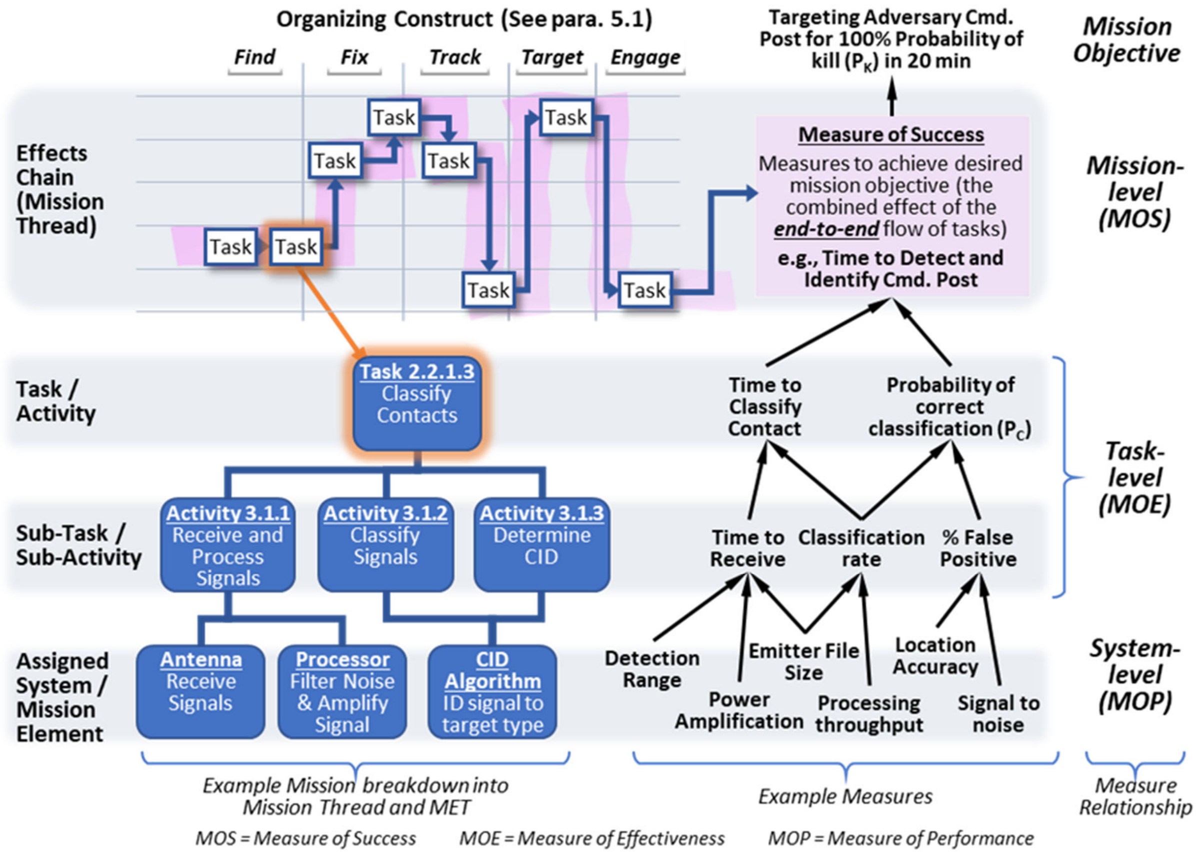


Figure 4-3 Linkage of measures and metrics from the system or system of systems to mission levels.

5.0 MISSION ARCHITECTURES

The architecture of a mission captures the structure of what activities, tasks, and events are essential to the mission and how these activities are executed to achieve end-to-end mission objectives. Mission architectures capture the relationships, sequencing, execution, information exchanges, DOTMLPF-P considerations, and nodal linkages of elements within the mission. Mission architectures provide a bridge between military operations on one side and functionality on the other. In addition, mission architectures should reflect tactics and timing to complete the necessary tasks to achieve mission objectives.

In mission engineering, there are two key elements of mission architectures: 1) ***mission threads***, which capture the activities of a given mission approach, and 2) ***Mission Engineering Threads*** (METs). These elements capture how the mission activities related to the actors, systems, and organizations are executed in a specific mission context captured in the scenario and related vignettes (See Figure 5-1). A mission architecture can be thought of as an interwoven *effects web*, or kill web, comprised of many mission threads and METs.

Mission architectures provide the means to compare *alternative* mission approaches to conduct a mission against a *baseline* mission approach. The models and data used to digitally represent mission architectures should be tailored to suit the level of detail required to address the purpose statement, investigative questions, and specific mission context of interest. The derivation of mission threads and METs is an iterative process.

There are multiple ways to document a mission architecture and several notational approaches that can be used to describe mission threads and METs, including BPMN, UML, SysML, UAFML, or other Department of Defense standard architecture views.

