Statistical Methods for Test and Evaluation, Volume 1: Combat Test Framework

Jeffrey Strickland, Ph.D.

United States Space Force, Colorado Springs, CO, USA

,

Statistical Methods for Test and Evaluation, Volume 1: The Combat Test Framework

ISBN: 978-1-304-26228-8

Table of Contents

Preface

Alas, we may not be number one on space. When the rankings come out next week we could be number two or three. That would not be all that bad if we were talking football, but the stakes are much higher. We have entered the Great Power Competition (GPC) and our lead is narrow.

In October 2023, Secretary Kendall released his guidance for the DAF's effort to reoptimize for Great Power Competition (GPC). The reason is simple: we must be ready for war. In the nation's first State of the Union Address, President Washington said, "*To be prepared for war is one of the most effectual means of preserving peace*." But that which has made us ready for the counter-VEO wars of the last two decades will not ready us for the challenges of the Great Power Competition.

The greatest risk the Space Force faces today is that of being too late. With a fast-moving adversary, standing still is the same as falling behind. Like the Merchant Marine, which uses a fleet of vessels to provide services through a peaceful environment, today's Space Force is built to reliably provide services without interference in space. Against a near-peer adversary, a contested space domain makes these capabilities vulnerable and prone to denial. Emerging from Merchant Marine foundations, the U.S. Navy is charged with domain control, and it prioritizes effectiveness through survivability, adaptability, and combat credibility. We are forging a purpose-built Space Force to contest and control the space domain as a warfighting Service. The Space Force is laser-focused on maintaining readiness to deter and, if needed, defeat any rival.

From a technological perspective, great powers have the resources to field advanced military technologies that increase the tempo, range, precision, and destructive capacity of military operations. Once achieved, however, relative technological advantages are fleeting, since a great power has the resources to rapidly mimic or counter a rival's advantage. This makes rapidly transitioning advanced technology to military applications a persistent element in great power competition. Additionally, under great power competition, the continental United States is not a sanctuary. Preparing for great power competition means, in part, fortifying our employed-in-place infrastructure in the continental United States against surveillance, interference, and attack.

Therefore, we are changing. The charge of Coach Herman Boone, portrayed by Denzel Washington in Remember the Titans, states what is necessary:

> *“Everything we gonna do is changing.*
>
> *We are change. We're gonna change the way we run.*
>
> *We're gonna change the way we eat.*
>
> *We're gonna change the way we block.*
>
> *We're gonna change the way we tackle.*
>
> *We're gonna change the way we win.”*

To get winning technology to the warfighter today is the change we are charged with. In 2021, the Department of Defense announced a change to our system of acquisition. New pathways have been established to streamline the process of build-test-deliver capability to the warfighter. While developing systems that work is not enough. We must develop system that work as intended by the operators who will use them to wage war.

To verify and validate the technology we deliver to the warfighter is the task of test and evaluation. We are the gatekeepers that must broker the development and delivery of technology needed by the warfighter today. This is a paradigm shift, and we must not miss the mark at the center of the target. Everything we think about and do is for one purpose: Prepare for and fight our nation’s wars.

The part played by the acquisition system in general and tester specifically has fundamentally changed: deliver required capability to the warfighter error-free and faster than we have before. Hence, the Combat Test Framework.

This is Part 1 of a five-volume set written specifically for our Space Force operational testers. The set, *Statistical Methods for Test and Evaluation*, includes:

Volume 1: The Combat Test Framework

Volume 2: Machine Learning Primer using R

Volume 3: Combinatorial Design using R

Volume 4: Experimental Design using R

Volume 5: Test Methods for System Analysis using Excel

Other Books by the Author

1. Practitioner's Guide to Military Modeling and Simulation, 2024 by Jeffrey Strickland. CC BY-SA. Lulu, Inc. ISBN 978-1-304-42780-9
2. *Building Scenarios in Freeciv: The Templars,* 2024 by Jeffrey Strickland, cc-BY-SA. Lulu, Inc. ISBN: 9-781304633087
3. *Discrete Event Simulation Using ExtendSim 10,* Copyright 2023 by Jeffrey S. Strickland. Lulu, Inc., ISBN: 978-1-716-20282-7
4. *Regression totum modum.* Copyright © 2023 by Jeffrey S. Strickland. Lulu, Inc., ISBN: 978-1-329-33732-9
5. *Orbital Mechanics using Python and R,* Copyright © 2022 by Jeffrey S. Strickland. Lulu, Inc., ISBN: 978-1-387-50683-5
6. *Systems Engineering Processes and Practice*, Second Edition, Copyright © 2022, Lulu, Inc., ISBN 978-1-387-81105-2
7. *The Space Handbook*, Copyright © 2022, Lulu, Inc., ISBN 978-1-387-97656-3
8. *Test Designs for Space Operational Test & Evaluation using Excel*, Copyright © 2022, Lulu, Inc., ISBN 978-1-387-90547-8
9. *The Python Guide for New Data Scientists,* Copyright © 2022, Lulu, Inc. ISBN 978-1-4583-2161-9
10. *The R Guide for New Data Scientists ,* Copyright © 2022, Lulu, Inc. ISBN 978-1-6780-0244-2
11. *Time Series Analysis and Forecasting using Python & R*. Copyright© 2020, Lulu, Inc. ISBN 978-1-716-45113-3
12. *Data Science Applications using Python and R*. Copyright© 2020, Lulu, Inc. ISBN 978-1-716-89644-6
13. *Data Science Applications using R*. Copyright© 2020, Lulu, Inc. ISBN 978-0-359-81042-0
14. *Predictive Crime Analysis using R*. Copyright© 2018, Jeffrey Strickland. Lulu, Inc. ISBN 978-0-359-43159-5
15. *Logistic Regression Inside-Out.* Copyright © 2017 by Jeffrey S. Strickland. Lulu, Inc. ISBN 978-1-365-81915-5
16. *Time Series Analysis using Open-Source Tools*. Copyright© 2016, Jeffrey Strickland. Glasstree, Inc. ISBN 978-1-5342-0100-2
17. *Data Analytics Using Open-Source Tools*. Copyright © 2015 by Jeffrey Strickland. Lulu Inc. ISBN 978-1-365-21384-7

18. *Missile Flight Simulation - Surface-to-Air Missiles*, 2nd Edition. Copyright © 2015 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-329-64495-3
19. *Predictive Analytics using R*. Copyright © 2015 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-312-84101-7
20. *Operations Research using Open-Source Tools*. Copyright © 2015 by Jeffrey Strickland. Lulu Inc. ISBN 978-1-329-00404-7.
21. *I Rode With Wallace*. Copyright © 2015 by Jeffrey S. Strickland. Lulu, Inc., ISBN: 978-1329565661
22. *Predictive Modeling and Analytics*. © 2014 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-312-37544-4.
23. *Verification and Validation for Modeling and Simulation*. Copyright © 2014 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-312-74061-7.
24. *Using Math to Defeat the Enemy: Combat Modeling for Simulation*. © 2011 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-257-83225-5.
25. *Mathematical Modeling of Warfare and Combat Phenomenon*. Copyright © 2011 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-45839255-8.
26. *Simulation Conceptual Modeling*. Copyright © 2011 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-105-18162-7.
27. *Systems Engineering Processes and Practice*, Copyright © 2011 by Jeffrey S. Strickland. Lulu.com. ISBN 978-1-257-09273-4.
28. *Discrete Event Simulation using ExtendSim 8*. Copyright © 2010 by Jeffrey S. Strickland. Lulu.com. ISBN 978-0-557-72821-3
29. *Fundamentals of Combat Modeling*, Copyright © 2011 by Jeffrey S. Strickland. Lulu.com, ISBN 978-1-257-00583-3.

Agent-Based Simulation to Study Multidimensional ISR Collection for the FCS Brigade Combat Team (F-BCT), with Steve Pierce, 2007

1 The Combat Testing Framework

I recently read a document from the Department of Defense about testing combat capability, yet other than the title, the document did not use the word or idea of combat capability testing.

On the other hand, the Air Force Operational Test and Evaluation Center (AFOTEC) stated:

> "Operational tests are designed to address critical issues regarding a system's performance in **combat-like environments** when operated by field personnel." (Air Force Operational Test and Evaluation Center)

An article from the DOT&E stated:

> "A comprehensive evaluation of operational effectiveness, operational suitability, and survivability provides the Acquisition Executive and operational users with information regarding a system's combat capability. This evaluation can only be done after operational testing (OT) under **combat realistic conditions**, which includes end-to-end testing with operational users across the intended operational envelope and within the context of the system-of-systems in which it will operate." (DOT&E)

So, there appears to be some variation with the idea of testing combat systems in combat realistic environments.

There are a number of reasons why we might miss the importance of testing in a combat relevant environment under combat or contested conditions. Here are a few:

- We have fewer people in the services and the defense industry who have experienced combat.
- Some people only equate combat systems to weapon systems.
- Testing constraints may limit the ability to generate combat conditions.
- Simulated combat is not viewed as combat-like to many testers.

Enter Star Delta 12’s Combat Testing Framework (CTF), championed by Col E. Lincoln Bonner. Although the exact formula was the idea of others in his command, no one dared to push it on the acquisition community until he did just that. His successor, COL Tomlinson is pushing forward as she continues CTF’s implementation in operational testing for the United States Space Force. These two leads for operational testing are having a positive impact on the expectations of the warfighter and other stakeholders.

This is more than simply dubbing an existing process as “combat” it is both a change in mentality and a paradigm shift. It is significant due to the cognitive challenges of being a part of the military forces in a time of relative peace. Yet, like the Great Power Competition (GPC), there are crucial reasons to make the mental and physical adjustments.

On the international front, several nations are beginning to challenge our former control of outer space. China's lunar sample collection mission Chang'e 6 has made history by successfully touching down on the far side of the moon, and it even sent back a stunning video of its landing. The China National Space Administration (CNSA) probe arrived at the moon on Sunday (June 2 at 6:23 a.m., 2024). (Lea, 2024) India's Chandrayaan-3 spacecraft aced its historic landing near the moon's south pole last August. (Kuthunur, 2023) Japan successfully soft landed on 19 January 2024 at 15:20 UTC, making Japan the 5th country to do so. (Yamaguchi, 2024). A Russian attempt last August failed as it raced against the Indian mission. (Faulconbridge, 2023)

Now that other flags adorn the lunar surface, we have to ask, “What’s next, and will we finally fall behind in space?”. That is a real possibility and risk that the United States and its new Space Force are not willing accept. This is no longer about science. It is now a matter of space superiority.

The Combat Test Framework (CTF) is poised to ensure that America does not fall behind in equipping our warfighters with capability that provides them with the upper hand. The CTC is depicted ***Figure 1-1*** I will explain each part of the figure as we process.

