DoD INSTRUCTION 5000.MEI

MISSION ENGINEERING AND INTEGRATION GUIDANCE AND PROCEDURES

Originating Component:	Office of the Under Secretary of Defense for Acquisition and Sustainment
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Approved by:	Dr. James D. Moreland Jr., Executive Director, Mission Engineering and Integration

Purpose: In accordance with the authority in DoD Directive 5134.01 and the July 13, 2018, Deputy Secretary of Defense Memorandum, this issuance establishes policy, assigns responsibilities, and provides procedures for conducting mission engineering in support of DoD acquisition programs.

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SECTION 1: GENERAL ISSUANCE INFORMATION

1.1. APPLICABILITY. This issuance applies to OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the DoD (referred to collectively in this issuance as the "DoD Components").

1.2. POLICY. The DoD will conduct mission engineering and integration analyses to provide information on the combat effectiveness and affordability of current and future weapon systems and capabilities and inform DoD acquisition program investment decisions.

SECTION 2: RESPONSIBILITIES

2.1. UNDER SECRETARY OF DEFENSE FOR ACQUISITION AND SUSTAINMENT. The Under Secretary of Defense for Acquisition and Sustainment:

a. Oversees implementation of the mission engineering and integration processes and procedures in Sections 4 and 5.

b. Develops clarifying guidance for implementation of this issuance, as needed.

c. Coordinates the establishment of DoD-wide mission engineering and integration frameworks to ensure consistent analyses across the DoD Components.

d. Coordinates mission engineering and integration analyses of existing systems, systems in the acquisition and sustainment phases, and system-of-systems portfolios for operational missions.

2.2. UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING. The Under Secretary of Defense for Research and Engineering:

a. Coordinates mission engineering and integration analyses of future systems either considered for funding or funded within the science and technology activity base.

b. Coordinates systems engineering processes and tools to assess mission engineering threads including architectures and modelling and simulation (M&S).

c. Coordinates digital engineering activities to support mission engineering and integration analyses.

d. Coordinates with the Director of Operational Test and Evaluation (DOT&E) to ensure test results are available to support mission engineering and integration analyses and to align test requirements to perform integrated mission engineering thread tests, including the establishment of appropriate test environments and tools.

2.3. UNDER SECRETARY OF DEFENSE FOR INTELLIGENCE. The Under Secretary of Defense for Intelligence:

a. Provides details on specific threats within mission areas with a path towards producing adversarial mission engineering threads.

b. Provides details on intelligence supportability dependencies within mission areas and within the theaters under investigation.

c. Provides details on specific threats within mission areas and intelligence supportability dependencies within mission areas and within the theater under investigation.

2.4. DIRECTOR OF COST ASSESSMENT AND PROGRAM EVALUATION. The Director of Cost Assessment and Program Evaluation:

a. Coordinates mission engineering and integration activities in support of program evaluation.

b. Supports mission engineering and integration activities in the development of cost estimates.

2.5. DOT&E. The DOT&E will coordinate with the Under Secretary of Defense for Research and Engineering to ensure test results are available to support mission engineering and integration analyses and to align test requirements to perform integrated mission engineering thread tests, including the establishment of appropriate test environments and tools.

2.6. DOD COMPONENT HEADS. The DoD Component heads implement this issuance and develop guidance to ensure internal procedures and analyses align with mission engineering and integration frameworks established across the DoD Components.

2.7. CHAIRMAN OF THE JOINT CHIEFS OF STAFF. The Chairman of the Joint Chiefs of Staff:

a. Selects and prioritizes missions for development and management.

b. Provides details on the relevant concepts of operation, training, tactics and procedures, and rules of engagement.

c. Provides joint logistics information to support mission engineering and integration analyses.

d. Provides detailed architecture products to represent critical mission areas and links between essential systems.

e. Integrates the mission engineering and integration process and products into the Joint Capabilities Integration and Development System.

f. Coordinates mission engineering and integration activities within and among the Functional Capability Boards, the Joint Capabilities Board, and the Joint Requirements Oversight Council established by Chairman of the Joint Chiefs of Staff (CJCS) Instruction 5123.01H.

SECTION 3: MISSION ENGINEERING OVERVIEW

3.1. FUNCTION. Mission engineering and integration supports the function of capability portfolio management as outlined in DoD Directive 7045.20. Mission engineering threads using the Effects/Kill Web Framework identify operational needs based on the way the forces plan to fight through mission threads (mission essential tasks) captured in the Combatant Commanders' operational plans and contingency plans. These mission threads also inform the functional issue of the systems needed to accomplish a mission within a system-of-systems (SoS) context.

3.2. SCOPE. Establishing mission engineering and integration at the DoD level is not intended to apply to all mission areas or issues. At the DoD level, mission engineering and integration is appropriate to address gaps, shortfalls, and overlaps involving:

a. Complex, joint, and high-priority missions, and problem sets.

b. Extensive collaborative and dynamic engineering analysis requirements.

c. High level of risk or uncertainty in solution decisions.

d. Emphasis on optimization or more than one doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF-P) area.

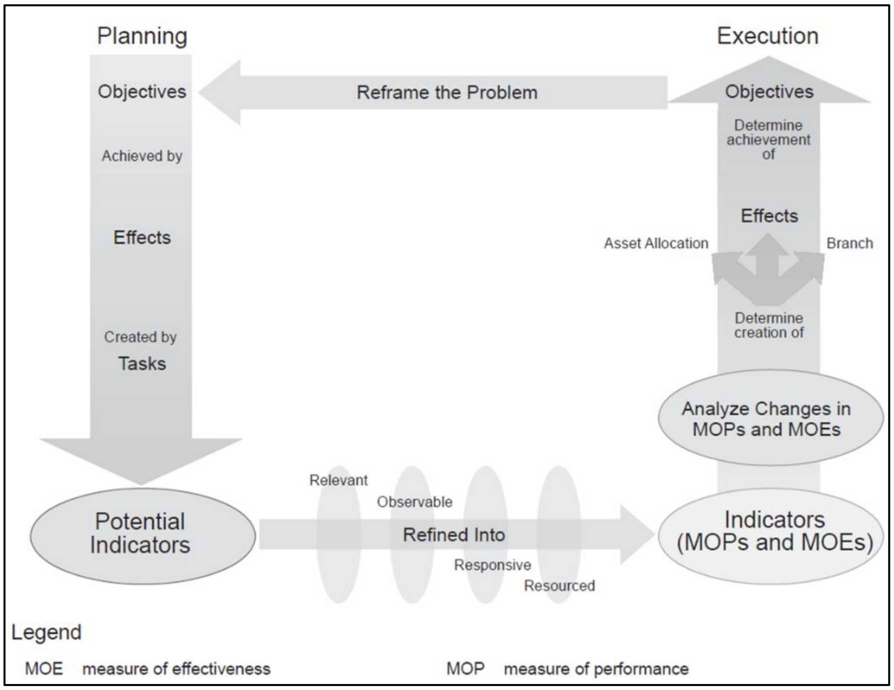
e. Continuing evolution of systems, networks, and capabilities.

f. Simultaneous M&S of a wide range of variables to understand the behavior of systems operating within a broader SoS.

g. Rigorous interface design and management of the capability across multiple platforms or locations, which might involve combinations of military and industry standards at multiple layers.