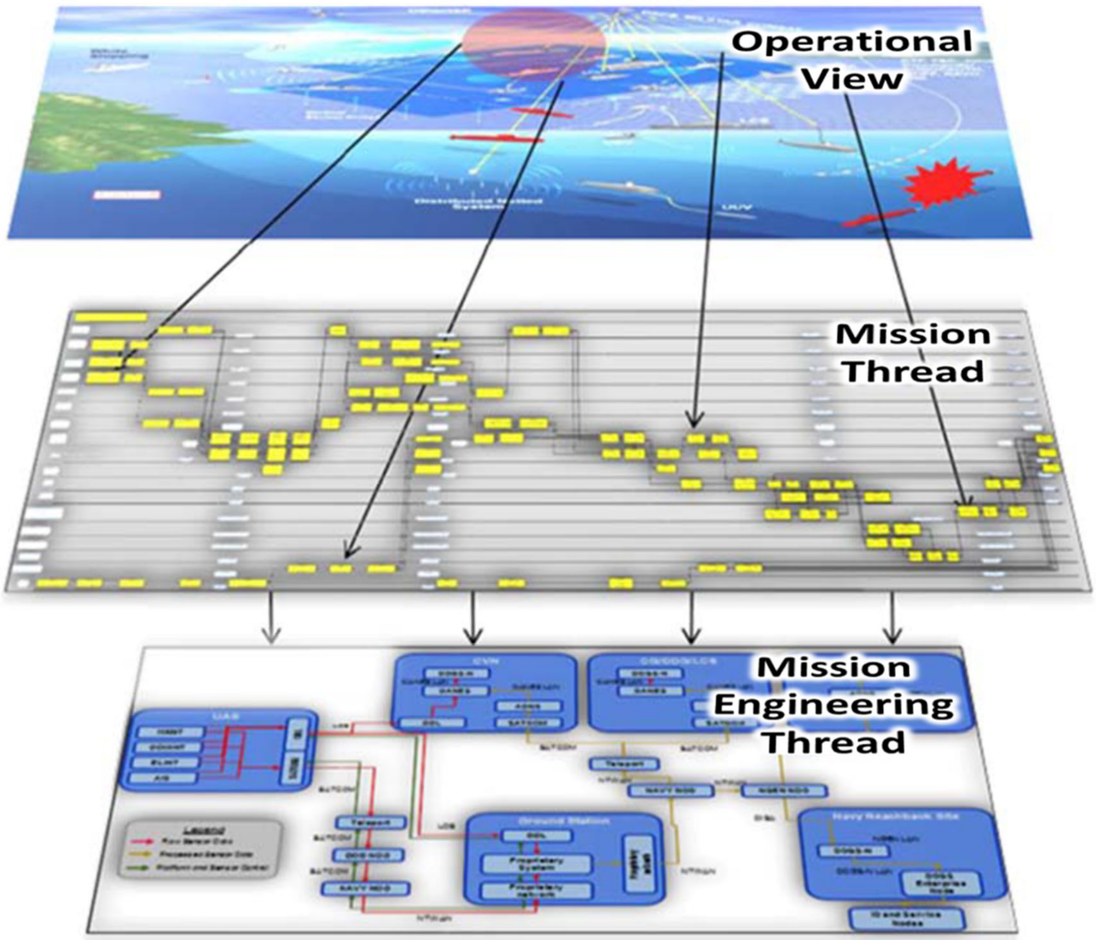


Figure 5-1. Relationship of elements in a mission architecture from an operational view (top, scenario), through an approach (middle, mission thread), to the assignment of actors and systems (bottom, MET).

5.1 Mission Threads

Mission threads characterize the sequence of events, activities, decisions, and interactions in an end-to-end mission approach to achieve an operational mission objective. Mission threads are distinct in that they describe the *task execution sequence in a chain of events*, not how or by whom each activity within the flow is to be accomplished.

> ***Mission Threads*** *describe a set of tasks, activities, and events in an approach to conduct a mission.*
>
> ***Mission Engineering Threads*** *assign the actors—people, systems, organizations, etc.—that perform the tasks, activities, and events in the approach to conduct a mission.*

There is no single source for mission threads; however, ample resources exist in the Joint Staff, Services, and Combatant Commands—discussion with stakeholders and subject matter experts from these organizations is critical and will help mission engineers properly characterize missions and develop mission threads. As inputs for mission thread development, practitioners may consider resources like the Joint Mission Essential Task List (JMETL), the Unified Joint Task List (UJTL), the Joint Common System Function List (JCSFL), and Service-specific task lists.

Practitioners should validate derived mission threads with stakeholders and subject matter experts.

In context of a specific scenario, mission threads describe tasks to be executed, leveraging doctrine, tactics, techniques, procedures, and associated decision-making cycles as well as any deviations from the Joint or Service task lists.

Organizing tasks into a sequential description of the mission approach is useful. There are several broad constructs that can serve as starting points, such as the task flow for a long-range fires (kinetic) mission thread may take the form of *Find–Fix–Track–Target–Engage–Assess (F2T2EA)*. Alternately, logistics and other supporting missions may take a different construct—for instance, a cyber (non-kinetic) mission thread may follow the task flow of reconnaissance, weaponization, and delivery, i.e., *Exploitation–Installation–Command and Control (C2)–Action on Objective*.

5.2 Mission Engineering Threads

The development of one or more METs will complete the representation of a given mission approach by adding the details on the actors—systems, technologies, organizations, and personnel—necessary to accomplish the mission tasks. METs provide insights that inform engineering designs and development considerations for systems and SoS.

The level of detail provided in a MET should be tailored to the purpose statement. Not all tasks in the mission thread need to be assigned an actor. Practitioners may make some assumptions regarding activities and events that are not central to the investigative questions—*as long as these assumptions are explicitly documented*. As with mission threads, practitioners should validate METs with stakeholders and subject matter experts.

Figure 5-2 depicts the relationship between an individual mission thread and a MET. In practice, the execution of a mission in a specific scenario may include the integration of multiple mission threads and METs as *effects webs or kill webs*. Practitioners should ensure that a complete set of threads and its associated relationships are represented in the mission architecture based on the purpose and scope of the mission engineering effort.