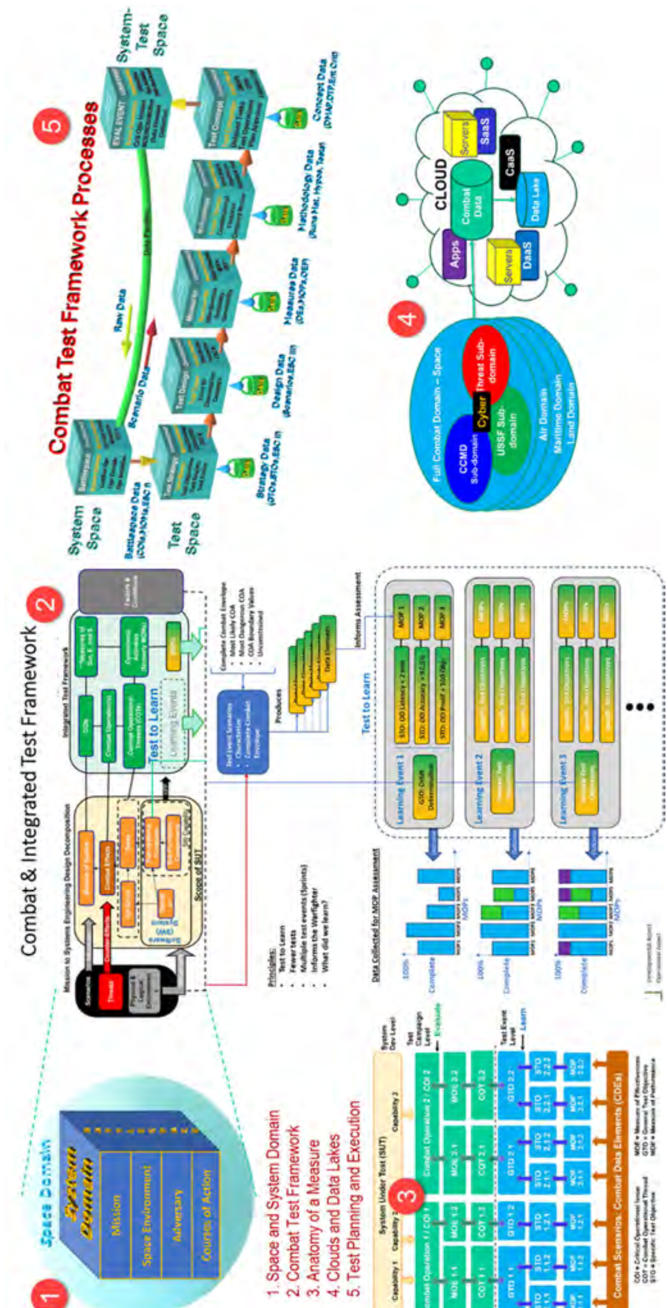

Figure 1-1. illustration of the Combat Test Framework

2 Test Design and Events

The Delta 12 Combat Test Framework starts with understanding the needs of the Warfighter. Our job as testers is to ensure that the warfighter receives the capabilities they require to perform their combat mission in a contested environment. This focus on delivering combat capabilities is captured in ***Figure 2-1.*** with four processes.

1. The System under Test (SUT) (capability need)
2. The Integrated Test Framework (test plans)
3. Combat Realistic Scenarios (produce test data)
4. Test Events driven by Combat Scenarios (Test-to-Learn)

The remainder of this brief disaggregates the framework.

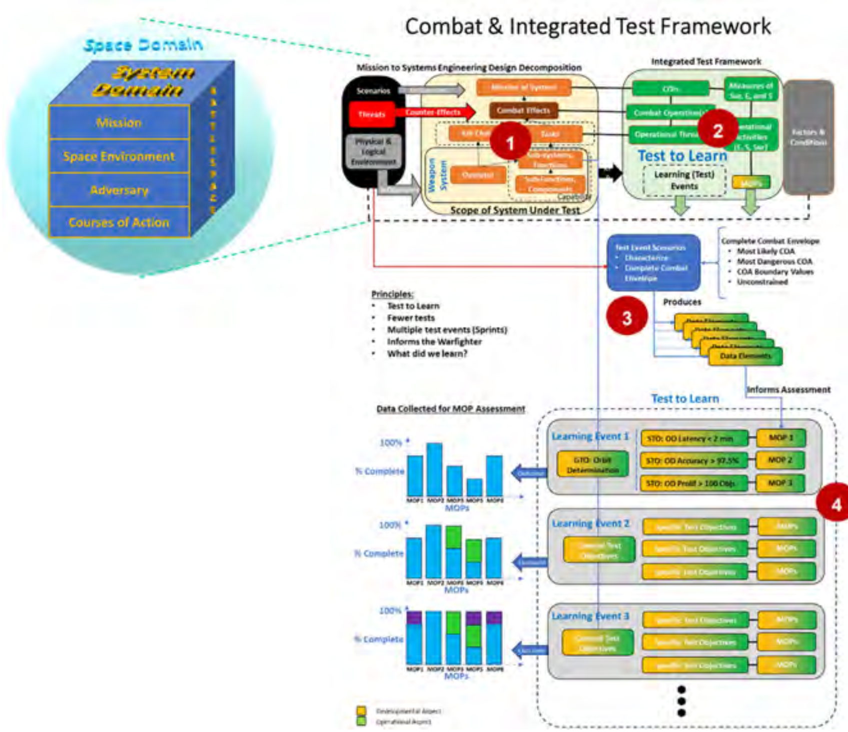

Figure 2-1. Combat Test Framework emphasizing learning events, where operationally relevant data is being cumulated over multiple events.

2.1 Overview

This chapter briefly describes the Delta 12 Combat Test Framework. Routine testing does not stress all systems under test to combat conditions or a contested environment. The **Great Power Competition** (GPC) teaches us the testing routine operations also does not stress all systems under test to combat conditions. Most test plans (capability- or requirements-base) are not created to test boundary points of the combat battlespace (see ***Figure 2-1, part 1***)

By performing multiple test events in a test campaign (see ***Figure 2-1***, ***part 4***), combat testing conditions are more readily obtained, especially when cumulative output is collected. This implies that each subsequent test event supplies additional data by which to evaluate performance measures under combat conditions.

An overarching test campaign strategy should be created by implementing multiple test events. Each test event would ideally provide combat-relevant data that could be used to evaluate (fully or partially) performance measures. The primary goal is to test-to-learn. However, more test events in a test campaign implies fewer test campaigns. So, a balance must be maintained, while keeping the warfighter informed (see ***Figure 2-2***).

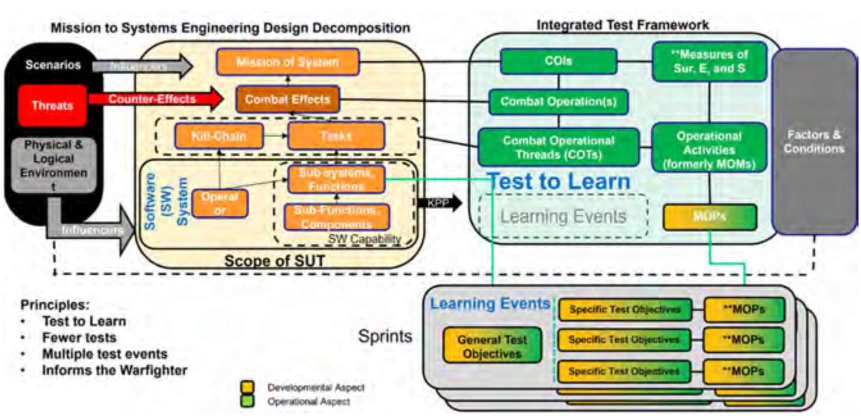

Figure 2-2. CTF principles include (1) testing to learn, (2) fewer test campaigns, (3) more test events, and (4) informing the warfighter.

The primary outcome from events would be accomplishment of specific objectives. In turn, we generalize the outcome of specific objectives as learning points to inform the warfighter on system development progress. Finally, data is generated for test events from the full battlespace domain, rather than the bounded system domain.

2.2 Test Objectives

Test objectives drive the planning for an integrated test. Without clearly stated objectives, testers have no indication of where to go and whether or not they arrived. During early planning, the test team should be able to formulate general test objectives (GTOs), at a minimum. We derive GTOs as we develop high-level measure of merit (MoMs), i.e., Measure of Effectiveness (MOEs). The GTOs focus primarily on Combat Operational Threads (COTs) and drive each learning event. If we have enough information to decompose combat operational threads to the operational activities, then we can develop specific test objectives (STOs). We will have more to say about formulating test objectives in "Anatomy of a Measure."

2.3 Overarching Test Strategy

Our overarching test strategy is to develop multiple Learning Events, during which contractor tests, software development tests, and operational assessment tests are integrated to provide the following:

1. Combat-like data that could be used to evaluate (fully or partially) performance measures.
2. Accomplishment of stated GTOs and STOs.
3. Generalization of the outcome for STOs as learning points to inform the warfighter on system development progress.
4. Data that is generated for test events from the full battlespace domain, rather than the bounded system (capabilities) domain.

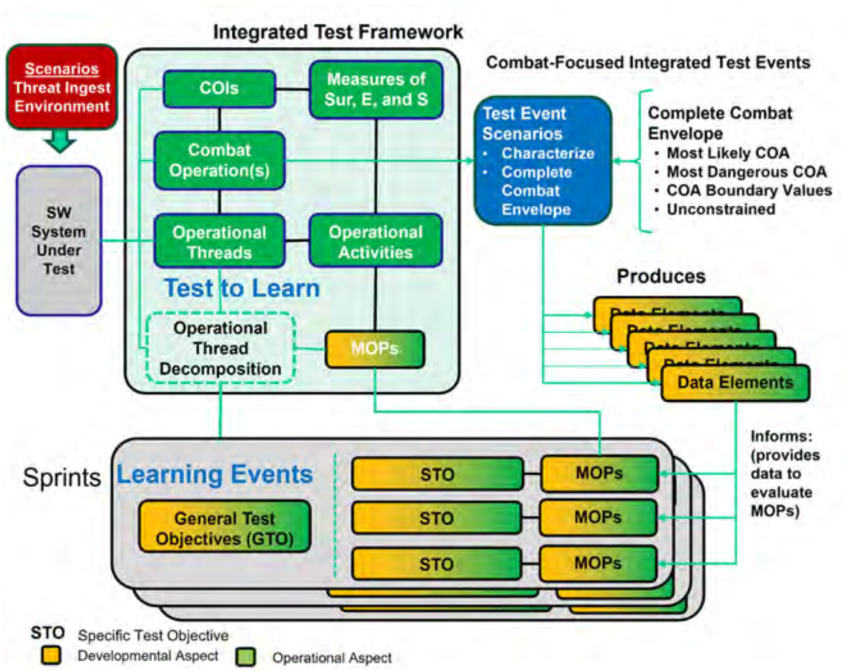

Figure 2-3. The Integrated Test Framework as a subset of Combat Test Framework. The emphasis in this illustration is on Learning Events and their relationship with test measurements and evaluation.

2.4 Data Elements and Collection

The data elements required for assessing or evaluating the SUT must be produced from the [combat] battlespace. Testing for specification or capability alone may not produce the data that is required for evaluating combat functionality/capability of a SUT for informing operational acceptance decision. In essence, Data Elements are a link between the combat battlespace and the test performance measures. For required data elements, see Appendix A.

When collecting data from a test event, the data does not need to be structured. While structured data is preferred, unstructured data placed in a data lake can be extracted and structured using machine learning algorithms before we perform analysis. Therefore, cloud storage is the preferred repository for test data.