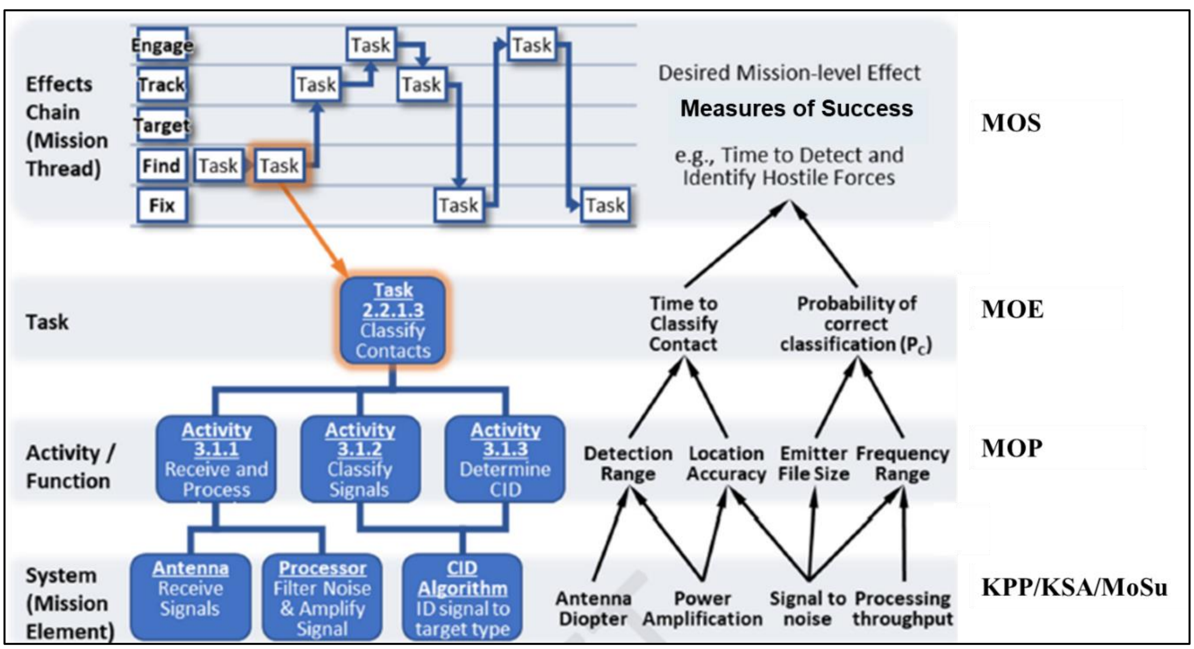
3.3. SCORING CRITERIA. Scoring criteria is used to define Measures of Success (MOS) at the strategic level, Measures of Effectiveness (MOE) at the operational level, and Measures of Performance (MOP) at the tactical or systems level which are represented by Key Performance Parameters (KPP), Key System Attributes (KSA), and Measures of Suitability (MOSu). The development and assignment of these measures is accomplished by working top down from mission success criteria to mission essential tasks criteria and then translation down to the individual platforms and systems using performance criteria. This process is illustrated in Figure 1 as an iterative loop to account for the changing and dynamic conditions in the operational environment.

Figure 1. MOE and MOP Development Process



It is critical that the measures are tightly linked across the hierarchical levels from strategic to operational to tactical. Figure 2 shows a representative mapping of these scoring criteria levels which exists to create continuity across all levels of operations with the goal of achieving unity of effort towards the defined mission success.

Figure 2. Levels of Scoring Criteria



3.4. FRAMEWORK.

a. The mission engineering and integration process builds around a horizontal integration framework to address the interaction of platforms, sensors, systems, and weapons that form mission area mission engineering threads. The intent of mission engineering and integration is to:

(1) Assess mission areas end-to-end, across system and platform boundaries, to identify and close gaps in mission critical capabilities.

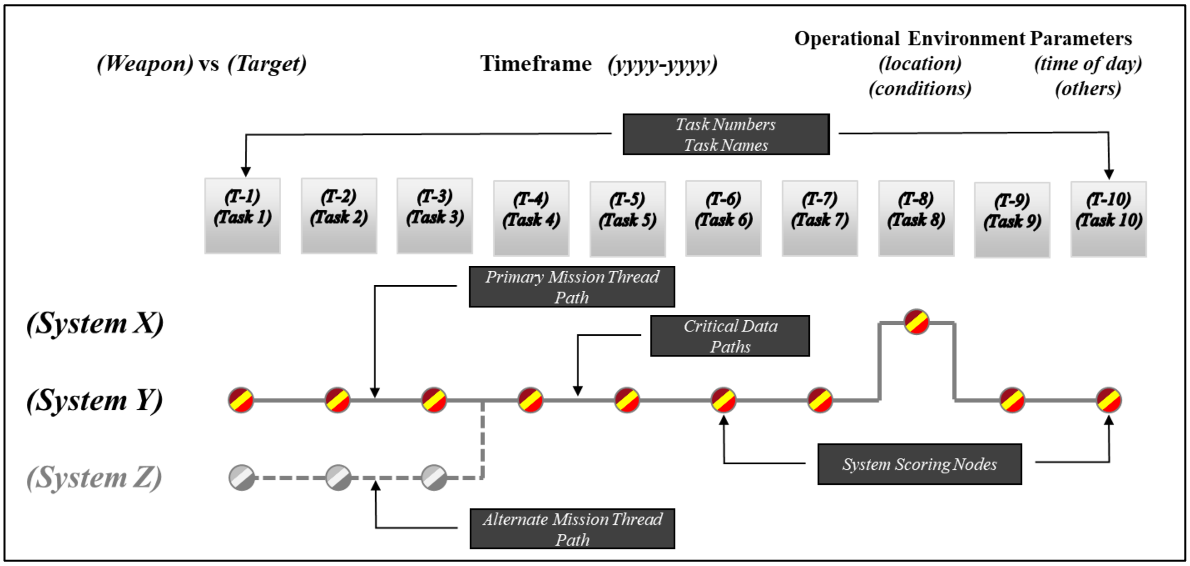
(2) Provide a common framework to compare like functionality and capability, while expanding the trade space from the system and platform level to the mission level.

(3) Improve warfighting capability by identifying gaps between systems and platforms and consider mission wholeness by providing gap closure recommendations across the range of DOTMLPF-P. Once identified, decision-makers can consider cost effective solutions to the gaps, to include materiel and non-materiel options, to ensure efficient system integration and effective force interoperability.

b. This process will not duplicate or circumvent existing Planning, Programming, Budgeting and Execution, and Joint Capabilities Integration and Development System processes; rather, it provides more informed inputs to these processes and leverages existing products.

3.5. MISSION ENGINEERING THREADS. Mission engineering threads represent the SoS required to execute operational missions by providing the necessary functions identified by the series of integrated, end-to-end mission threads. The resulting mission engineering threads are linked by interoperable interfaces required to employ a specific blue force weapon against a specific red force target within a given tactical situation to achieve a desired effect. Figure 3 is a representative Effects/Kill Web Framework used to determine the mission engineering thread as a result of mapping systems to the mission essential tasks or mission thread.