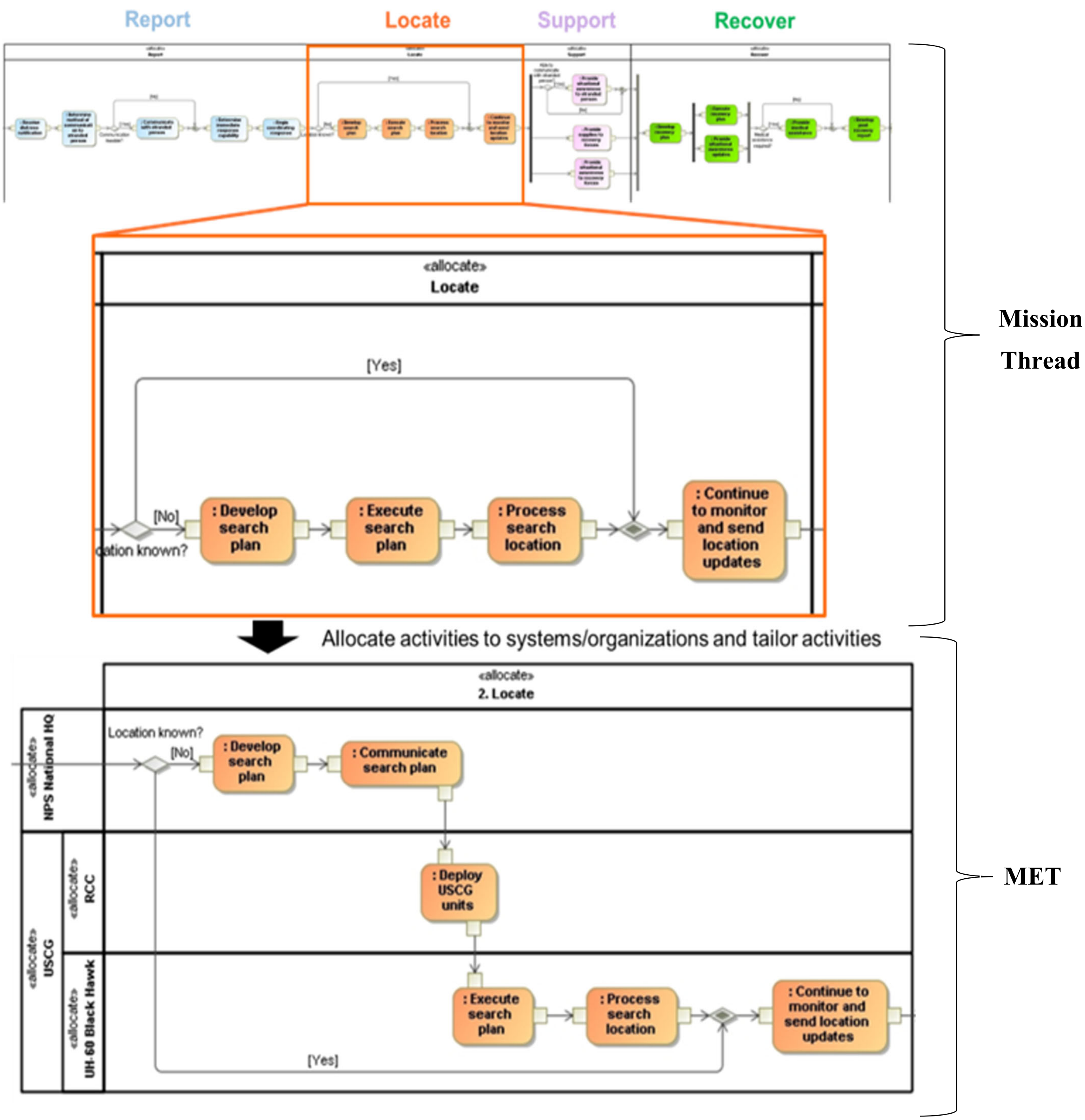


Figure 5-2. Example of a single mission thread and associated MET modeled in digital engineering tool.

5.3 Develop Baseline and Alternative Mission Threads and Mission Engineering Threads

The mission threads and METs against which alternative mission approaches will be assessed are called the *baseline mission approach*. Typically, the baseline is a starting point, or an initial approach to the mission for the epoch (present or near future) of interest. When considering new ways to improve mission outcomes, those changes should be represented by adding the modified activities to the mission threads or by integrating the new technologies or systems to the METs. These changes become *alternative mission approaches.* These alternatives are excursions from the baseline mission approach, directly derived from the purpose statement and the investigative questions. For example, if the mission engineering purpose is to explore cause and effect, then the alternatives could be driven by a sensitivity to a particular parameter. If the purpose is to address potential solutions or new opportunities, then the alternatives could model the implementation of the driving forces behind those opportunities. In addition, alternatives can be chosen based on known issues or gaps identified from the baseline. For each alternative, practitioners may need to develop and validate separate METs (and possibly mission threads). Each baseline and alternative MET should be clearly documented with controlled configurations. The documentation should reflect any associated changes, including traceable sources of information and references.

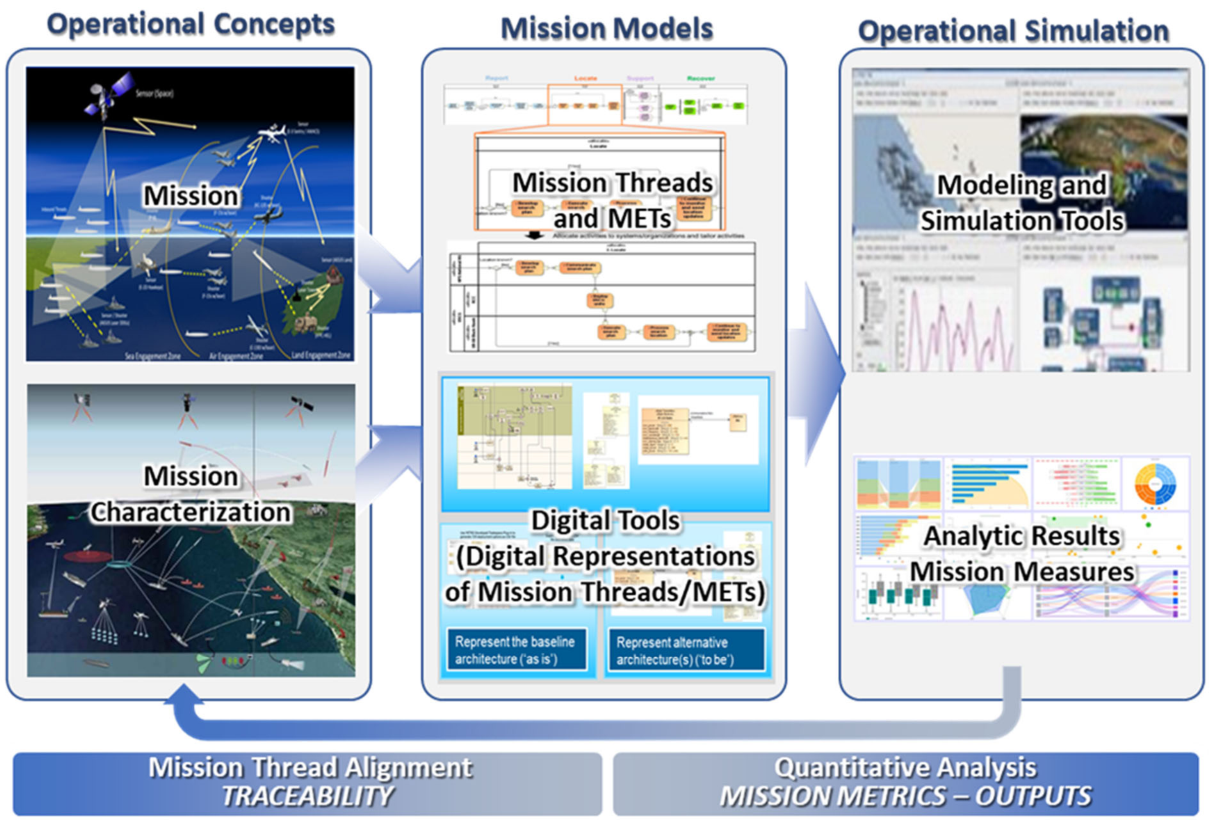
To be most effective in interpreting results of the mission engineering activity, practitioners should clearly understand and capture the changes being made between the baseline and alternative mission approaches. Depending on the scope of the mission engineering activity, changes could be focused on a single system or SoS within the baseline. Alternative mission approaches may become new baselines for subsequent mission engineering efforts.