A Test Campaign can be comprised of multiple test events and there are two types of test events: learning events and evaluation events. The primary goal of the learning event is to Test-to-Learn. Learning events are:

- Learning focused with General Test Objectives (GTOs)
- Discovering with Specific Test Objectives (STOs)

Evaluation events require a complete collection of data elements before one can perform an analysis for effectiveness, suitability, and survivability. During evaluation events:

- Data is cumulatively collected to support MOP assessment
- Complete data collection may require multiple events

Figure 2-4 depicts a test with data being collected for five MOPs. This required three test events to get all of the required data.

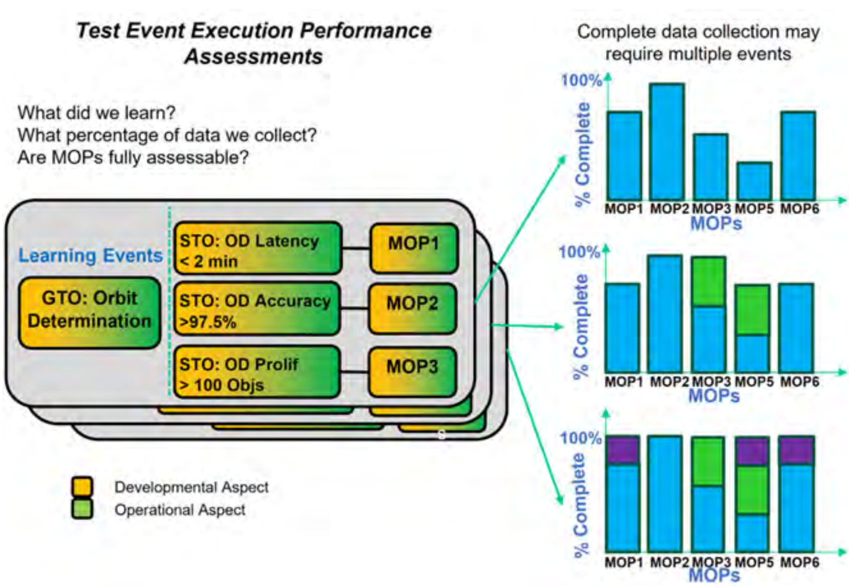

Figure 2-4. Cumulative collection of data through multiple test events

2.5 Summary

- The primary goal of test is to learn – Test-to-Learn
- TES performs testing on fewer prioritized systems/programs

- Test is comprised of multiple events
- Events are learning focused
- Events are designed to inform the warfighter on combat capability delivery progress

3 Testing in Adaptive Acquisition Framework

The manner in which one implements the CFT may vary depending upon the acquisition model one uses to develop the defense system.

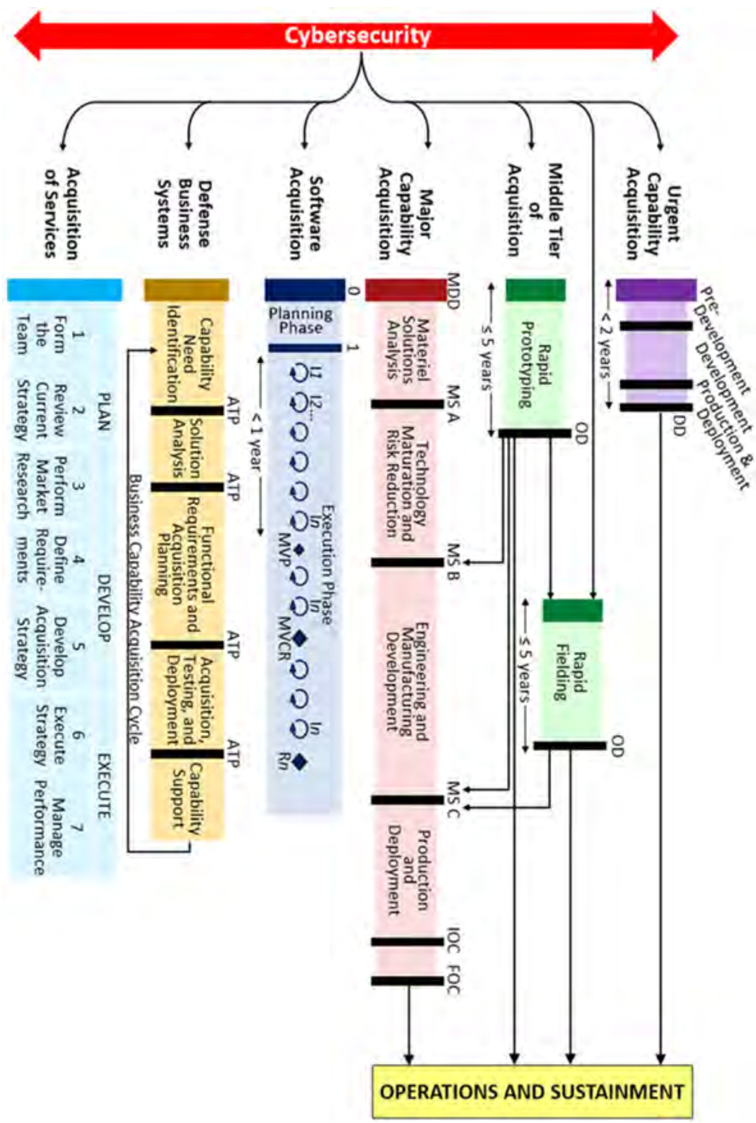

Figure 3-1. A set of acquisition pathways to enable the workforce to tailor strategies to deliver better solutions faster

The DoD's Adaptive Acquisition Framework arose from a reconstruction of a failing system in the 2020. The entire DODI 5000 series was revamped to align with the new acquisition pathways more relevant to this era of defense acquisition. The pathways include:

1. Major Capability Acquisition
2. Middle of Tier Acquisition
3. Software Acquisition
4. Urgent Capability Acquisition
5. Defense Business Systems (not addressed here)
6. Acquisition of Services (not addresses here)

3.1 Major Capability Acquisition (MCA)

To acquire and modernize military unique programs that provide enduring capability. These acquisitions typically follow a structured analyze, design, develop, integrate, test, evaluate, produce, and support approach. This process is designed to support major defense acquisition programs, major systems, and other complex acquisitions. Acquisition and product support processes, reviews, and documentation will be tailored based on the program size, complexity, risk, urgency, and other factors. Software-intensive components may be acquired via the software acquisition pathway, with the outputs and dependencies integrated with the overall major capability pathway.

3.1.1 Program Planning

A rapid, iterative approach to capability development reduces cost, avoids technological obsolescence, and reduces acquisition risk. Consistent with that intent, acquisitions will rely on mature, proven technologies and early tester involvement. Planning will capitalize on commercial solutions and non-traditional suppliers, and expand the role of warfighters and security, counterintelligence, and intelligence analysis throughout the acquisition process.

Acquisition programs will be designed to facilitate capability enhancements by using open systems architectures and common, open, and consensus-based standards. An open system design supports sustainment and rapid integration of new or updated subsystems into the platform.

To facilitate a flexible and rapid acquisition process, Milestone Decision Authorities (MDAs), program managers (PMs), and other relevant authorities will implement certain processes described in Flexible Implementation.

3.1.2 Decision Reviews

The purpose of decision reviews embedded in the acquisition procedures described in this section is to carefully assess a program's readiness to proceed to the next acquisition phase and to make a sound investment decision committing the Department's financial resources. Consequently, reviews will be issue and data focused to facilitate an examination of relevant questions affecting the decisions under consideration and to allow the MDA to judge whether the program is ready to proceed. The policies outlined in [the bullets below] will guide decision reviews:

The MDA is the sole and final decision authority. Staff members and staff organizations support and facilitate the MDA's execution of that authority.

The Defense Acquisition Board (DAB) will advise the Defense Acquisition Executive (DAE) on critical acquisition decisions when the DAE, or designee, is the MDA. The DAE or designee will chair the DAB. Similar procedures will be established at the DoD Component level for use by other MDAs. An acquisition decision memorandum (ADM) will document decisions resulting from reviews.

Overarching Integrated Product Teams at the Office of the Secretary of Defense (OSD) level, and similar organizations within the DoD Components, are expected to collectively assist the MDA in making sound investment decisions for the department, and to ensure programs are structured and resourced to succeed. These organizations are not decision bodies and they and their leaders do not supplant the authority of the PM, Program Executive Officer (PEO), component acquisition executive (CAE), or DAE.

3.1.3 DoD Process Relationships

Acquisition, requirements, and budgeting are closely related and must operate simultaneously in close coordination. Validated requirements provide the basis for defining the products that will be acquired through the acquisition system. The budgeting process determines DoD priorities and resource allocations and provides the funds necessary to execute planned programs. Adjustments may have to be made during a program's life cycle to keep the three processes aligned to ensure programs are executable and to adapt to evolving circumstances. Decisions in this context must consider mission area or portfolio considerations as well as those directly impacting the program under review.

3.1.4 Flexible Implementation

The MDAs structure program strategies and oversight, phase content, the timing and scope of decision reviews, and decision levels based on the specifics of the product being acquired, including complexity, risk, security, and urgency to satisfy validated capability requirements.

PMs "tailor-in" the regulatory information that will be used to describe their program at the Materiel Development Decision (MDD) or program inception. In this context, "tailor-in" means that the PM will identify and recommend for MDA approval, the regulatory information that will be employed to document program plans and how that information will be formatted and provided for review by the decision authority.

- The PM's recommendation are reviewed by the MDA and the decision will be documented in an ADM.
- MDAs resolve issues related to implementation of this approach, and coordinate, when necessary, with other regulatory document approval authorities to facilitate its implementation.
- Statutory requirements are not waived unless permitted by the relevant statute.

Technologies successfully demonstrated in an operational environment via the Rapid Prototyping procedures in the Middle Tier Acquisition pathway, or other prototyping authorities, may be transitioned to major capability acquisition programs at decision points proposed by the PM and approved by the MDA. The technologies may provide the technical foundation for a formal acquisition program, incrementally improve a program capability in support of approved requirements or support the development and insertion of more efficient program components. Similarly, products and technologies that have been successfully demonstrated via the Rapid Fielding procedures under the Middle Tier Acquisition pathway may provide the basis for a program developed in accordance with the procedures in this issuance. PMs for Middle Tier programs may identify and develop the statutory and regulatory information needed to facilitate an efficient pathway transition. DoDI 5000.80 provides additional direction for middle-tier acquisitions.

3.1.5 Acquisition Process Decisions and Phases

Acquisition definitively and made at the lowest authorized level, commensurate with the Acquisition Category (ACAT) and program risk, to ensure they are timely, and made by those with the greatest knowledge of the program. ***Figure 3-2*** depicts a major capability acquisition model. The paragraphs that follow describe the decision points and activity phases that apply to almost any acquisition.