Figure 3. Effects/Kill Web Framework (Generic)



a. The mission engineering thread provides a representation of a mission capability through the execution of the identified mission thread. As such, the Effects/Kill Web Framework is used to map systems, platforms, sensors, weapons, and networks to mission essential tasks resulting in a mission engineering thread in the context of a specific tactical situation (TACSIT).

b. The mission essential tasks or mission thread form the columns of this product to represent the mission functions performed for the specific mission under assessment. The rows provide the platforms, sensors, systems, and weapons that represent the blue force employment forming a SoS construct referred to as the mission engineering thread. The lines connecting the individual system nodes represents the networks required to move information between the systems (i.e., Link 11, Link 16, CEC, Tactical Radios, etc.).

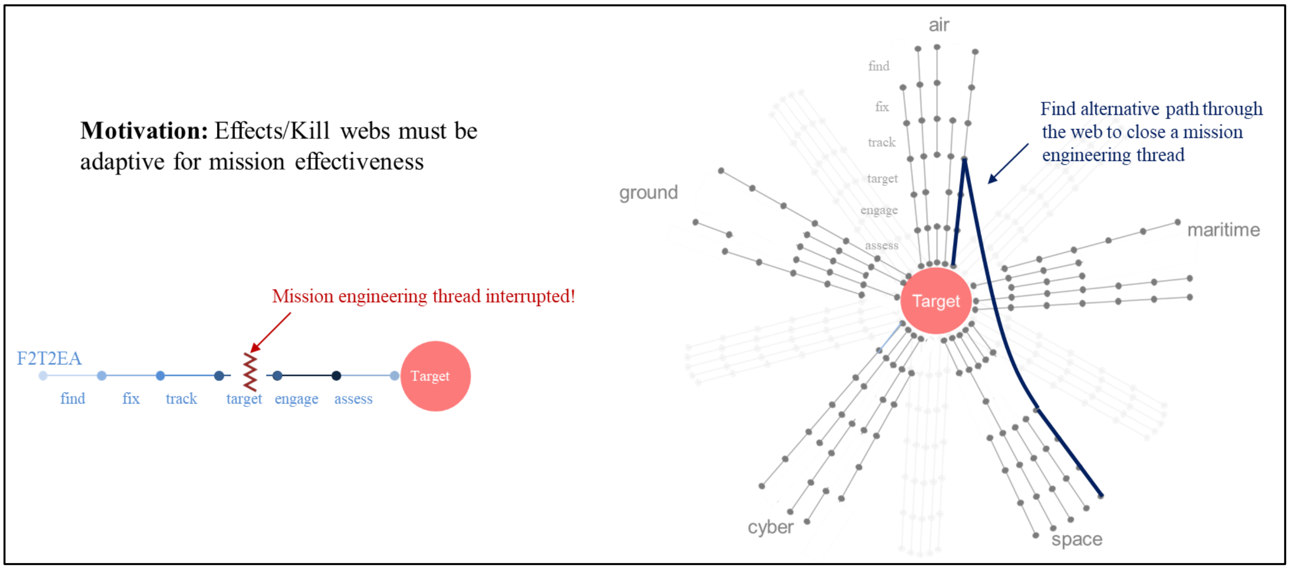
c. The assessment of these currently fielded/fielding systems forms the foundation for informing efforts to improve the seams between these existing and future systems.

1). Applying this framework to the ‘as-is’ force architecture for an identified threat, timeframe, and operational conditions provides insight on the actual operational gaps across the SoS.

2). Likewise, this framework can be used to evaluate the ‘to-be’ force architecture to gain an understanding of the interdependencies and increased effectiveness of potential solutions as well as the most effective Concept of Employment for these new technologies.

d. This effects/kill web common framework also allows for the apple-to-apple comparison of platforms and systems comparisons across the Military Services and warfighting domains since the assessment structure is the same with like ontologies and taxonomies representing the mission decomposition, see Figure 4.

Figure 4. Multi-Domain Mission Engineering Webs



SECTION 4: MISSION ENGINEERING PROCESSES OVERVIEW

Mission engineering and integration relies on a 10-step process starting with the prioritization of operational mission areas and ending with the continuous management of end-to-end mission engineering threads to maintain the execution health of warfighting capabilities. The implementation of this process comes with challenges associated with governance structure, data availability and collection, stakeholder coordination across the DoD, multiple system life cycles due to maturation (legacy to new), and workforce/tool development to name a few. However, the Effects/Kill Web Framework provides a mechanism to translate what the DoD plans to procure to the resulting capability.

a. The 10-step process for mission engineering includes the following:

(1) Identify the missions and tasks.

(2) Define mission success and desired effect.

(3) Identify mission success factors.

(4) Identify conditions for each mission success factor.

(5) Map mission success conditions to mission tasks.

(6) Identify critical conditions for each mission task.

(7) Map systems into mission tasks.

(8) Define appropriate scoring criteria for each mission task.

(9) Apply the scoring criteria.

(10) Manage the assigned mission areas.

b. Section 5 of this issuance uses a sample mission as an example to characterize the ten steps in the mission engineering and integration process. Users must tailor the process steps to the specific mission under evaluation, to the time available to conduct an analysis, and to the information available at each step along the way. With experience, teams will learn to combine certain steps, to iterate around a set of steps to refine the products, and to identify the key aspects of the mission that need further study.

c. Several factors inherent in the mission engineering and integration process influence how to apply the scoring criteria and how to interpret the results.

(1) The basis for mission engineering and integration analysis is the TACSIT. Users must tailor the definition of measures and scoring criteria to specific threats.

(2) Because overall platform scores reflect a roll up of subsystem performance as well as tactics, doctrine, etc., a score that reflects no capability does not necessarily indicate that the

platform is at fault. The fault might lie in the doctrine or tactics in use. The users must determine and document the specific causes of mission failure.

(3) Deficiencies in one mission task do not carry forward to succeeding mission essential tasks. The assessment of a specific mission essential task assumes all preceding mission essential tasks are fully effective, regardless of the actual assessment of those preceding mission essential tasks.

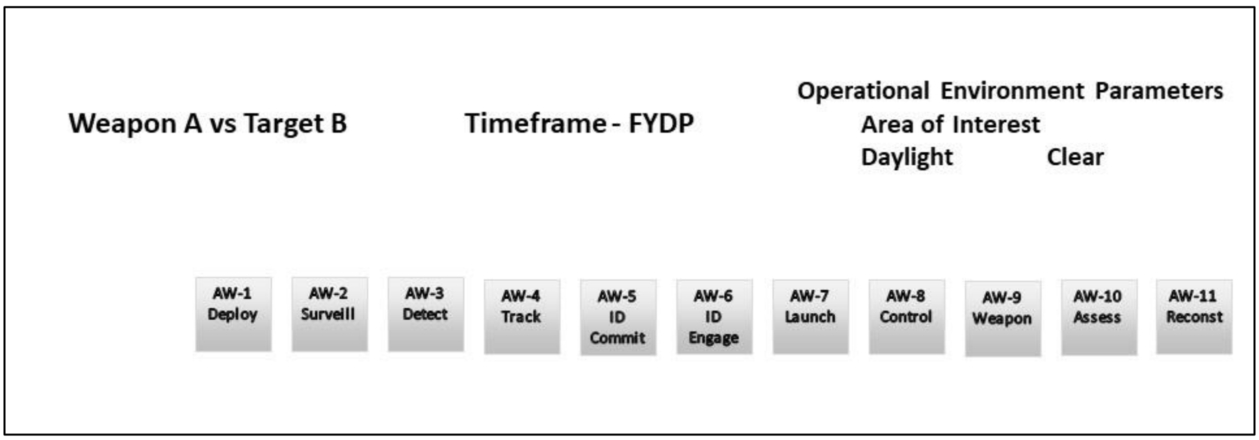
(4) The process focuses heavily on the examination of test data, with M&S used only as a fill for areas where there is no test data. In order to score a complete mission engineering thread, it is likely that data will piece together from separate events that occurred under different sets of conditions. Consequently, users must consider the availability, applicability, and consistency of test data during the scoring process, when interpreting the results, and when drawing any conclusions.