For illustration, Table 5-1 provides examples of baseline and alternative mission approaches when considering an opportunity statement that is focused on understanding the mission impacts of integrating new weapon systems with associated enhancements and enablers.

Table 5-1. Approaches to be examined

Identifier	Short Description
Baseline Approach	
A. Conventional Approach	Employ Global Positioning System (GPS)-guided standoff missiles from *blue* force bomber aircraft, supported by jammers and aerial refueling, to attack *red* force aircraft
Alternative Approaches & Excursions	
B1. Bomber-launched glide vehicle with GPS	Substitute new bomber-launched glide vehicle weapon, GPS-guided
B2. Surface-launched glide vehicle with GPS	Excursion: Substitute launch platform to employ same glide vehicle weapon from approach B1, but launched at extended range from Surface Ship, GPS-guided
C. Bomber-launched subsonic cruise missile with GPS	Substitute new bomber-launched subsonic cruise missile, GPS-guided

As already noted, mission architectures include mission threads and METs executed in the specific mission context. The interdependencies revealed across this mission architecture underscore the importance of reflecting all METs applicable within the scenario. This set of integrated METs should be traceable to the mission engineering analysis and can serve as the blueprint for further mission engineering activity as depicted in Figure 5-3.



1. Digitally represent the baseline mission threads & METs within scenario, vignette and mission use-case (including threat & environment); conduct baseline analysis of mission measures
2. Update mission threads & METs to address alternative concepts with associated changes; update systems' attributes & behaviors; conduct analysis alternatives & assess impact on mission measures

Figure 5-3. Mission architectures are traceable to the mission engineering analysis.

6.0 MISSION ENGINEERING ANALYSIS

The core function of mission engineering analysis is to evaluate mission architectures within the specific scenario-based mission context to provide quantitative outputs (i.e., measures and metrics) that explore mission success. The analysis focuses on simulating the behaviors and effects of executing the mission—the baseline and alternative mission approaches—amid potential variations in conditions to assess mission impacts.

In conducting analysis of mission architectures, practitioners can benefit from expertise in systems engineering (e.g., reliability engineering or risk management) and related processes, such as failure mode and effects analysis, to assess the impact of system or task failure on the overall mission. Powered by constructive simulations and predicated on operations research, mission engineering analysis provides quantitative measures and metrics based on mission execution. The results can inform the refinement and modifications to the mission architectures.

6.1 Complete Design of Analysis

A mission engineering analysis should be designed such that its outputs are provided to address the purpose statement and answer the investigative questions. Some key aspects of the design of analysis include:

- Development of a *run matrix*
- Identification of the appropriate computational and simulation analysis tools
- Refinement of datasets

6.1.1 Develop and Organize Evaluation Framework (Run Matrix)

A *run matrix* is a structured set of mission approaches to be analyzed in a specified mission scenario or vignette for the mission engineering analysis. The matrix should include the mission baseline approach and various alternatives for comparison. Based on the questions to be addressed, excursions should reflect the varying considerations and changing variables within the mission context and baseline mission approach. The practitioner may consider identifying alternative approaches to be explored based on known issues or gaps identified from the baseline. These alternatives are the changes in the METs, described in Section 5.3. The run matrix is a useful way to plan analysis and inform the selection of analytical approaches.

The primary elements of the run matrix are the mission approaches to be evaluated and the operational conditions that may impact performance. For each entry in the run matrix, practitioners should consider the availability of datasets and the fidelity and statistics needed from models and simulations. Assumptions, limitations, and boundary conditions imposed on the run should be included. Practitioners should also weigh the analytic methods and modeling tools appropriate to obtain meaningful results.

Run matrices begin with trials, or excursions, associated with the baseline approach. Practitioners should validate run matrix with stakeholders and subject matter experts. Boundary conditions, constraints, and limitations associated with each conducted run should be captured. Practitioners may find a tabular format, such as that shown in Figure 6-1, can be a useful way to summarize and organize relevant information derived from the run matrix.