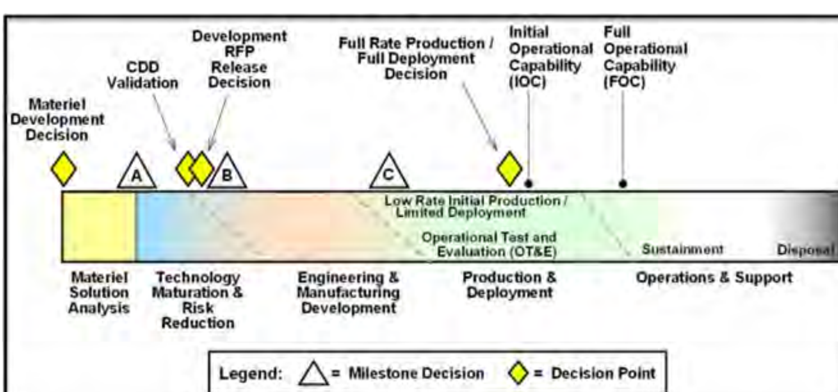

Figure 3-2. Major Capability Acquisition Model

3.1.6 Operational Test and Evaluation Activities

3.1.6.1 Operational Assessments

The lead Operational Test Organization (OTO) prepares and reports results of one or more Early Operational Assessments (EOAs) as appropriate in support of one or more of the design phase life-cycle events (namely, the capability development document validation, the development RFP release decision point, or MS B). An EOA is typically an assessment, conducted in accordance with an approved test plan, of the program's progress in identifying operational design constraints, developing system capabilities, and reducing program risks. For programs that enter development at MS B, the lead OTA will (as appropriate) prepare and report EOA results after program initiation and before the critical design review. Reference Source: DODI 5000.89 Section 6.2

The lead OTA conducts an OA in accordance with a test plan approved by the DOT&E for programs that are under T&E oversight. OAs can include dedicated early operational testing, as well as developmental test results, provided they are conducted with operational realism. As a general criterion for proceeding through MS C, the lead OTA will conduct and report results of at least one OA. For an acquisition program using an incrementally deployed software program model, a risk-appropriate OA is usually required in support of every limited deployment. An OT, usually an OA, is required before deployment of accelerated or urgent acquisition programs that are under T&E or LFT&E oversight. The OTA may combine an OA with training events. An OA may not be required for programs that enter the acquisition system at MS C.

3.1.6.2 Requests for Proposals

The Military Services will provide to the DOT&E and USD(R&E) an approved final draft TEMP or other test strategy documentation before release of Requests for Proposals (RFPs) for MS B and MS C. To the maximum extent feasible, RFPs should be consistent with the OT program documented in the TEMP, or other test strategy documentation.

3.1.6.3 OT&E for Reliability and Maintainability

The TEMP, or other test strategy documentation, will include a plan to allocate top-level reliability and maintainability requirements and rationale for the requirements that may be allocated down to the components and sub-components. Reliability allocations may include hardware and software and may include commercial and non-developmental items.

3.1.6.4 Operational Test Readiness

The DoD Components will each establish an operational test readiness review process to be executed before any OT. Before IOT&E, the process will include a review of DT&E results; an assessment of the system's progress against the KPPs, key system attributes, and critical technical parameters in the TEMP, or other test strategy documentation; an analysis of identified technical risks to verify that those risks have been retired or reduced to the extent possible during DT&E or OT&E; a review of system certifications; and a review of the IOT&E entrance criteria specified in the TEMP, or other test strategy documentation.

3.1.6.5 Certifications

Testing in support of certifications should be planned in conjunction with all other testing.

The PM is responsible for determining what certifications are required, involving the representatives of applicable certifying authorities in the T&E working-level integrated product team WIPT, and satisfying the certification requirements.

The PM will provide the MDA, DOT&E, and the lead OTA with all data on certifications as requested.

In accordance with DoDI 8330.01, all program TEMPs must reflect interoperability and supportability requirements, and serve as the basis for interoperability assessments and certifications. The preceding policies are summarized together with associated DOT&E guidance and TEMP outlines at:

http://www.dote.osd.mil/temp-guidebook/index.html.

3.2 Middle Tier of Acquisition (MTA)

The Middle Tier of Acquisition pathway is used to rapidly develop fieldable prototypes within an acquisition program to demonstrate new capabilities and/or rapidly field production quantities of systems with proven technologies that require minimal development.

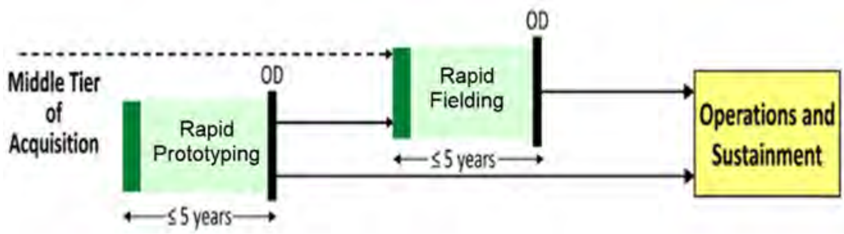

Figure 3-3. The Middle Tier of Acquisition Pathway model

The MTA pathway is intended to fill a gap in the Defense Acquisition System (DAS) for those capabilities that have a level of maturity to allow them to be rapidly prototyped within an acquisition program or fielded, within five years of MTA program start. The MTA pathway may be used to accelerate capability maturation before transitioning to another acquisition pathway or may be used to minimally develop a capability before rapidly fielding.

3.2.1 Rapid Prototyping

The **rapid prototyping path** provides for the use of innovative technologies to rapidly develop fieldable prototypes to demonstrate new capabilities and meet emerging military needs. The objective of an acquisition program under this path will be to field a prototype meeting defined requirements that can be demonstrated in an operational environment and provide for a residual operational capability within five years of the MTA program start date. Virtual prototyping models are acceptable if they result in a fieldable residual operational capability. MTA programs may not be planned to exceed five years to completion and, in execution, will not exceed five years after MTA program start without Defense Acquisition Executive (DAE) waiver.

3.2.2 Rapid Fielding

The **rapid fielding path** provides for the use of proven technologies to field production quantities of new or upgraded systems with minimal development required. The objective of an acquisition program under this path will be to begin production within six months and complete fielding within five years of the MTA program start date. MTA program production start date will not exceed six months after MTA program start date without DAE waiver. MTA programs may not be planned to exceed 5 years to completion and, in execution, will not exceed five years after MTA program start without DAE waiver.

3.2.3 Program Requirements

Not all programs are appropriate for the MTA pathway. Major systems intended to satisfy requirements that are critical to a major interagency requirement or are primarily focused on technology development or have significant international partner involvement are discouraged from using the MTA pathway.

MTA programs are not subject to the guidance in Chairman of the Joint Chiefs of Staff Instruction 5123.01H and DoD Directive 5000.01 [Change 2, 31 Aug 2018]. Each DoD Component develops a streamlined process that results in a succinct requirement document no later than 6 months from the time the operational needs process is initiated. Approval authorities for each capability requirement will be delegated to a level that promotes rapid action.

DoD Component-required procedures are compliant with applicable statute and consistent with the requirements for acquisition programs stated in this issuance. When necessary, requests for waivers to the provisions of this issuance will be submitted to the Defense Acquisition Executive (DAE).

3.3 Software Acquisition Pathway

This pathway is designed for software-intensive systems. The pathway objective is to facilitate rapid and iterative delivery of software capability to the user. This pathway integrates modern software development practice such as Agile Software Development, DevSecOps, and Lean Practices.

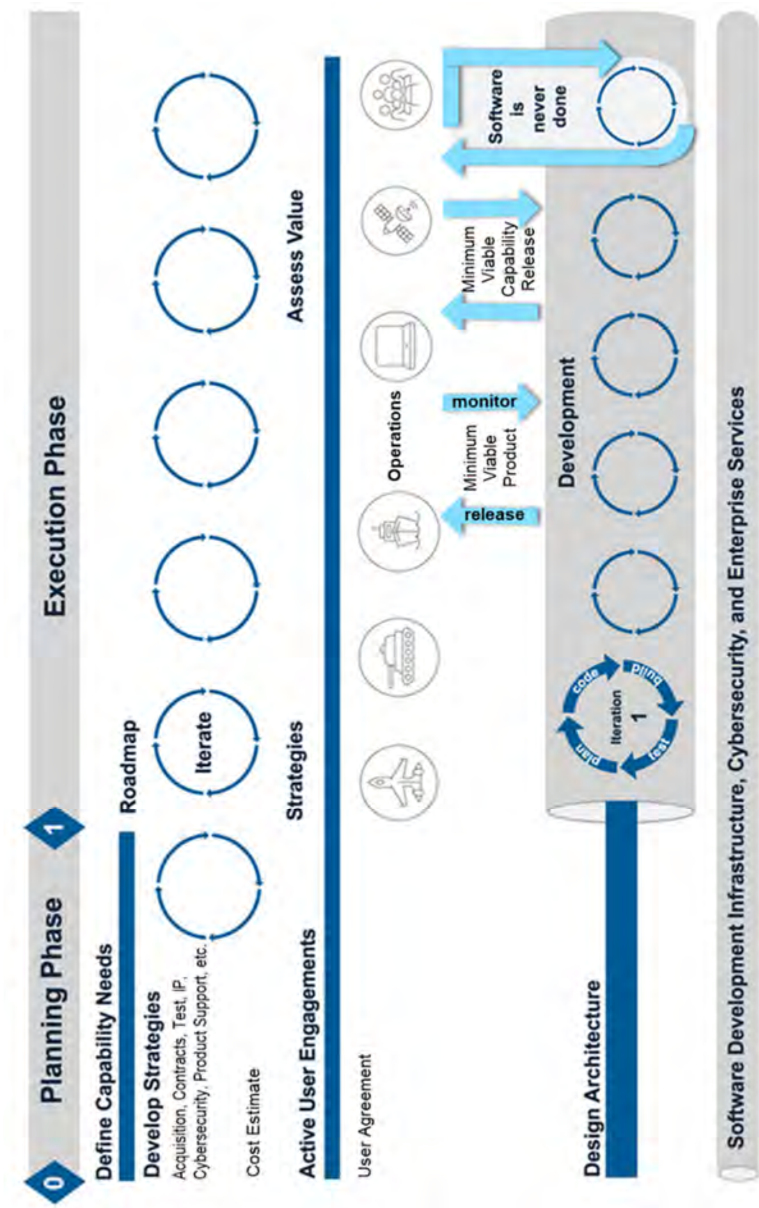

Figure 3-4. Software Acquisition Pathway model

3.3.1 Warfighter Engagement

The system program office (SPO) capitalizes on active user engagement and leverages enterprise services, to rapidly and iteratively deliver working software to meet the highest priority warfighter needs. Tightly coupled mission-focused government-industry software teams leverage automated tools for development, integration, testing and certification to iteratively deploy software capabilities to the operational environment.

3.3.2 Development Environment

The SPO assembles software architecture, infrastructure, services, pipelines, development and test platforms, and related resources from enterprise services and development contracts. They leverage existing services from enterprise services and development contracts over acquiring new services to the extent consistent with the program acquisition strategy and IP strategy.

3.3.3 Automated Testing

The SPO maximize use of automated software testing and security accreditation, continuous integration and continuous delivery of software capabilities, and frequent user feedback and engagement. They consider the program's lifecycle objectives and actively manage technical debt. Programs use modern, iterative software practices to continuously improve software quality (e.g., iteratively refactor design and code, reduce cybersecurity vulnerabilities, and create effective modular open systems approaches to support future capabilities). Programs using the embedded software path align test and integration with the overarching system testing and delivery schedules.