SECTION 5: CONDUCTING MISSION ENGINEERING ANALYSES

The overall goal of the mission engineering and integration process is to assess the current health of mission engineering threads using the common Effects/Kill Web Framework within a mission area. Users accomplish this goal by determining how well particular platforms and systems support the mission essential tasks that make up the mission engineering thread. This section outlines the steps that define the assessment process using a specific example of an air warfare mission.

a. Step 1: Identify the Missions and Tasks. The first step in the mission engineering and integration process involves identifying operational functions and mission essential tasks necessary to execute critical mission areas. With the emphasis on operational relevance, it is critical to determine both the prioritization of mission areas and how the DoD plans to fight these missions. Figure 5 provides an example of mission essential tasks for the air warfare mission.

Figure 5. Mission Essential Tasks for Air Warfare Mission Example



b. Step 2: Define Mission Success and Desired Effect. The second step in the mission engineering and integration process involves defining mission success and desired effects. Users must tie the measures and scoring criteria used to assess the health of a mission engineering thread to mission success. This mission success measure is referred to as the Measure of Success (MoS). Users should consider fratricide (or minimizing fratricide) when characterizing mission success. Table 1 defines mission success and effects for the example air warfare mission.

Table 1. Definition of Mission Success for Example

Mission Success Defined	Desired Effects
All hostile force threats defeated with no friendly force losses or collateral damage.	• Detect and identify hostile forces. • Neutralize detected threats. • Prevent damage to battle group assets.

c. Step 3: Identify Mission Success Factors. The third step of the process identifies factors that have a major impact on the ability to achieve mission success and are under control of friendly forces. Examples of factors that would not be under control of friendly forces include threat type, raid size and spacing, as well as weather and other environmental conditions. Table 2 lists and describes the mission success factors. Since the mission engineering thread assessment relies on achieving mission success, users must consider these factors during the assessment process.

Table 2. Mission Success Factors for Example

Mission Success Factor	Description
Battle Management	Battle Management is the ability to achieve and maintain situational awareness in the operational area to effectively combat threats to the force
Battle Space	Battle Space consists of the amount of decision time afforded to the shooter and how much time the shooter has to engage a track (i.e., the engagement window).
Communications Link Effectiveness	Communications link effectiveness is the ability to achieve required connectivity (range, performance against threats), timely (latency), bandwidth (capacity), and interoperability.
Track Management	Track Management is the ability to maintain unique tracks on threats with correct identification (ID) for a sufficient duration and of sufficient quality to support successful weapon engagement.
Engagement Decision	The Engagement Decision determines which tracks to engage and which weapon to use. It culminates with the issuing of an Engagement Order (EO) in accordance with the ID policy and Rules of Engagement (ROE).
Engagement Rate	Engagement Rate determines the total number of tracks that can be engaged and the number of missiles that can be scheduled over a given time period.
Engagement Effectiveness	Engagement Effectiveness refers to the ability to achieve a mission kill on the assigned target. It includes the contribution of engagement support as well as the missile's capability to guide to and kill the assigned threat.
Re-engagement Decision	The Re-engagement Decision determines the need to re-engage a track.
Readiness	Readiness refers to the availability for the duration of the operation of all the elements in and supporting an effects/kill chain.

d. Step 4: Identify Conditions for Each Mission Success Factor. In step 4, users will define the conditions for each mission success factor. The conditions should expand the definition of the mission success factors into more specific statements or questions that describe mission success. Table 3 identifies some representative conditions for some of the mission success factors; however, this step should be completed for all mission success factors in Table 2.

Table 3. Conditions for Mission Success Factors for Example

Mission Success Factor	Conditions
Battle Management (BM)	BM1) Does the platform provide data that enhances situational awareness in support of battle management execution? BM2) Does the platform sufficiently enhance situational awareness when underlying intelligence data is missing or incomplete? BM3) Can platform capability be reconstituted within required timeframes for re-deployment/re-engagement?
Battle Space (B)	B1) Does the platform detect targets of interest at a range to support or exceed the desired weapons employment or enhance decision time? B2) Does the platform detect targets of interest with sufficient accuracy to cue TRACK sensor? B3) Does the platform detect targets of interest when there is missing or incomplete intelligence data about targets of interest? B4) Does the platform meet/exceed firing doctrine requirements for the shooter?
Communications Link Effectiveness (CL)	CL1) Do required communication links have the ability achieve required connectivity in terms of necessary range against expected threats? CL2) Are required communication links timely (i.e. – data is received without too much latency)? CL3) Do required communication links have necessary bandwidth (capacity) to support the kill/effects chain purpose? CL4) Are required communication links interoperable to allow for the exchange of data needed to perform the kill/effects chain mission? CL5) Are platforms interoperable above the basic communication link level (e.g. – Layer 1, 2, 3 of the 7 Layer Protocol stack)?

e. Step 5: Map Mission Essential Tasks to Mission Success Conditions. This step relates the conditions for mission success to each mission essential task. This relationship should be the result of some logical action, for example: "To what extent does Condition A support the accomplishment of Mission Task B?" This mission essential task measure is referred to as the

Measure of Effectiveness (MoE). Table 4 is an example of relating mission success conditions to mission essential tasks and should be completed for all mission success factors.

Table 4. Mission Success Conditions Correlated to Mission Essential Tasks for Example

Mission Success Factors	Conditions	Mission Essential Tasks										
		Deploy	**Surveil**	**Detect**	**Track**	**Identify: Commit**	**Identify: Engage**	**Launch**	**Control**	**Weapon**	**Assess**	**Reconstitute**
Battle Management (BM)	BM1) Does the platform provide data that enhances situational awareness in support of battle management execution?											
	BM2) Does the platform sufficiently enhance situational awareness when underlying intelligence data is missing or incomplete?		H									
	BM3) Can platform capability be reconstituted within required timeframes for re-deployment/re-engagement?											H
Battle Space (B)	B1) Does the platform detect targets of interest at a range to support or exceed the desired weapons employment or enhance decision time?			H			M					
	B2) Does the platform detect targets of interest with sufficient accuracy to cue TRACK sensor?											
	B3) Does the platform detect targets of interest when there is missing or incomplete intelligence data about targets of interest?											
	B4) Does the platform meet/exceed firing doctrine requirements for shooter?							M				
Communication Links Effectiveness (CL)	CL1) Do required communication links have the ability achieve required connectivity in terms of necessary range against expected threats?											
	CL2) Are required communication links timely (i.e. – data is received without too much latency)?											
	CL3) Do required communication links have necessary bandwidth (capacity) to support the kill/effects chain purpose?											
	CL4) Are required communication links interoperable to allow for the exchange of data needed to perform the kill/effects chain mission?											