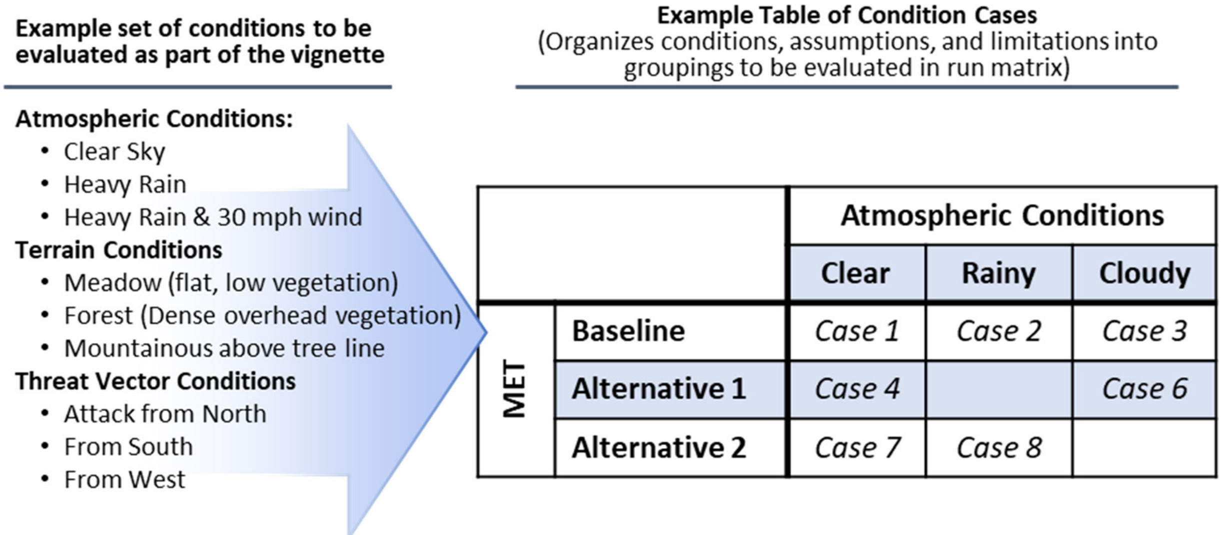


Figure 6-1. Illustrative grouping of cases and set-up conditions.[15]

6.1.2 Identify Computational Methodology and Simulation Tools

There are many analytical methods to assess the different mission approaches in the run matrix. Practitioners should select the method most appropriate to the mission engineering purpose and investigative questions. Potential methods include:

- Bayesian analysis
- Markov chain
- Monte Carlo simulation
- Regression analysis
- Optimization analysis
- Sensitivity analysis
- Cost-benefit analysis
- Stochastic modeling
- Empirical modeling
- Parametrization

Some instances of when to apply these methods for implementing mission engineering include using *optimization analysis* to help find the best value for one or more variables under certain constraints; using *sensitivity analysis* to determine how variables are affected by changes in other variables; and using *parametrization* to express system, process, or model states as functions of

[15] Author's note: depending on the mission engineering effort, not all cases may need to be executed.

independent variables. The application of these methods can help refine assumptions and inputs when more than one variable is unknown.

The investigative questions, the measures and metrics, and the selected type of analysis will drive the practitioner to choose the appropriate analytic tools for modeling and computing the run matrix to assess mission impacts. As is the case with the selection of analytical methodology, practitioners should select tools that best support the mission engineering activity. In selecting tools, practitioners should account for the computational time of each trial, which is determined by the model and analytic complexity, against the total time allotted for the mission engineering analysis.

Potential tools for mission engineering application include both government-owned and commercial modeling, simulation, and architecture software. These tools enable the development of models and the execution of analysis at the strategic, operational, and tactical levels and in different domains (e.g., maritime, air, land, and space). These tools also enable analysis of different mission operations—including electromagnetic, cyber, communications, jamming, and non-kinetic versus kinetic operations—with different degrees of computational rigor, fidelity, or complexity.

The choice of tools is driven by the complexity of the scenario, vignette, and mission threads. Other factors influencing the choice of tools include the mission duration and computational timesteps, the fidelity requirements of the data, and the number of variables feeding the measures and metrics. The models derived from the selected toolset will handle error propagation (e.g., random and systematic) and uncertainty differently. Practitioners should understand the tools and the relationship between a model and the pedigree of source data necessary to effectively use that model.

6.1.3 Organize and Review Datasets

Much of the data needed for the analysis has been collected thus far from mission characterization and the development of mission architectures. The different baseline and alternative options within the run matrix will structure the analysis and may require additional data to develop models for the simulation and analysis. Therefore, organizing and reviewing the data collected will help assess additional data needs for the mission engineering effort. Datasets should come from trustworthy data sources and be reviewed by subject matter experts to lend credibility to the models, simulations, and results.

6.2 Execute Models, Simulations, and Analysis

Using the run matrix developed, practitioners should execute the simulation for the baseline and alternative mission approaches to output results—mission measures and metrics. Depending on the scope of the mission engineering activity, the baseline mission approach could be executed before fully defining the run matrix to identify gaps or mission areas with which to focus alternatives. Once processed and verified, the results will provide quantitative insights describing the impact of the approaches on mission outcomes.

Practitioners should consider the following in the execution of modeling runs:

- Executing and analyzing the baseline mission approach
- Adjusting the run matrix, as necessary
- Executing and analyzing the alternative mission approaches
- Validating the analytic findings

6.2.1 Execute and Analyze the Baseline

Practitioners should model the baseline MET within the context of the scenario and vignette using the tools to simulate and execute the mission. All relevant peoples and organizations, system attributes, behaviors, and effects should be represented. Practitioners should conduct baseline trials, as planned in the run matrix. The baseline runs should be critically examined to ensure the modeled MET has captured known operational behavior and that simulation results match the judgement of subject matter experts. In most cases, more information is known about the baseline than the proposed alternative mission approaches, allowing practitioners to more readily check that the models and analytic tools will deliver results consistent with expectations. Practitioners should document mission measures and metrics, observations, and assumptions.

6.2.2 Adjust the Run Matrix (as Needed)

If unexpected results or additional gaps are discovered with the baseline output, practitioners should consider adjusting the run matrix with appropriate alternative METs. It is more efficient to adjust the run matrix at this stage than to wait until all trials have been run. Once adjustments are made, practitioners should revalidate the run matrix with subject matter experts.