3.3.4 Product Roadmaps

The sponsor and SPO develop and maintain a product roadmap to plan regular and iterative deliveries of software capabilities. The product owner and SPO also develop and maintain program backlogs that identify detailed user needs in prioritized lists. The backlogs allow for dynamic reallocation of current and planned software releases. The SPO capture issues, errors, threats, and defects identified during development and operations, including software updates from third parties or suppliers, in the program's backlogs to address in future iterations and releases. Regular stakeholder feedback and inputs shape the product roadmap and program backlogs.

3.3.5 Minimal Viable Product

The SPO and the sponsor use an iterative, human-centered design process to define the minimum viable product (MVP) recognizing that an MVP's definition may evolve as user needs become better understood. Insights from MVPs help shape scope, requirements, and design.

Minimal Viable Capability Release

The SPO and the sponsor use an iterative, human-centered design process to define a minimum viable capability release (MVCR) if the MVP does not have sufficient capability or performance to deploy into operations. The MVCR delivers initial warfighting capabilities to enhance mission outcomes. The MVCR for applications programs must be deployed to an operational environment within one year after the date on which funds are first obligated to acquire or develop new software capability including appropriate operational test. If the MVP version of the software is determined sufficient to be fielded for operational use, the MVP will become the MVCR.

- Subsequent capability releases are delivered at least annually. Software updates to address cybersecurity vulnerabilities will be released in a timely manner, potentially including out of release cycle as needed, per the program's risk-based lifecycle management approach.
- Programs should deploy embedded software upgrades at least annually to an environment (e.g., development, staging, or operations) consistent with the overarching weapon system testing delivery strategy.

3.3.6 Continuous Improvement

Programs continuously improve or refine software development processes, practices, tools, and program strategies to reflect them. They should employ small, empowered teams and scale larger efforts across multiple teams. This includes integrating and aligning efforts across government and software development organizations. Continuous warfighter feedback and self-assessments help balance investments between short-term capability deliveries and longer-term enduring solutions.

3.3.7 Integrated Test Force

The Integrated Test Force (ITF) integrates, streamlines, and automates software development testing, government developmental testing, and operational testing to the maximum extent possible to accelerate delivery timelines based on risk strategies. The ITF makes available automated test scripts and test results to the test community so that critical verification functions (e.g., performance, reliability), and validation functions (e.g., effectiveness, suitability and survivability) can be assessed iteratively and incrementally.

3.3.8 Cyber Testing

Automated cyber testing and continuous monitoring of operational software are designed and implemented to support a continuous Authority To Operate (cATO). These may support an accelerated accreditation process, augmented with additional testing where appropriate, in accordance with cybersecurity policies, and in coordination with the assigned authorizing official. All safety critical software standards and guidance apply for programs using the software acquisition pathway. Programs implement recurring cybersecurity assessments of the development environment, processes and tools.

3.3.9 Cybersecurity and Software Assurance

Cybersecurity and software assurance are integral to strategies, designs, development environment, processes, supply chain, architectures, enterprise services, tests, and operations. Continuous and automated cybersecurity and cyber threat testing identify vulnerabilities to help ensure software resilience throughout the lifecycle. The SPO works with stakeholders to provide sufficient controls to enable a cATO where appropriate. Ensuring software security includes:

- Secure development (e.g., development environment, vetted personnel, coding, test, identity and access management, and supply chain risk management).
- Cybersecurity and assurance capabilities (e.g., software updates and patching, encryption, runtime monitoring, and logging).
- Secure lifecycle management (e.g., vulnerability management, rigorous and persistent cybersecurity testing, and configuration control).

3.3.10 Software Quality Metrics

Reference Source: USD(A&S) Guidance

Metrics related to the quality of the work delivered. These metrics identify where in the overall system software quality has been achieved and where it may be degraded. It supports identification of specific software architecture/components or team specific challenges that contribute to degraded quality.

- **Acceptance Rate** – $ and % of stories delivered vs accepted.
- **Recidivism Rate**– The % of stories that are returned to the team for various reasons. # of stories returned/total number of stories completed.
- **Defect Count by Story Count**– Measures the number of defects per iteration/total number of stories in the iteration.
- **Change Fail Rate**– The percentage of changes to the production system that fail.
- **Mean Time to Recover/Restore** (MTTR) – the average time it takes to restore a module, component, or system after it fails.
- **Escaped Defects** – the number of defects found after they are in production.
- **Code Coverage Rate** – Tells the proportion of the lines of code covered by the testing approach.
- **Automated Test Coverage** – Tells the % of the system covered by automated testing vs the % manually performed.
- **Release/Deployment Failure Rate** – how often deployment results in outages, remediations, or degraded performance.

3.3.11 Cyber Security Metrics

Reference Source: USD(A&S) Guidance

Metrics related to protecting software products, infrastructure, and data from unauthorized access and use. These should consider attempts, detection, and remediation.

- Intrusion Attempts – number of times intrusions were attempted, typically compared against a benchmark and/or # of incidents.
- Security Incident Rate – #/% of times attackers breached your data, systems, or networks.
- Mean Time to Detect – Amount of time it takes to discover a security incident/threat.
- Mean Time to Remediate (MTTR) – the average time it takes to repair/restore a module, component, system to functional use after a security incident.

3.3.12 Defining Capability Needs

Programs executing the software acquisition pathway are not subject to the Joint Capabilities Integration and Development System (JCIDS) and will be handled as specifically provided for by the Vice Chairman of the Joint Chiefs of Staff, in consultation with Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) and each service acquisition executive. Software development occurs in active collaboration with operators, representing key operator groups, to ensure software deliveries address their priority needs, maximize mission impact, and undergo regular assessment of software performance and risk.

SWP programs that Joint Staff views as having "Joint Equities" are required to use a Software Initial Capabilities Document (SW-ICD) to capture high level needs. Those that do not have Joint Equities can use the Capability Needs Statement (CNS) via their Service/Agency requirements process. Under Secretary of Defense for Acquisition & Sustainment OUSD(A&S) recommends SWP programs work with their Service/Agency requirements headquarters organizations to get an early "read" from Joint Staff on the Joint equities determination before proceeding with the SW-ICD or CNS.

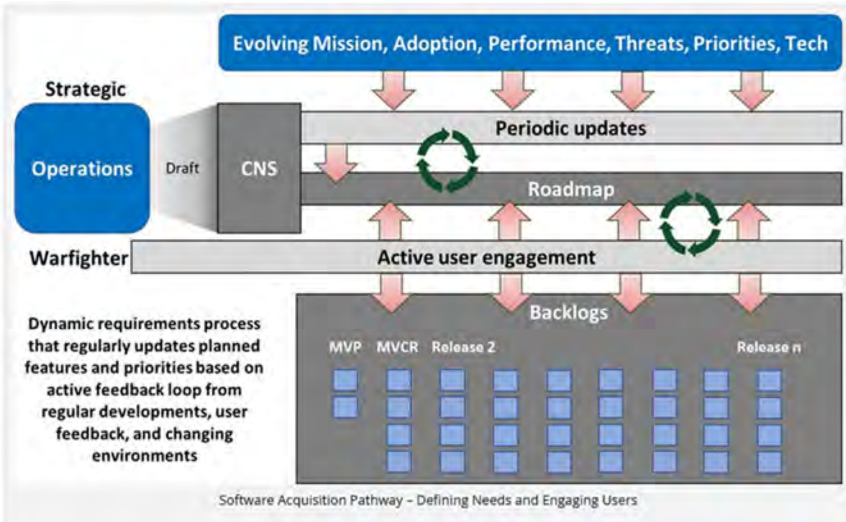

Figure 3-5. Software Acquisition Pathway – Defining Needs and Engaging Users

3.4 Urgent Capability Acquisition

The purpose of the Urgent Capability Acquisition (UCA) pathway is to field capabilities to fulfill urgent existing and/or emerging operational needs or quick reactions in less than 2 years.

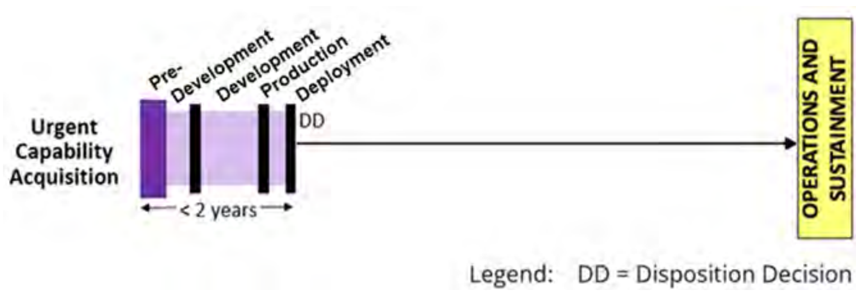

Figure 3-6. Urgent Capability Acquisition (UCA) pathway model

It is DoD's highest priority to provide warfighters involved in conflict or preparing for imminent contingency operations with the capabilities needed to overcome unforeseen threats, achieve mission success, and reduce risk of casualties, as described in DoDD 5000.71.

The estimated cost for acquisition programs that provide capabilities to fulfill urgent operational needs and other quick reaction capabilities that can be fielded in less than 2 years must not exceed $525 million in research, development, and test and evaluation, or $3.065 billion for procurements in Fiscal Year 2020 constant dollars.

Due to operational urgency the normal acquisition processes are aggressively streamlined. The goal is to plan for the capability in a few weeks with development and production measured in months. The imperative is to quickly deliver useful capability to the warfighter in a timely manner. Reference Source: DoD 5000 Series Acquisition Policy Transformation Handbook, January 9, 2020

The purpose of **Pre-Development** is to assess and select a course or courses of action to field a quick reaction capability and develop an acquisition approach.

Development includes an assessment of the performance, safety, suitability, survivability, supportability, including software, and lethality, if appropriate, of the capability. It does not require that all identified deficiencies, including those related to safety, be resolved prior to production or deployment. The Milestone Decision Authority will, in consultation with the user and the requirements validation authority, determine which deficiencies must be resolved and what risks can be accepted.

During **Production and Deployment**, the acquiring organization provides the warfighter with the needed capability, to include any required training, spares, technical data, to include known hazards and accepted mishap risks, computer software, temporary or permanent facilities or infrastructure, support equipment, maintenance, or other logistics support necessary for operation.

Operations and Support: The program manager executes a supportability strategy that meets materiel readiness and operational support performance requirements, is safe, and sustains the capability in the most cost-effective manner over its anticipated total life cycle. Planning for Operations and Support, including support funding, will begin during pre-development and will be documented in the acquisition strategy.