Mission Success Factors	Conditions	Mission Essential Tasks										
		Deploy	Surveil	Detect	Track	Identify: Commit	Identify: Engage	Launch	Control	Weapon	Assess	Reconstitute
	CL5) Are platforms interoperable above the basic communication link level (e.g. – Layer 1, 2, 3 of the 7 Layer Protocol stack)?											
H - High M - Medium L - Low [blank] - None												

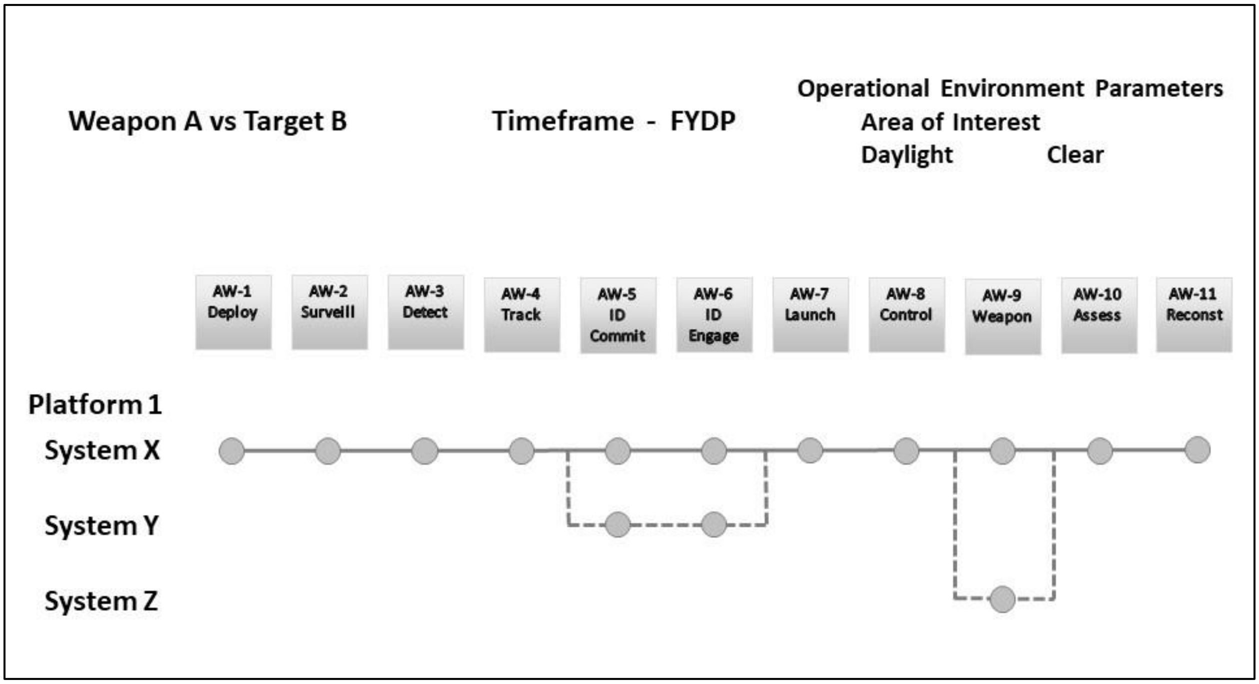
f. Step 6: Identify Critical Conditions for Each Mission Task. Using the results from steps 3 to 5, users identify the critical conditions that define mission success for each mission essential task. Table 5 shows example critical conditions for some mission essential tasks which must be completed for all mission essential tasks.

Table 5. Critical Conditions for Example

Mission Task	Critical Conditions
Deploy	RR1) Is the platform available/or can it be deployed or made ready within required timelines?
Surveillance	BM2) Does the platform sufficiently enhance situational awareness when underlying intelligence data is missing or incomplete?
Detect	B1) Does the platform detect targets of interest at a range to support a desired weapons employment or enhance decision time? B2) Does the platform detect targets of interest with sufficient accuracy to cue Track sensor? B3) Does the platform detect targets of interest when there is missing or incomplete intelligence data about targets of interest?
Track	TM1) Can the platform provide a weapon quality track? TM2) Is the required range to each target in a group provided? TM3) Does the platform track targets sufficiently when is has less than complete mission data?

g. Step 7: Map Systems into Mission Tasks. Determine Military Service platforms and systems that perform the functionality required of the mission essential tasks and assign to form the mission engineering thread. This system performance measure is referred to as the Measure of Performance (MoP) usually captured as a Key Performance Parameter (KPP), Key System Attribute (KSA), and/or Measure of Suitability (MoSu). Identify alternate paths through the mission engineering thread to accomplish mission essential tasks using multiple platforms and systems for added resiliency. Figure 6 is an example of a system to mission essential task mapping.

Figure 6. Systems Mapped to Mission Essential Tasks for Example



h. Step 8: Define Appropriate Scoring Criteria for Each Mission Task.

(1) Users define scoring criteria to assess how well a platform or system supports one of the mission essential tasks that comprise the mission engineering thread. In this example, three criteria define the scoring for each task: Full Capability to support (GREEN), Limited Capability (YELLOW), and No Capability (RED). The scoring criteria must relate to the task's critical conditions identified in Step 6 and must be appropriate to the platforms, systems, sensors, and weapons being assessed.

(2) Assessment scoring criteria is necessary to evaluate the ability of the individual platforms and systems engaged in the mission engineering thread to meet mission success criteria and therefore achieve the desired effect of the mission. Each mission essential task example shown below includes a general description of the task, and examples of critical conditions with corresponding scoring criteria: (this should be completed for all mission essential tasks)

(a) Deploy Scoring (DEP).

1. DEP covers availability of the platform to deploy.

2. DEP 1. Platform is available/or can be deployed or made ready within required timelines.
(scoring criteria – green: yes; red: no)

(b) Surveillance Scoring (SUR). SUR provides non-weapon quality tracks and data to support early warning, situational awareness, ID, and cues to weapon quality sensors. Scoring reflects enhancing the strike group's situational awareness. Examples of critical measures are:

1. SUR-1. Platform covers surveillance area as required by tactics, techniques, and procedures (TTP) (scoring criteria - green: full coverage; yellow: degraded coverage; red: no coverage).

2. SUR-2. Data availability, integration and correlation capability (scoring criteria - green: sufficient; yellow: degraded; red: unable to support mission in TACSIT environment).