6.2.3 Execute and Analyze the Alternative Mission Approaches

Practitioners should model the alternative METs within the context of the scenario and vignette using the chosen tools to simulate and execute the mission. Special cases should be noted, including when runs do not go as predicted, where statistical convergence is not achieved, and where models and simulations unexpectedly crash or yield an interesting singularity. Practitioners should rerun trials where needed and record all encountered anomalies and events occurring within the runs. Practitioners should capture mission measures and metrics, and observations or assumptions. Interesting and unexpected results can be the source of excursions, variations on the mission threads and METs, or further sensitivity analysis around specific parameters. Finally, practitioners should document results for all entries in the run matrix.

6.2.4 Validate the Fidelity of Analytic Results

Three important considerations in any mission engineering analysis are:

- *Accuracy*—systematic error, random error, anomalies, and artifacts
- *Precision*—error analysis and statistical regression

- *Confidence*—the interval, or range of possible values for a given parameter based on a set of data, e.g., simulation results and the level or probability that the interval contains the value of the parameter

Before executing additional analyses, practitioners should first evaluate whether the results from the initial trials yield the *fidelity—the* accuracy, precision, and confidence—needed to answer the investigative questions. With actual values now available for review, measures and metrics identified as important in the design of the analysis may not be as hard-hitting as initially thought. Other critical measures and metrics might have been overlooked. The aggregation of measures and metrics should be reviewed to ensure findings will support the conclusions that inform stakeholders and decision makers.

Practitioners should review the analytic findings with stakeholders and subject matter experts.

Practitioners should critique the results for both proper execution of the analytic methods as well as the soundness of results. The results should be graphed or visualized to inspect the output. Practitioners should assess whether the comparison of baseline and alternative mission approaches has meaning and to obtain insights on the impacts of changes to mission outcomes. Example questions that practitioners should confidently answer include:

- *Does the comparison of results from the baseline to the alternative mission approach trials yield quality data sufficient to answer the investigative questions?*
- *Are the results of these trials, i.e., the measured performance of the mission approach, justifiable and explainable as a narrative and consistent with input from subject matter and operational experts?*
- *How do the assumptions and constraints for the analysis, impact the interpretation of the results?*
- *Do the results address the investigative questions in a way that meaningful conclusions can be drawn?*

6.3 Adjust Mission Threads and Mission Engineering Threads

If answers to these questions are inadequate, or if other behaviors of interest are observed, then practitioners should revisit the cycle of mission thread and MET development. Further adjustments to the run matrix and trials may need to be made. The cycle follows the following pattern:

- Observe the mission
- Conject a reason for that observation
- Create an alternative mission approach to evaluate that conjecture
- Evaluate if the conjected case confirms the observation (i.e., fully answers the investigative questions)
- If the case does not confirm the observation, then repeat the cycle

7.0 RESULTS AND RECOMMENDATIONS

The final phase of the mission engineering process comprises three elements: 1) synthesis and documentation of mission impacts and outcomes obtained from the mission engineering analysis, 2) the capture and presentation of recommended mission architectures, and 3) the curation of mission engineering artifacts for future use.

The products of mission engineering help focus attention on a set of recommendations associated with the purpose statement and investigative questions. Recommendations are used to inform leadership, shape requirements, advise prototyping efforts, and substantiate acquisition decisions. Recommendations help explain the attributes of recommended mission architectures, reflect the MOSs as aligned with the original questions and highlight the need for further analyses.

Major mission engineering products include:

- Digital models of mission architectures—mission threads and METs
- Collection of information on missions, scenarios, and current and future capabilities
- Datasets—system performance parameters, models, metrics, and measures
- Documented results, findings, and recommendations—visualizations, reports, briefs, digital artifacts

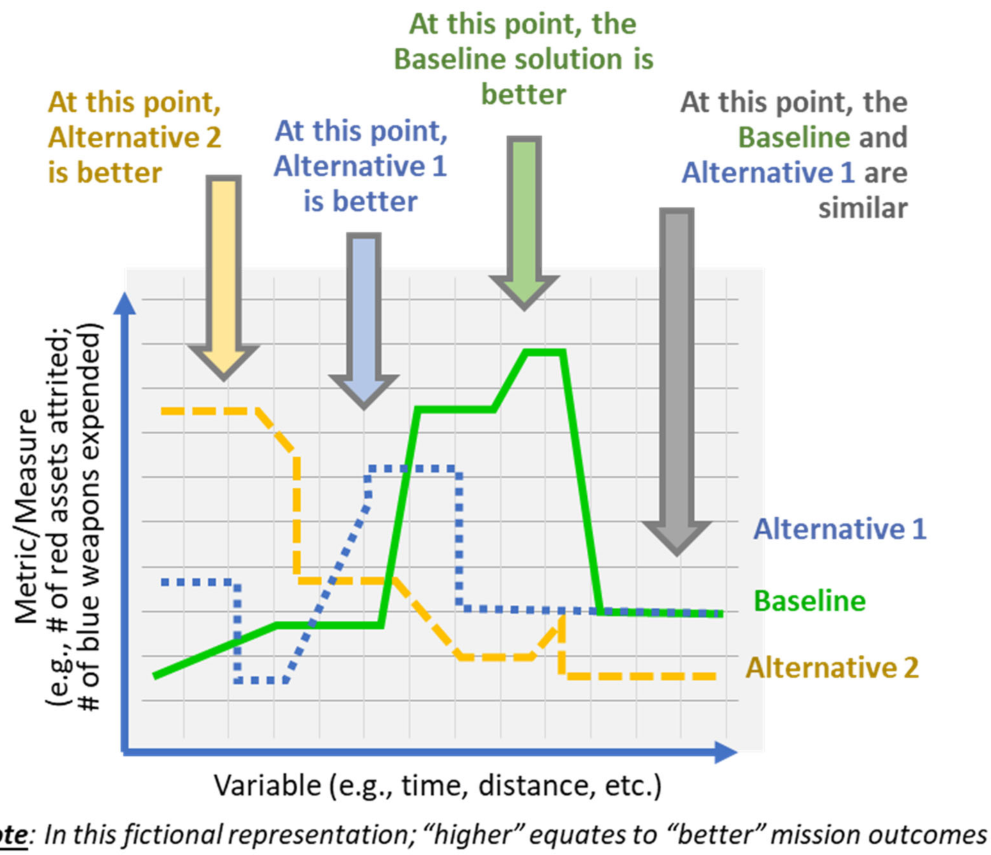


Figure 7-1. Example visualization of results from mission engineering analysis.