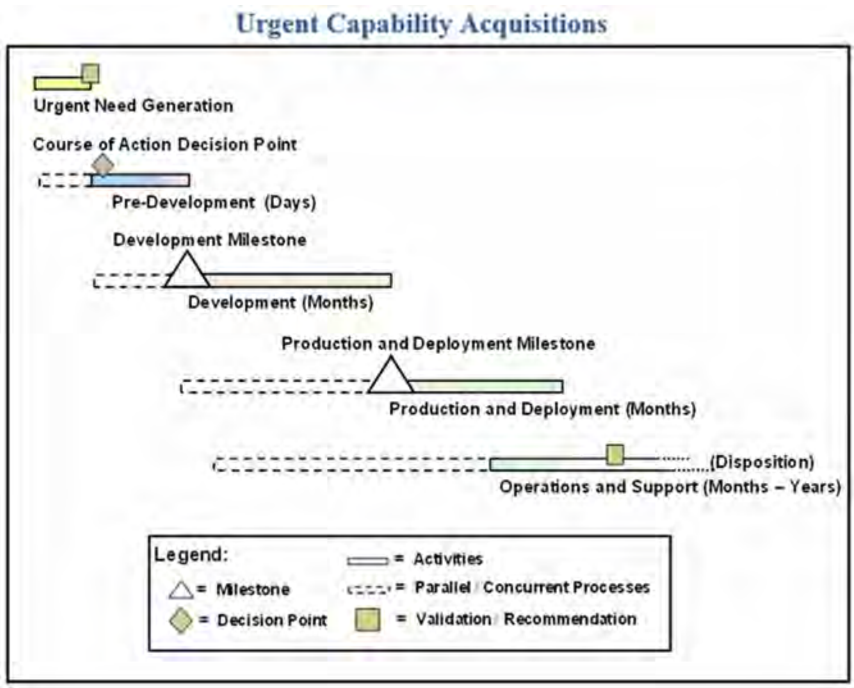

Figure 3-7. Urgent Capability Acquisitions timeline

3.4.1 Test & Evaluation for the UCA Pathway

The Directorate Operational Test & Evaluation (DOT&E) will monitor all programs using the urgent capability pathway to determine placement under T&E oversight. A TEMP is not normally required. Designated programs for DOT&E operational and live fire oversight will adhere to the policies established by the DOT&E for oversight programs. *Reference Source: DoDI 5000.89, Section 4.2*. These include:

Approval by the DOT&E of OTPs and live fire test plans (LFTPs) at the production and development milestone. The Military Services are required to deliver test plans to the DOT&E 60 days before the start of testing.

Approval by the DOT&E of post-deployment assessment plans at the production and deployment milestone.

Programs not under T&E oversight are approved at the Service level; the program may require a rapid and focused operational assessment (OA) and live fire testing (if applicable) before deploying an urgent need solution. The acquisition approach will identify any requirements to evaluate health, safety, or operational effectiveness, suitability, survivability, and lethality.

As applicable, the DOT&E will submit independent OT and live fire reports to the Secretary of Defense, the USD(A&S), congressional defense committees, and Military Services. The Secretary of Defense may authorize certain programs to defer some testing until after fielding if he or she determines the testing would unnecessarily impede the deployment of the needed capability. Testing should normally include user feedback to support design and operational use improvements and the PM's plans to correct identified deficiencies.

4 Combat Test Framework Planning Processes

Test planning and execution is not a two-dimensional process, hence the cubes in ***Figure 4-1***. Each cube represents a phase of test campaign planning. The names in white font, i.e., Test Design, is the name of the phase.

The next line (yellow font) is the major process or product from one or more of the pervious phases, i.e., the Test Strategy phase uses input from Battlespace Development.

The third and subsequent rows (front facet of the cube) are phase activities. For instance, using the combat operations from during the Test Measures phase, we validate the measures the Test Strategy, determining the data elements required for assessing the measures.

The right facet of a cube indicates the activity or product that provides outputs of the current phase that are inputs to next phase. For instance, in the Test Design phase, the combinatorial/factorial corresponding to (Error ID and Characterize) drive the measures of Test Measures phase that are required for assessing Effectiveness / Suitability / Survivability.

The Factors/Levels of the Test Measure phase drive the Test Methodologies needed to acquire correct data, including variables that will become factors for your experiments.

The data buckets (with the drops of water) are data (artifacts) produced by the phase activities. For instance, the COTs from Test Strategy and the scenarios from Test Design constitute data for the data buckets, which feed the data pipeline.

The last cube, Evaluation (Test) Event / Learning Event, is slightly different. The two facets represent two separate concepts that are independent events that can occur simultaneously.

Putting it all together, the framework exists to produce the combat relevant data needed to evaluate the COIs.

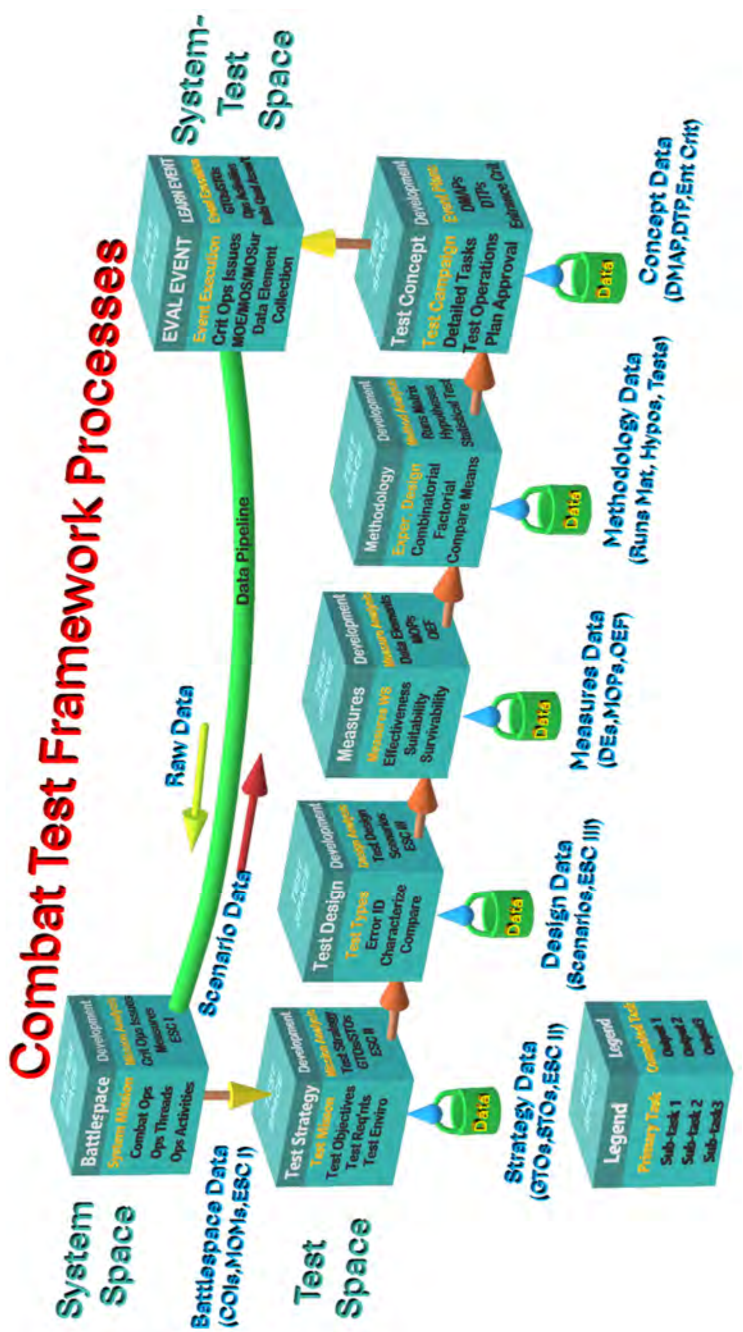

Figure 4-1. The Combat Test Framework Campaign Planning Phases

5 Battlespace Development

Battlespace development (BD) is an analysis of three domains: the Space Domain, the Combat Domain, and the System Domain. These domain spaces may overlap but are all within the Space Domain.

5.1 Domain Spaces

5.1.1 The Space Domain

The Space Domain (SpD) is much larger than (>>) any system's domain or any set of combined systems. The SpD includes the space from the earth's surface, the atmosphere, and outer space. The SpD outer boundary points are difficult to define (there is no fixed boundary).

5.1.2 The Combat (Contested Space) Domain

This is the Contested Space Domain (CSpD) may be all or a subset of the Space domain, depending on the existing level of warfare. This domain starts at the Earth's surface and extend into deep space.

5.1.3 The System Domain

System domain (SysD) generally have hardened boundaries based on required capabilities and are generally bounded by normal daily operational activities. However, system domain boundaries do not represent the full combat spectrum

5.2 Battlespace Development Process

The BD process focuses on the combat **mission** in the full contested space spectrum or domain. In BD Analysis, we identify combat operations and decompose them into combat operational threads (COTs). BD "explodes" the system boundaries.

The battlespace **environment** is holistic (land, sea, air, and space) and support nearly every Space mission. It accounts for the analysis of the **adversary's** strategic, operational, and tactical objectives and capabilities. It identifies **adversary** courses of action (COAs): Most likely, most dangerous, and other COAs.

BD considers combatant commands' **COAs** to preempt and defeat the adversary.

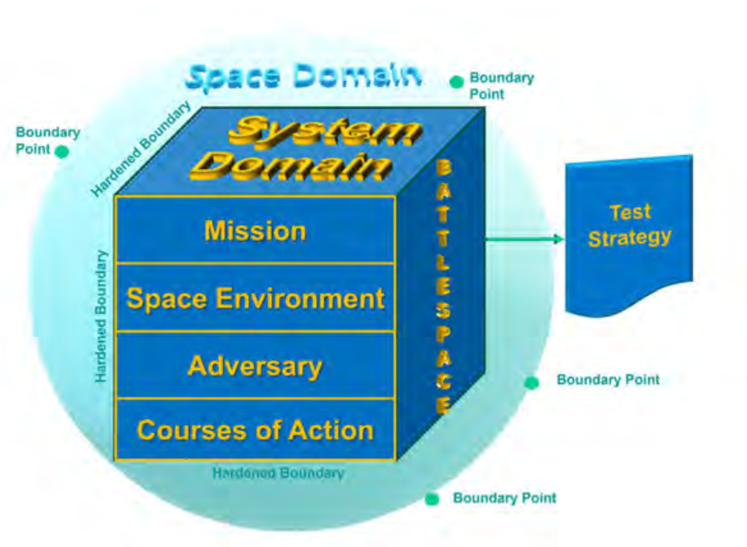

Figure 5-1. The Space Domain and its subset, system domain

During BD, we perform functions that will inform testers about the System Under Test (SUT). There are three essential tasks that the test team must be initiated:

1. Perform Mission Research to determine what capability is required for combat.
2. Perform Intelligence Preparation of the Battlefield to determine possible adversary courses of actions (COAs), particularly the most likely and most dangerous (COAs)
3. Perform "terrain" analysis to determine how the SUT will operate in various conditions (natural and manmade), from normal to extreme (i.e., increase solar flares, thermosphere cooling, etc.)
4. Formulate critical operational issues (COIs) as questions that the test team will evaluate after the system is tested and they have analyzed the resulting test data.
5. Develop potential Measures of Merit using available capability documentation (CNS, CDD, SW-CDD, VMP, MVCR)
6. Formulate potential test objective when possible, including general test objectives (GTOs) and specific test objectives (STOS).