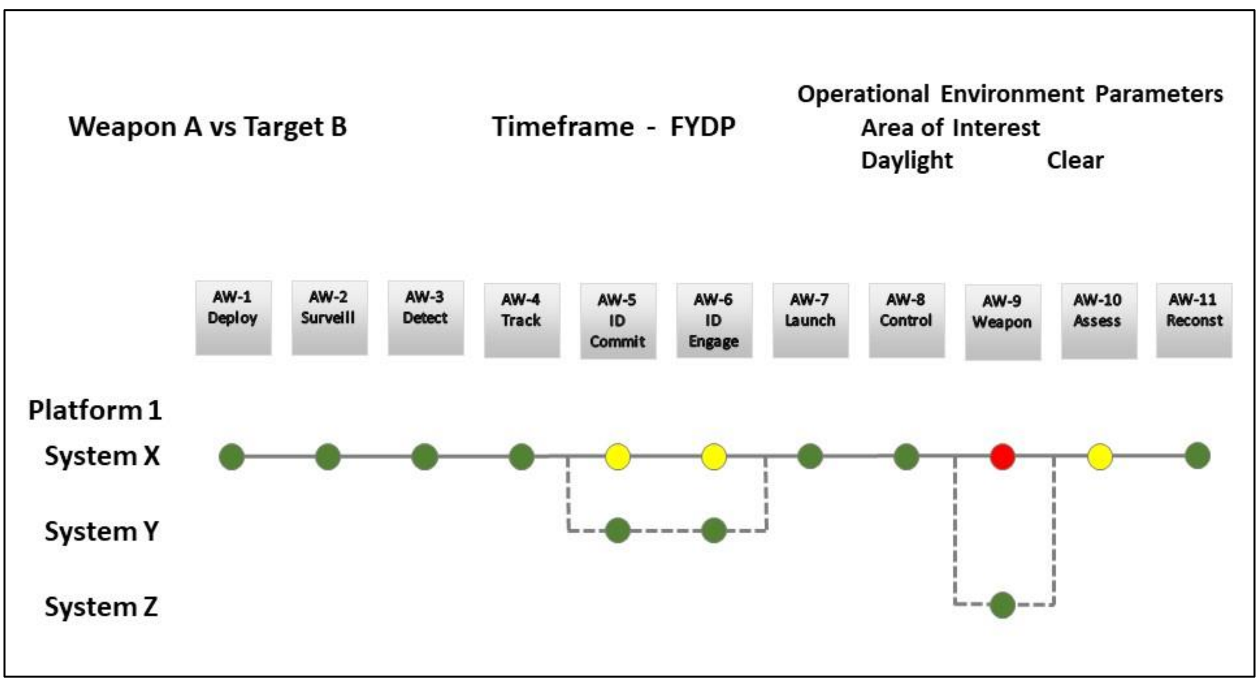
i. Step 9: Apply the Scoring Criteria. The capability of a platform or system to support a given mission essential task will be assessed against the task's critical measures using the scoring criteria presented in earlier sections. Test data is preferred as the basis of the assessment.

(1) Score each test event GREEN, YELLOW, or RED based on the appropriate scoring criteria. It is expected that the test data will not all fall into one of the three categories, but will be spread across the three.

(2) Unless the scoring criteria explicitly calls out the proportion of tests that are required to satisfy GREEN or YELLOW criteria, the Principal Investigators and other Subject Matter Experts will analyze the test results in greater detail to determine the overall score.

(3) The final output will present the findings and document the rationale behind each. Figure 7 is a sample of scoring applied to the platform and system mapping.

Figure 7. Scoring Criteria Applied for Example



j. Step 10: Manage the Assigned Mission Areas. Manage the end-to-end mission engineering thread, for specific mission areas, through the implementation of the Effects/Kill Web Framework. The goal is to emphasize the effectiveness of the mission engineering thread by managing the seams of the programs forming the capability, a SoS context, by driving mission criteria/requirements. Some form of mission review boards might evaluate the performance of mission areas within a portfolio structure. This continuing effort supports Mission Capability Portfolio Management and Section 855 of Public Law 114-328.

a. In the digital age, DoD should operate using dynamic capability portfolios which requires the development of a common portfolio structure across the requirements, budget, and acquisition enterprises.

b. These capability portfolios can be mapped and managed across 10 notional major capability areas: aircraft systems; shipbuilding and maritime systems; ground-based systems; space-based systems; C4ISR—command, control, communications, intelligence, surveillance, and reconnaissance, cybersecurity; missiles and munitions; missile defense programs; nuclear, chemical, and biological defense programs; business systems; and defense health systems.

c. The managed capabilities within these portfolios should align with the Joint Capability Areas or the new Joint Warfighting Concepts. The requirements across the portfolios should be continuously aligned with evolving strategic direction, threats, technologies, and operations.

SECTION 6: MISSION ENGINEERING PROCESS CHALLENGES

6.1. INTEGRATING MISSION AREAS. Executing a mission can be viewed as a collection of systems, or a SoS, working together to accomplish a desired effect. When addressing integration of a mission area within a SoS environment, there exists a large and complex set of challenges to successfully integrate independently useful systems into a larger system that delivers unique capabilities, a SoS within the DoD. Drawing from the lessons of SoS Engineering practitioners and from experience with mission engineering and integration analyses, mission integration management attempts to address challenges in numerous areas such as management and oversight, operational environment definition, implementation, and design/engineering considerations.

6.2. DEFINING STAKEHOLDERS. In a mission or SoS environment, defining who the stakeholders are can be difficult since there are stakeholders at both the system and mission levels with competing interests and priorities and no directed interest in mission engineering and integration. Many times, stakeholders, program mangers specifically, want to know where the requirements are to "participate." There are added levels of complexity not usually seen in a system upgrade since management and funding allocations occur at individual systems; thus, there is no authority over all the systems. Additionally, the participants need to meet a set of operational objectives using systems whose objectives may or may not align with the "Joint" mission objectives. This lack of authority and alignment with program managers and funding makes prioritization of capability upgrades and supporting resourcing and funding truly a challenge.

6.3. ACQUISITION AND TESTING AND ASSESSMENT. Acquisition and testing and assessment of a SoS comes with its own set of challenges. There are multiple system lifecycles across the acquisition programs: legacy systems, systems under development, emerging solutions, and technology insertion. During the mission engineering and integration process, there may be different participants in any or all phases of the lifecycle, even among individual systems. Not only does this introduce challenges to the requirements and the balance of the needs of the system versus the mission capability, but it also poses challenges to synchronization of the testing, assessment, and fielding of the systems.

6.4. REORIENTING OSD. Reorienting the Office of the Secretary of Defense (OSD) around the sustainment of mission engineering threads will require some adjustments to existing job functions, and creative thinking by analysts who have traditionally focused on programs and services individually. Sustainment of mission engineering threads can support joint portfolio and capability area analyses supporting operational plans and mission areas because OSD:

(1) Holds a unique position to assess risk in both current and planned sustainment networks supporting joint mission engineering threads, and to serve as an independent arbiter among individual Military Service priorities that could undermine the readiness posture of the entire mission engineering threads' effectiveness.

(2) Has functional capabilities in sustainment, cost estimating, resourcing, systems engineering (especially reliability, availability, and maintainability analysis), personnel, and readiness. While these functions may warrant investment to enhance analytical capabilities, the current expertise is adequate to the task of brokering the cross-Military Service information exchange necessary to perform an assessment of bottom-up mission engineering threads' readiness risk posture at a level of accuracy to support resourcing decisions.

(3) Has a well-established relationship with the Joint Staff, particularly between the sustainment functions in the current Assistant Secretary of Defense for Sustainment and the Director of Logistics, J4. These relationships enable the effective formulation of policy, requirements, operational guidance, and joint service problem solving.