At a minimum, mission engineering products should document the overall purpose of the analysis and its planning. The products also should include the influences that drove the selection of an analytic framework—including assumptions and constraints, tools, models, measures and metrics, and the results obtained. Practitioners should quantify the gain or loss toward the MOSs and other key measures and metrics that help address the purpose statement. Identify any secondary, or new, mission gaps that were discovered or could emerge from an implemented solution. Observed trends or implications and relationships or correlations deduced from the data should be included. When documenting the overall mission engineering effort, practitioners should consider the following outline of desirable points:

- State the problem or opportunity, the questions, and the mission
- Describe the scenario and vignettes, to include describing the operational environment
- Identify *blue-* (U.S.), *red-* (adversary), and *green-* or other non-adversary forces as well as DOTMLPF-P considerations
- Delineate measures and metrics for the mission (MOSs, MOEs)
- Describe the mission architectures—the baseline, alternative mission threads and METs
- Identify key assumptions and constraints about the mission, technology, or capabilities
- Document details of the baseline mission approach and related condition cases
- Explain the analytical methodology
- Describe the results obtained from the analysis citing the fidelity and credibility of the models, data, and results
- Identify any non-error propagated uncertainties or other issues with the results
- Justify or explain the fidelity of the results with a statistical basis
- Describe the conclusions from the analysis and discuss how the results address the problem or opportunity statement
- Identify and capture risks in each mission architecture
- Recommend actions for decision makers
- Recommend further analysis and next steps

8.0 SUMMARY

The mission engineering process helps practitioners decompose missions into constituent parts and analyze end-to-end mission execution. The process helps to identify and resolve capability gaps and quantify impacts of alternative mission approaches. The process assesses systems or SoS within that mission context and enables exploration of trade-space opportunities across that mission.

The mission engineering process can help decision makers align resources to desired mission outcomes by identifying the most promising potential materiel or non-materiel solutions and opportunities. The goal of mission engineering is to engineer missions by *identifying the right things*—the technologies, systems, SoS, or processes—to achieve the intended mission outcomes; and provide mission-based inputs into the systems engineering process to aid the Department in *building things right*.

The mission engineering process is scalable to the problem or opportunity under evaluation, the availability of data, and decisional needs. This flexible, iterative methodology allows analysis to improve as information is gained throughout modeling and simulation runs, providing traceability to data sources, assumptions, and constraints.

Mission engineering uses mission architectures to analyze the design and integration of systems, SoS, and emergent capabilities within the context of a particular operational scenario and vignette to yield desired mission outcomes. The results of mission engineering analyses inform decision makers on potential trade-spaces in resource allocation to ensure the Warfighters will have the capabilities, technologies, and systems they need to successfully execute their missions. Simultaneously, mission engineering informs the evolution of requirements, system design, and capability development via performance measures.

9.0 APPENDIX

9.1 Mission Engineering Glossary

Alternative Mission Approach: A change to the baseline mission approach for how the mission will be executed. (OUSD(R&E))

Assumption: A specific supposition of the operational environment that is assumed true, in the absence of positive proof, essential for the continuation of planning. (JP 5-0, Department of Defense Dictionary)

Baseline Mission Approach: The agreed upon starting point for how the mission will be executed to address the mission engineering effort; driven by the mission, scenario, and epoch. (OUSD(R&E))

Blue Force: U.S. combatants. (OUSD(R&E))

Capability: The ability to complete a task or execute a course of action under specified conditions and level of performance. (CJCSI 5123.01H, DAU Glossary)

Concept of Operations (CONOPS): A verbal or graphic statement that clearly and concisely expresses what the commander intends to accomplish and how it will be done using available resources. (JP 5-0, Department of Defense Dictionary)

Constraint: In the context of planning, a requirement placed on the command by a higher command that dictates an action, thus restricting freedom of action (JP 5-0 Department of Defense Dictionary). Constraints may also refer to the range of permissible states for an object (Department of Defense CIO architecture Framework)

Data Curation: The ongoing processing and maintenance of data throughout its lifecycle to ensure long-term accessibility, sharing, and preservation. (National Library of Medicine)

Digital Engineering: Digital engineering is an integrated digital approach using authoritative sources of system data and models as a continuum throughout the development and life of a system. (OUSD(R&E))

Epoch: A *time period* of static context and stakeholder expectations, similar a snapshot of a potential future. For acquisition planning, three epochs are usually defined: 1) near term—up to two years into the future 2) FYDP (Future Years Defense Program), up to five years into the future, and 3) beyond the FYDP, 5–10 years into the future. (Naval Postgraduate School; MIT)

Fidelity: A measure of the accuracy, precision, and statistical confidence to which the data, result, etc. represents the state and behavior of a real-world object or the perception of a real-world object, feature, condition, or chosen standard in a measurable or perceivable manner.

Green Force: Allied combatants. (OUSD(R&E))

Kill Chain: A Mission Thread with a kinetic outcome. Dynamic targeting procedures often referred to as F2T2EA by air and maritime component forces; and Decide, Detect, Deliver, and Assess methodology by land component forces. (JP 3-09)

Kill Web: An inclusive set of multiple integrated Mission Threads and METs for the applicable scenario or vignette of interest. (OUSD(R&E))

Measure: The empirical, objective, numeric quantification of the amount, dimensions, capacity, or attributes of an object, event, or process that can be used for comparison against a standard or similar entity or process. (AFOTECMAN 99-101; Science Direct)

Measure of Effectiveness (MOE): Measurable military effects or target values for success that are derived from executing tasks and activities to achieve the MOS. (OUSD(R&E))

Measure of Performance (MOP): Measurable performance characteristics or target parameters of systems or actors used to carry out the mission tasks or military effect. (OUSD(R&E))