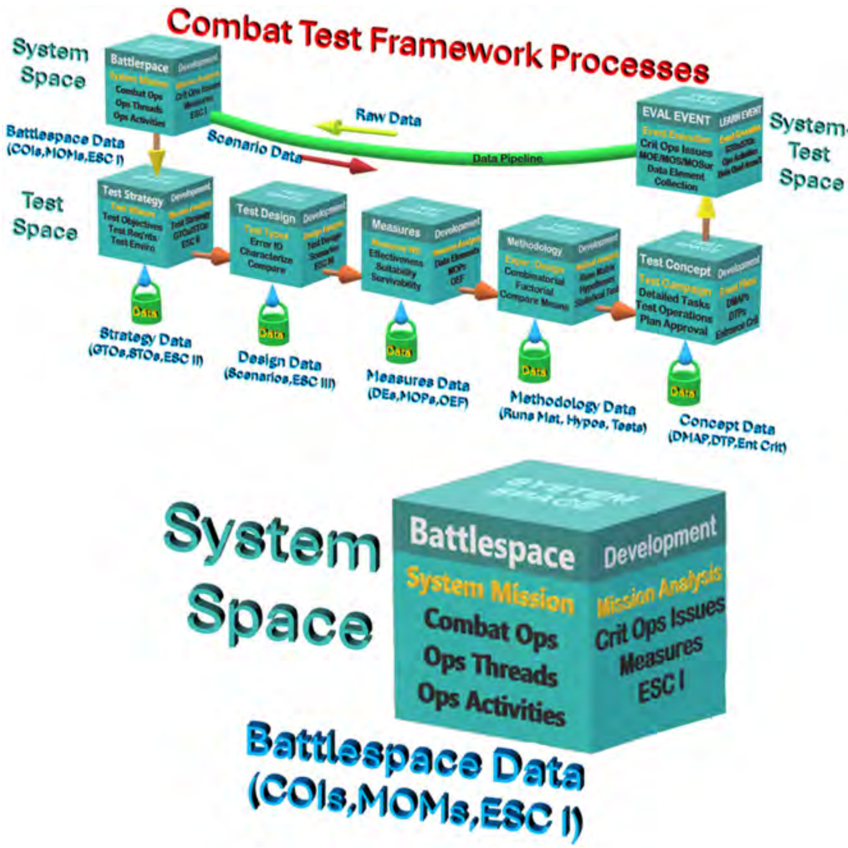

Figure 5-2. Battlespace Development flowchart

5.3 Inputs

- Combat Capabilities
- Adversary Capabilities
- Misson System
- CONOPS
- CNS, ICD, and/or MVP

5.4 Outputs

- Critical Operational Issues
- Critical Operational Threads (COTs)
- Test Objectives
- Evaluation Summary Chart 1

- SUT Mission

Correspondence to Five-Paragraph OPLAN: Paragraph 1 - Situation

5.5 Responsibilities

5.5.1 Test Project Officer

Test project managers and other team personnel use the mission research to:

1. Establish critical operational issues (COIs)
2. Decompose the mission to combat operational threads (COTs) needed for mission success
3. Determine or specify the combat operational activities that comprise each COT
4. Develop the general test objectives (GTOs) that will achieve defined outcomes for learning and evaluation.

5.5.2 Test Engineers and Analysts

Use mission research to determine the combat capability needed for the SUT, including:

1. Define the Critical Operational Issues associated with capability requirements
2. Define overarching measures required for evaluating the COIs
3. Define the performance measures and the required data elements needed to assess the measure of effectiveness (MOEs), suitability (MOSs), and survivability (MOSurv)
4. Develop an Evaluation Summary Chart 1.

5.5.3 The test team:

1. Will ensure the alignment of COIs to the COTs
2. Will align the measures to the OAs
3. Will ensure there are specific test objectives aligned to the appropriate MOPs.

The tasks that are begun during battlespace development are usually not complete and will evolve through the test planning process, and particularly the Test Strategy development phase.

Specific analysis/research tasks (combat mission vs. capability focused) include the following:

1. Mission Analysis/Research
    a. System Combat Mission Thread(s)
    b. System Combat Operational Threads
    c. System Test Operational Activities
2. Space Environment Analysis
    a. Effects in Space
    b. Effects on System
3. Adversary (Red) Analysis
    a. Five W's and an H
    b. Most Dangerous COA
    c. Most Likely COA
4. Courses of Action Analysis (COAs)
    a. Capability Required to defeat 3a
    b. Capability Gaps
5. Domain Boundaries Analysis
    a. Space Domain Boundaries
    b. Battlespace Domain Boundaries
    c. Combat Domain

5.6 System Preliminary Capabilities

Most software tests are designed to check the performance of the SUT against the minimal viable product (MVP) at the current stage of testing. These tests are not designed to test boundary points of the combat battlespace. However, by performing multiple test events in the system test campaign, combat testing conditions are more readily addressed, especially when cumulative output is collected. This implies that each subsequent test event supplies additional data by which to assess test objectives (GTOs and STOs) and cumulatively evaluate performance measures under combat conditions. During test learning events, testers do not evaluate measures of performance (MOPs) but use them as information to address test objectives.

After minimum viable capability releases (MVCRs), testers use the cumulative collection of test data from prior testing, as well as ongoing testing, to evaluate MOPs and perform analysis of the measures of effectiveness (MOEs), measures of suitability (MOSs), and measures of survivability (MOSurs).

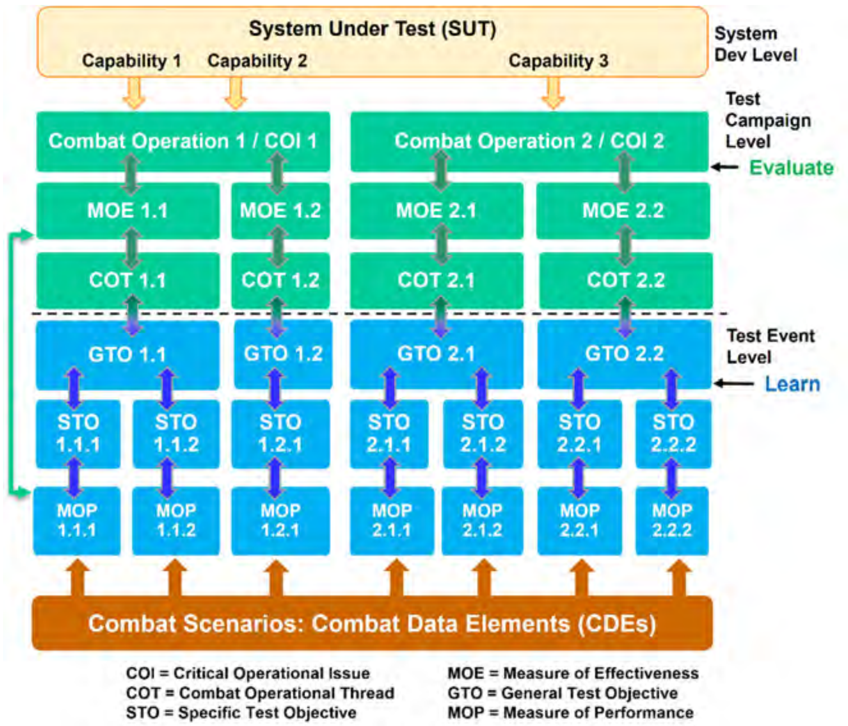

Figure 5-3. Combat Test Framework Anatomy of Measures

When MOPs are developed from Specific Test Objectives (STOs), there may be a need to add MOEs, MOSs, and/or MOSVs that were overlooked.

Conversely, if MOEs, MOSs, and/or MOSVs are missing the MOPs used to evaluate the measures, then the specific test objectives may not be complete.

We can use the STO to MOP to MOE (and MOS, MOSV) mappings to check our logic for measure development.

There is a tendency for testers to jump directly into writing test measures before establishing the test objectives.

6 Test Strategy Development

6.1 Test Strategy

During the Test Strategy phase, we perform additional Mission Research activities to validate or add test objectives for the Test Campaign. While the Battlespace development phase was focused on the combat or battle space, the focus here is on the Test Space. That is, Battlespace Development focuses on the System, while Test Strategy Development adds the dimension of the System Under Test (SUT).

What distinguishes Mission Research in Battlespace Development and in Test Stagey development?

- The former dealt with the mission of the SUT
- The latter deals with the mission of the testers or test mission
- Your Test Campaign Strategy focuses the team on obtaining the data needed to show what the system can and cannot do.

6.1.1 Inputs from Battlespace Development

- Critical Operational Issues (COIs)
- Initial MOMs, i.e., COIs, COTs, MOEs, etc.
- Evaluation Summary Chart I (ECS I)

6.1.2 Outputs

- Test Strategy
- Test Objectives (GTOs and STOs)
- Evaluation Summary Chart II (ESC II)

6.2 Responsibilities

6.2.1 Test Project Officer:

1. Perform test mission research
2. Develop a test mission statement
3. Ensures consistency of mission with the battlespace
4. Produce a test campaign strategy artifact (SharePoint Wiki) and include all progress to date

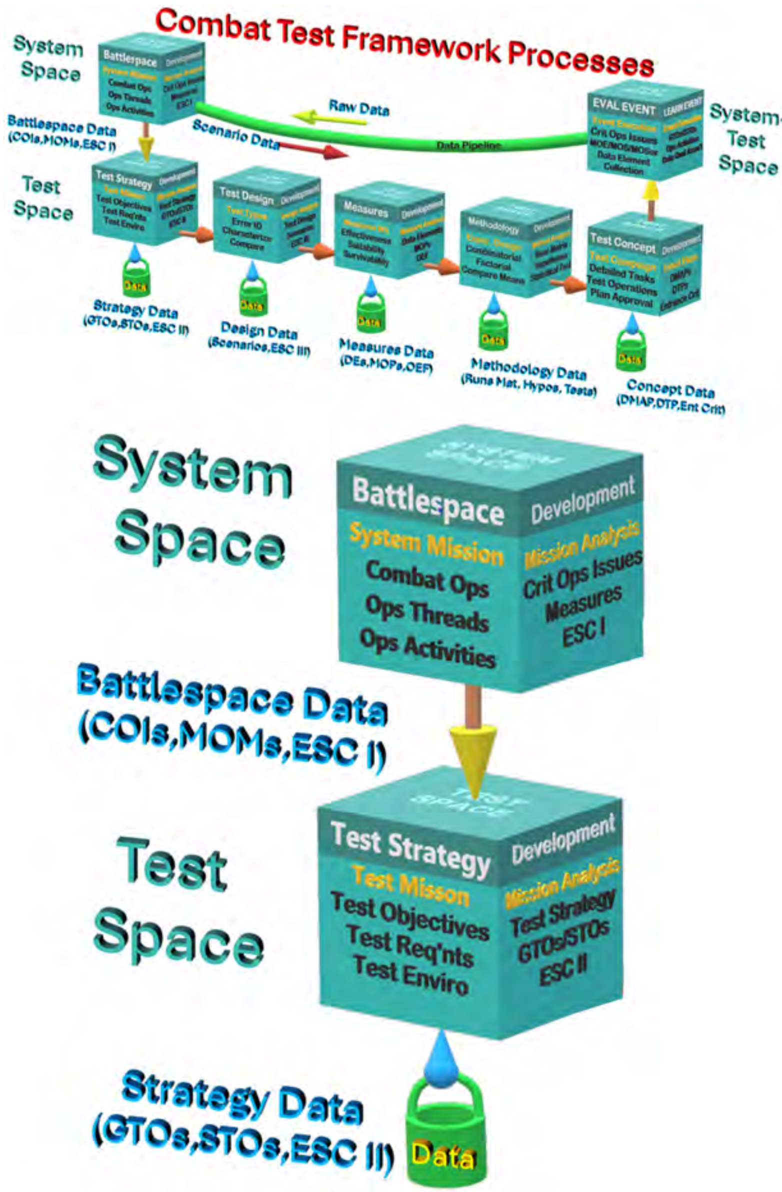

Figure 6-1. Illustration of the test strategy development phase, with inputs from the battlespace development. The yellow font addresses input from the previous phase. Mission research now focuses on the test mission, rather than the combat mission from battlespace development.