SECTION 7: MISSION ENGINEERING APPLICATIONS

7.1. GENERAL. To support the operating forces, the DoD also has the mission of delivering and sustaining timely, cost-effective capabilities and establishing policies on, and supervising, all elements of the DoD relating to acquisition (including research, system design, development, and production, and procurement of goods and services) and sustainment (including logistics, maintenance, and materiel readiness). This includes the establishment of policies for access to, and maintenance of, the defense industrial base and materials critical to national security, and policies on contract administration. The mission engineering threads and mission engineering and integration process can serve as a translation mechanism to inform decisions on providing capability to the warfighter through effective mission engineering threads based on operational needs. The sections below describe applications of the mission engineering and integration process using the Effects/Kill Web Framework to influence other critical decision areas within the DoD.

7.2. RESEARCH. The Effects/Kill Web Framework provides a mechanism to advance technology and innovation for the armed forces and the DoD, establishing policies on, and supervising defense research, technology development, technology transition, prototyping, experimentation, and developmental testing activities and programs, including the allocation of resources for defense research, and unifying defense research efforts across the DoD. The resulting mission engineering threads provide a framework to identify gaps in mission threads, to address with either S&T insertion or the creation of new basic research areas. Since the mission engineering threads identify gaps in specific areas of a mission thread, this could serve as critical information on the development of S&T transition plans.

7.3. ENGINEERING. The Effects/Kill Web Framework provides a mechanism to advance and establish policies on, and supervising, all defense engineering, rapid prototyping, experimentation, and developmental testing activities and programs, including the allocation of resources for defense engineering, and unifying defense engineering efforts across the DoD.

7.4. ACQUISITION. Address determination and evaluation of cost and schedule impacts associated with fixing any gaps discovered in these mission engineering threads. Identify potential alternatives to mitigating gaps, with associated resource requirements, will need to be a key part of this process.

7.5. SUSTAINMENT. Even the most capable mission engineering thread can be constrained or rendered ineffective by inadequate sustainment. Individual weapon systems must be mission capable in sufficient quantities and in the right locations to satisfy the entire mission need. Warfighters must be present and competent to perform their respective portion of the mission profile. Spare parts, fuel, food, and many other sustainment items and supporting trained work force, both government and contracted, must be arrayed in a manner consistent with the mission need, for a duration that might vary from days to years.

a. Where mission engineering threads depend on capabilities from different services, so to the sustainment network depends, as recent experience demonstrates, on close alignment and collaboration among Military Services, Defense Logistics Agency, United States Transportation Command, the Combatant Commands, the interagency, and partner nations. The sum contributions of this network of sustainment providers achieves readiness states at individual nodes in the mission engineering thread that in turn deliver a readiness level for the entire mission. For the sustainment network to be effective at the moment and location of need, organizations must accomplish a number of key activities well in advance. Among these activities:

(1) Sustainment planning.

(2) Resourcing, provisioning

(3) Prepositioning/staging

(4) Contracting

(5) Recruitment and training of operators and maintainers

(6) Establishing sustaining engineering and logistics reach-back capabilities.

b. The outcome of these activities is to ensure that necessary transportation, supply and repair chain, base support, and force protection capabilities are available to support contingency operations and enduring missions. Additionally, there is a need to measure, assess, and improve the Department's readiness to execute across this network of activities.

c. The Military Services, Combatant Commanders, regional partners, and Defense Agencies play key roles in the sustainment network that supports mission engineering threads and these organizations have demonstrated effective global reach and sustainment. Looking forward, a number of factors will stress these organizations to continue to maintain the effectiveness of the sustainment networks supporting individual mission engineering threads, especially those with extensive joint character. Among these factors are increasing dependence on joint networks both government and commercial, allied and partner access and agreements, and increasing sustainment costs which in turn constrain investment in new capability, and continuing resource uncertainty coupled with local programming optimization around individual Military Service priorities.

7.6. ANALYSIS.

a. The future vision of this mission-level analysis capability is to interject warfare system technical details into the major acquisition processes to drive the planning, programming, budgeting, and execution process for future integrated warfighting capabilities.

(1) This analysis can identify additional system requirements to the acquisition community or the need to change the information plans or available platforms and systems for the operational community to complete the mission.

(2) Further analysis can begin to identify integration and interoperability issues such as how specific platforms and systems will be used, how specific missions enable analysis to determine where functionality is duplicated in the force; or where the same data is transferred via more than one communication path, which can lead to interoperability issues.

b. In another critical analysis domain, cost analysis can accurately predict costs across a spectrum of mission solutions. An accurate prediction of costs enables decision makers to utilize efficiently their resources to attain the maximum performance for the minimal cost, identify potential trade-offs, and identify areas for cost reduction and/or avoidance.

(1) Cost estimates are required for each proposed solution in fixing a mission engineering thread. Having estimates of the required funding for each solution allows decision makers to make informed decisions.

(2) Generally, cost estimates, similar to most other systems engineering tasks, are program focused. Cost estimating within the context of mission engineering and integration requires a paradigm shift from program-focused estimates to mission-focused estimates to predict costs accurately across a spectrum of mission solutions. When implemented, this type of analysis is similar to a large-scale analysis of alternatives and requires the cost analyst to have breadth vs. depth of analysis.

7.7. M&S.

a. Many of the current M&S tools used within the Department analyze the interactions of multiple systems through an additive process of synthesizing individual system M&S results together to gain insights on SoS performance. This introduces error and redundancy by having each M&S entity create its own models, which they seldom share or review across organizations. A government-owned, modular, and scalable software framework capable of allowing the models to interact in a common environment – federation framework – can solve this dilemma.

b. Traditional modeling uses a set of equations to dictate how the system operates and interacts, both independently and with other systems. This equation-based approach is used with many of the current SoS M&S tools. SoS M&S tools often rely on the systems being described by varying degrees of complexity. Further, enormous energy is spent modeling system behaviors down to the minutest detail and attempting to fully exploit all possible outcomes of SoS behavior. While the high-fidelity M&S approach is quite feasible, it requires an abundance of time and funding. Mission engineering and integration does not eliminate the need for M&S at the lower levels since independent, detailed characterization of system performance is still required, especially when an issue reveals at the mission level. However, using behavioral models allows program managers to be aware of a larger set of solutions across the DOTMLPF-P spectrum, vice the current paradigm of primarily looking at system materiel solutions. This approach will be extremely useful to explore "what-if" scenarios for mission engineering and integration, which focuses on how changes to tactics and doctrine may close gaps in mission engineering threads.

c. Since the integration of new and legacy systems is required, the community must develop a live/virtual environment to incorporate M&S, hardware-in-the-loop and virtual testbeds to include virtual worlds. Agent-based M&S techniques and frameworks has become a critical research and development area for investigating the behaviors between systems, which provides insights on emergent behaviors not characterized in requirements. Likewise, virtual worlds and virtual testbeds exist to provide a representative environment for both training and the development of mission-level requirements. Integration of the laboratories should be facilitated through local and global secure network connectivity, M&S environments to generate and exercise the synchronized warfighting scenarios across the disparate locations, and representative architectural laydowns of the effects/kill web within (and between where necessary) platforms and systems that house the warfighting capability.

d. The community must conduct future data collection in accordance with capability-based modeling practices that describe dependencies and enable predictable mission performance across the mission engineering threads. Use of M&S should continue as needed to support requirements definition, analyze the Force Package configuration and design, and mitigate identified risks through engineering analyses. M&S supports the assessment of functional and performance characteristics, integration and interoperability, network throughput and bandwidth, supportability, and human system integration issues such as maintainability, usability, operability, and safety. Moreover, M&S provides the ability to predict SoS performance as specified before system design and testing.