Measure of Success (MOS): Measurable attributes or target values for success within the overall mission in an operational environment. Measures of success are typically driven by the mission objectives of the *blue* force). (OUSD(R&E))

Metric: a unit of measure that coincides with a specific method, procedure, or analysis (e.g., function or algorithm). Examples include mean, median, mode, percentage, and percentile. (AFOTECHMAN 99-101)

Mission: The task, together with the purpose, that clearly indicates the action to be taken and the reasoning behind the mission. (JP 1-02)

Mission Architecture: A view or representation that depicts the ways and means to execute a specific end-to-end mission, with relationships and dependencies amongst mission elements. This includes elements such as mission activities, approaches, systems, systems of systems, organizations, and capabilities. (OUSD(R&E))

Mission Characterization: The aggregate of factors associated with military objectives and operations; this includes the mission to be accomplished in a specific time and place, the measures of success, the threats, and constraints. Changes in any factors of the mission characterization may cause the mission to be redefined. (OUSD(R&E))

Mission Context: The elements that describe *who*, *what*, *when*, *where*, and *why* elements of the mission to be accomplished. Changes in any elements of the mission context may cause the mission to be redefined. (OUSD(R&E))

Mission Element: A person, organization, platform, and/or system that performs a task. (OUSD(R&E))

Mission Engineering: An interdisciplinary process encompassing the entire technical effort to analyze, design, and integrate current and emerging operational needs and capabilities to achieve desired mission outcomes. (OUSD(R&E))

Mission Engineering Analysis: The approach to evaluate mission architectures within the specific scenario-based mission context to provide quantitative outputs that explore mission impacts. (OUSD(R&E))

Mission Engineering Thread (MET): Mission threads that include the details of the capabilities, technologies, systems, and organizations required to execute the mission. (OUSD(R&E))

Mission Tasks: A clearly defined action or activity specifically assigned to a system, individual or organization that must be complete. (Adapted from JP-01).

Mission Thread: A sequence of end-to-end mission tasks, activities, and events presented as a series of steps to achieve a mission. (OUSD(R&E))

Model: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. (DoDI 5000.61, DoDI 5000.70) per MSE. Per the Systems Engineering Body of Knowledge, Models are often categorized as Descriptive, Analytic, etc. (Systems Engineering Body of Knowledge)

Operations: 1. A sequence of tactical actions with a common purpose or unifying theme. (JP 1) 2. A military action or the carrying out of a strategic, operational, tactical, service, training, or administrative military mission. (JP 3-0, Department of Defense Dictionary) There are Operations–sequences of tactical actions with a common purpose or unifying theme; Major Operations–series of tactical actions to achieve strategic or operational objectives; and Campaigns–series of related major operations aimed at achieving strategic and operational objectives within a given time and space. (JP-1)

Planning, Programming, Budgeting, and Execution (PPBE) Process: The primary resource allocation process of Department of Defense. (DAU Glossary)

Red Force: Adversary combatants. (OUSD(R&E))

Scenario: Description of the geographical location and timeframe of the overall conflict. A scenario includes information such as threat and friendly politico-military contexts and backgrounds, assumptions, constraints, limitations, strategic objectives, and other planning considerations. (OUSD(R&E))

Sensitivity Analysis: Determines how different values of an independent variable affect a particular dependent variable under a given set of assumptions. (Investopedia website, https://www.investopedia.com/terms/s/sensitivityanalysis.asp)

Tactical: The level of employment, ordered arrangement, and directed actions of forces in relation to each other, to achieve military objectives assigned to tactical units or task forces (TFs). (Adapted from JP 3-0, Chapter 1, 6.d.)

Threat: The sum of the potential strengths, capabilities, and strategic objectives of any adversary that can limit U.S. mission accomplishment or reduce force, system, or equipment effectiveness. The threat does not include (a) natural or environmental factors affecting the ability or the system to function or support mission accomplishment, (b) mechanical or component failure affecting mission accomplishment unless caused by adversary action, or (c) program issues related to budgeting, restructuring, or cancellation of a program. (DAU Glossary, CJCSI 5123.01H)

Verification: The process of determining that a model or simulation implementation and its associated data accurately represent the developer's conceptual description and specifications. (JP 3-13.1, Department of Defense Dictionary)

Validation: The process of determining the degree to which a model or simulation and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model. Applicable to an expressed user need and consistent with program concept of operations. (Space and Missile Systems Center Mission Engineering Primer and Handbook)

Vignette: A narrow and specific ordered set of events, and behaviors and interactions for a specific set of systems, to include *blue* force capabilities and *red* force (threats) within the operational environment. Vignettes can represent small, ideally self-contained parts of a scenario. (OUSD(R&E))

White Force (White Units): Non-combatant or neutral units. (OUSD(R&E))

9.2 Abbreviation List

C2	Command and Control
CCMD	Combatant Command
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
CONEMP	Concept of Employment
CONOPS	Concept of Operations
DAU	Defense Acquisition University
DOTMLPF-P	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DPG	Defense Planning Guidance
F2T2EA	Find, Fix, Track, Target, Engage, Assess
FY	Fiscal Year
FYDP	Future Years Defense Program
GPS	Global Positioning System
JFACC	Joint Force Air Component Commander
JFOS	Joint Force Operating Scenario
JP	Joint Publication
MEG	Mission Engineering Guide
MET	Mission Engineering Thread
MT	Mission Thread
MIM	Mission Integration Management
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOS	Measure of Success
M&S	Modeling and Simulation
NDS	National Defense Strategy

NMS	National Military Strategy
OOB	Order of Battle
OSD	Office of the Secretary of Defense
Pk	Probability of Kill
PNT	Position, Navigation, and Timing
PPBE	Planning, Programming, Budgeting, and Execution
SE	Systems Engineering
SoS	Systems of Systems
SysML	System Modeling Language
TTP	Tactics, Techniques, and Procedures
UAFML	Unified Architecture Framework Modeling Language
UJTL	Universal Joint Task List
UML	Unified Modeling Language
USD(R&E)	Under Secretary of Defense for Research and Engineering
U.S.	United States

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