7.8. INTELLIGENCE.

a. Mission success for advanced sensor enabled mission engineering webs relies upon advance characterization of the battlespace. This dependency upon battlespace characterization delivered through intelligence community systems lacks adequate characterization and quantification at present.

b. The Intelligence Community cannot support 100 percent of the requirements necessary to support all mission success factors. Testing of joint mission engineering threads will require assessment of the risk and associated impact on mission effectiveness derived by current and projected limitations in the availability of intelligence support.

c. As the DoD evaluates alternative solutions that would reduce and/or mitigate dependence on advance battlespace characterization, data flows among and across intelligence and operational communities and operational entities will be required to ensure interoperability, effective command and control, and mission effectiveness. With the increasing pace of change in threat systems, effective policy, governance, expertise focused on integration of threat, and intelligence supportability, considerations within mission engineering and integration assessments is more essential than ever. A mechanism needs development and implementation across the enterprise to provide this focus within the capability development and weapon system lifecycle.

7.9. EXPERIMENTATION, TEST, AND EVALUATION.

a. Experimentation has an advantage over tests in flexibility - design space - to explore new ideas. Acquisition tests are restricted to testing something concrete - in hand, a component or prototype - even if it is only software algorithms. Experimentation, in contrast, has few reality constraints. Experimentation on future weapons that exist only as concepts might occur entirely in simulation as constructive experiments or as analytic war games. The focus of this experimentation is not on “does it work,” but on the potential impact of these ideas on future warfighting operations.

b. Tests are one way to assess the quality of something. Other means include reliance on logical and mathematical relationships, authority, historical precedent, and natural observations. Evaluation derived from testing imply empirical measurements under specified conditions.

c. There are many approaches or ways to coordinate a mission-based test environment and the mission integration manager identifies the level of coordination required based upon the complexity and type of testing required. This step could be as extensive as establishing a persistent, distributed Live, Virtual, Constructive test capability to simply assisting programs in scheduling participation in Joint Test Environment events. The key objective is that the mission integration manager is responsible in facilitating the incorporation of mission-based testing artifacts into program and Military Service testing to the maximum extent possible.

SECTION 8: MISSION ENGINEERING TOOLS AND MODELS

The mission engineering and integration process requires a set of tools and models to effectively assess the missions and tasks. No specific tools and models identified to date. Current users employ spreadsheets and locally developed charts and tables to conduct and present the mission engineering and integration analyses. Updates to this instruction will identify useful tools and models when they become available. The list below identifies other tools and models that can support the mission engineering and integration process, but which are not yet available within DoD to support mission engineering and integration. In addition, tools that support the traceability of mission engineering and integration results from missions and mission success factors to critical conditions and to systems, platforms, sensors, weapons, and networks assigned to mission essential tasks are currently under development.

Mission engineering and integration tool and modelling needs:

- Integration of next generation threat system with the Office of Naval Research Strike Group Defender.
- Virtual world visualization software to improve leadership interface and ability to see mission play out.
- Architecture Management Integration Environment to open interfaces and integration plug-ins with host of simulation models and analysis tools to include Magic Draw Suite, Rational Rhapsody, and Dynamic Object-Oriented Requirements System. Architecture product development should be driven by a common framework like the DoD Architecture Framework or Unified Architecture Framework.
- Networked suites of tools integrated into the Defense Research and Engineering Network or Secret Defense Research and Engineering Network. Tie into laboratories with tactical code in the loop such as the Joint Simulation Environment, the Naval Surface Warfare Center Dahlgren Division Ship Labs, or Army labs. Long term, provide a standard process interface that ensures representation of systems that come together to create mission capability have accurate representations of test performance in projected operational mission environments.
- Integrate with early Model Based Systems Engineering tools and system engineering representations in System Modeling Language, Rational Software Architect, or others as appropriate.
- Integrate improved data analytics and tools. Add in complex machine assist" algorithms or other game changers and assess mission improvement. Robust cyber effects, both offensive and defensive, are gaps that also would need future investment.

GLOSSARY

G.1. ACRONYMS.

ASMT	assessment scoring
B	battle space
BM	battle management
CEC	Cooperative Engagement Capability
CJCS	Chairman of the Joint Chiefs of Staff
CL	communications link effectiveness
CTL	control scoring
DEP	deploy scoring
DET	detect scoring
DOT&E	Director of Operational Test and Evaluation
DOTMLPF-P	doctrine, organization, training, materiel, leadership and education, personnel, facilities and policy
ED	engagement decision
EE	engagement effectiveness
EO	engagement order
ER	engagement rate
G	g-force
ID	identification
IDCOM	identification commit scoring
IDENG	identification commit scoring
LNCH	launch scoring
M	Mach
M&S	modeling and simulation
R	re-engagement decision
RCNST	reconstitute scoring
ROE	Rules of Engagement
RR	readiness
SoS	System-of-Systems
SUR	surveillance scoring
TACSIT	tactical situation
TM	track management

TRK	track scoring
TTP	tactics, training and procedures
WPNKIN	weapon kinematics

G.2. DEFINITIONS. Unless otherwise noted, these terms and their definitions are for the purpose of this issuance.

critical conditions. Quantitative and qualitative measures used to support scoring how well each platform supports a mission essential task in a specific effects/kill web.

effects/kill web framework. The framework defined by the mission essential tasks (mission thread) with the mapping of platforms, systems, weapons, and networks to execute specific missions.

mission. The tasks, together with the purpose (desired effect), that clearly indicates the actions to be taken and the reason therefore.

mission engineering and integration. Planning, analyzing, organizing, and integrating current and emerging operational concepts to evolve the end-to-end operational architecture and capability attributes, across the DOTMPLF-P spectrum, including anticipated friendly force and opposing force behaviors, that are needed to inform the communities of interest involved in fulfilling mission needs statements.

mission integration manager. An individual responsible and accountable for a capability portfolio of assigned mission areas.

mission engineering thread. A set or arrangement of systems mapped to the mission essential tasks that results when independent and useful systems integration into a larger system-of-systems to deliver unique capabilities.

mission essential tasks. The functions/tasks that comprise a particular mission area. For example: surveillance, detection, track, identification, launch, control, weapon, and assess.

mission thread. A series of integrated end-to-end mission essential tasks linked by interoperable interfaces required to successfully achieve a desired outcome within a given tactical situation.

scoring criteria. Scoring criteria measure how well a platform or system supports one of the mission essential tasks. Three criteria measure each task: full capability to support (green), limited capability (yellow), and no capability (red). The scoring criteria must reference the tasks' critical measures.

system-of-systems. A set or arrangement of systems that results when independent and useful systems integrate into a larger system that delivers unique capabilities.

tactical situation. The specific tactical scenario that provides the context needed to assess baseline capability.

weapon quality track. A track that has sufficient quality to support hand-over or targeting requirements of the mission engineering thread weapon for the 'Engage' mission essential task.

REFERENCES

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