6.2.2 Test Engineers and Analysts

1. Using the overarching objective(s) from Battlespace Development, decompose them to General Test Objectives (GTOs) and align them to COs and COIs
2. Align the GTOs with COTs
3. Decompose general test objectives into specific test objectives (STOs) that evaluation and learning
4. Align STOs with Operational Activities (OAs)
5. Develop the Evaluation Summary Chart 2 (ESC2)

6.2.3 Test Team

1. Capture data as artifacts (i.e., mission statements, test objectives, etc.)
2. Assist in developing the test mission statement
3. Assist in developing /refining GTOs and STOs

Correspondence to Five-Paragraph OPLAN: Paragraph 2 - Mission

6.3 Test Strategy Template

EXAMPLE:

Test Campaign Strategy ID with classification markings, e.g. (U) MNC-I Operation Order 05-03

(U) References: Include documents that provide authorities and guidance for the order.

(U) TIME ZONE: (ZULU)

TEST ORGANIZATION: See Annex A (TEST Organization).

1. (U) Situation.

Description:

Describes current event: may include political situation and possible adversary forces in the expected area of operation, a brief description of the area of operation, actions of neighboring and/or friendly nations other and/or amplifying information as necessary.

1.A. (U) Assessment or General.

Description:

Describe the general politico-military environment that would establish the preconditions for execution. Identify the primary enemy and summarize the competing political economic, social/cultural and security (military) goals that could cause the conflict. State US policy goals and the estimated goals of other parties. Outline political decisions needed from other countries to achieve US policy goals and conduct effective US military operations to attain US military missions to include, but not limited to, theater access, weapons employment, participation in operations, and disclosure of information requirements.

1.B. (U) Area of Concern.

Description:

Describes the area for which the plan's designated commander is responsible. The designated commander for a plan may be the CCDR, a Joint Task Force Commander, a Commander of Combined/Multinational Forces, or any other commander designated.

Note: Other terms commonly used: (1) Area of Responsibility. Describes the area for which the plan's designated commander is responsible. (The designated commander for a plan may be the CCDR, a Joint Task Force Commander, a Commander of Combined/Multinational Forces, or any other commander designated); (2) Joint Operational Area. Describes the joint operational area. Description may be brief if Annex C will be included. (e.g., a list of latitude/longitude boundary points).

1.C. (U) Enemy.

Describes the enemy and provides details regarding the following categories. The categories listed provide a starting point but should be adapted to the situation.

- *(1) Centers of Gravity.*
  - *(a) Strategic.*
  - *(b) Operational.*
- *(2) Critical Factors.*
  - *(a) Strategic*
  - *(b) Operational*

(3) Courses of Action (COA). Provide both Most Likely and Most Dangerous COAs as it relates to the following:
   - *(a) General*
   - *(b) End State*
   - *(c) Strategic Objectives*
   - *(d) Operational Objectives*
   - *(e) Concept of Operations*

(4) Logistics and Sustainment
(5) Other Forces/Capabilities
(6) Reserve Mobilization

1.D. (U) Friendly.

Provides details regarding the following categories. The categories listed provide a starting point but should be adapted to the situation.

(1) Centers of Gravity.
   - *(a) Strategic (e.g. US Public Support, World Opinion, etc.)*
   - *(b) Operational (e.g. JTF Level: 3D MEB; JFMCC Level: CSF)*

(2) Critical Factors. (i.e. Critical Strengths, Critical Weaknesses)
   - *(a) Strategic*
   - *(b) Operational*

(3) Multinational Forces
(4) Supporting Commands and Agencies
(5) Operational Contract Support. Based on the commander's guidance for use of contractor support.

1.E. (U) Legal Considerations.

(1) International law, including the law of armed conflict
(2) Domestic law
(3) Host-nation and coalition laws
(4) Rules of engagement
(5) Status of forces agreements

Reference: CJCSM 3130.03A, C-A-1 (Orders Format)

Note: Other items that may be included: Operational Limitations (restraints – those things we cannot do, and constraints – those things we must do). List of actions prohibited or required by higher headquarters such as ROE, termination criteria, etc.; risk, legal concerns.

Note: The numbering shown in the MNC-I example does not align completely with this format. The paragraph numbers are as written in MNC-I OPORD 05-03. Each example is provided for content, not numerical alignment.

MNC-I Example:

1. (U) Situation. This order supersedes OPORD 05-02, 01 April 2005, and 05-02 Update, 01 July 2005, and serves as the base guidance for Multi-National Corps- Iraq (MNC-I) operations beginning 20 November 2005. As expected, conditions have changed over time and the course of operations. This order does not dictate significant course corrections from the previous operations order (OPORD) and Update. However, it incorporates emergent campaign planning at Multi-National Forces, Iraq and the United States Embassy, Baghdad (MNF- I/USEMB) and it reorganizes and restructures the content. The intent of this order is to provide necessary guidance to ensure MNC-I maintains operational and tactical momentum beyond the Iraqi National Elections and through the seating of the constitutionally elected Government of Iraq.1.A. (U) General. (U) Operation IRAQI FREEDOM (OIF) must be viewed in the context of the Global War on Terror and USCENTCOM's role in this effort. Relevant guidance is contained in the March 2005 USCENTCOM PLANORD "Posturing for the Long War" and its counterpart the August 2005 PLANORD "Countering Al Qaida and Associated Movements.

1.A.3. (U) Area of Concern.

1.A.3.A. (U) Area of Interest. The Area of Intertest is Iraq's neighboring countries and the broader Middle East, including both North Africa and the Horn of Africa, which generate and transmit Terrorists and Foreign Fighters (T&FF) into Iraq. The region contains allies and friends that support the mission (such as Kuwait, Turkey, Jordan, and Saudi Arabia…)

1.A.3.B. (U) Area of Operations. CG MNC-I is responsible for operations within the national borders of Iraq. The Area of Operations (AO) and force disposition is described in the figure below…)

1.B. (U) Enemy Forces.

1.B.1. (U) Terrorists and Foreign Fighters (T&FF). Terrorists and foreign fighters continue to be the greatest near-term threat to security in Iraq. They continue to demonstrate the ability to coordinate and execute precision suicide attacks and create the perception of instability within Iraq...

1.B.2. (U) Saddamist (SDM). Saddamists remain the facilitators for other groups. Their infiltration of local governments and security forces will ensure their influence over segments of the Sunni population. Intimidation and coercion of those who support the GOI at the local level remains their TTP…

1.B.4. (U) Most Likely Course of Action (MLCOA). The most likely course of action between December 2005 and July 2006 is the maintenance of the status quo. Attacks will average…

1.B.5. (U) Most Dangerous Course of Action (MDCOA). The most dangerous course of action is that the people quickly lose faith in the new GOI because it fails to provide the services…

1.C. (U) Friendly Forces. USCENTCOM and MNF-I/USEMB are the MNC-I higher headquarters…other friendly forces include the Iraq Security Forces (ISF), elements of the United Nations (UN), the Government of Iraq (GOI), and a range of international governmental and nongovernmental organizations…

Note: Refer to the Joint Guide for Joint Intelligence Preparation of the Operational Environment (JIPOE) for additional information on MLCOA, MDCOA, and COGs.

2. (U) Mission.

Description*:*

A concise statement of the task and purpose of the operation (usually one sentence). The mission statement is derived from Commander's intent and nested with higher headquarters operations order.

The mission statement describes the mission in terms of the elements of who, what, when, where, and why. The commander's operational *approach informs the mission statement and helps form the basis for planning. The commander includes the mission statement in the planning guidance, planning directive, staff estimates, commander's estimate, CONOPS, and completed plan.*

Reference: JP 5-0, III-20

MNC-I Example:

2. (U) Mission. MNC-I builds capable Iraqi Security Forces and conducts counterinsurgency operations to neutralize1 the insurgency and to defeat Al Qaida in Iraq in order to transition the security lead to Iraqi Security Forces and the Government of Iraq.

3. (U) Execution.

3.A. (U) Concept of Operations.

Note: *A COA is a potential way (solution, method) to accomplish the assigned mission. Staffs develop multiple COAs to provide commanders with options to attain the military end state. A good COA accomplishes the mission within the commander's guidance, provides flexibility to meet unforeseen events during execution, and positions the joint force for future operations. It also gives components the maximum latitude for initiative. All COAs must be suitable, feasible, acceptable, distinguishable, and complete. Reference: JP 5-0 Pg III-32*

Description*:*

A description of how the operation will be conducted to accomplish the mission. For a CCDR's contingency plan, the appropriate commander's estimate can be taken from the campaign plan and developed into a strategic concept of operation for a campaign or OPLAN. Otherwise, the CONOPS will be developed as a result of the COA selected by the JFC during COA development.

The concept should be stated in terms of who, what, where, when, why, and how. It also contains the JFC's strategic vision, intent, and guidance for force projection operations, including mobilization, deployment, employment, sustainment, and redeployment of all participating forces, activities, and agencies.) (Refer to annex C [Operations] in the CONOPS.

This section includes Commander's (CDR's) intent, purpose, end state, phasing, tasks, and coordinating instructions. It includes a narrative of the actions to be taken and a generic organization for combat (main and supporting effort, reserve, etc.). The concept of operations is the course of action approved by the commander during planning. It may be summarized here if a detailed concept of operations is contained in Annex C (Operations). The concept of operations provides a basis for supporting concepts such as:

(1) (U) Concept of Maneuver.

(2) (U) Concept of Fires.

(3) (U) Concept of Support.

(4) (U) Other Concepts as Required.

Reference: JP 5-0, A-5, CJCSM 3130.03A, C-A-2

MNC-I Example:

3.B. (U) Concept of the Operation. To ensure simplicity and unity of effort, MNC-I adopts the phasing convention of the MNF-I/USEMB Joint Campaign Plan and conducts operations aligned with the higher headquarters' lines of operation. Although MNC-I operational tasks fall primarily within the Security Line of Operation, all MNF-I/USEMB lines of operation are affected to some extent by MNC-I actions. Furthermore, MNC-I operations and allocation of forces within the MNC-I area of operations are characterized by the battlefield organization of decisive, shaping, and sustaining operations. MNC-I employs an effects-based methodology to achieve desired objectives and assess effectiveness of MNC-I operations.

3.A.1. (U) Commander's Intent.

Description*:*

This should describe the JFC's intent (purpose and end state), overall and by phase. This statement deals primarily with the military conditions that lead to mission accomplishment, so the commander may highlight selected objectives and their supporting effects. It may also include how the posture of forces at the end state facilitates transition to future operations. It may also include the JFC's assessment of the enemy *commander's intent and an assessment of where and how much risk is acceptable during the operation. The commander's intent, though, is not a summary of the CONOPS.*

The commander's intent identifies the major unifying efforts during the campaign or operation, the points and events where operations must succeed to control or establish conditions in the OE, and where other instruments of national power will play a central role. The intent must allow for decentralized execution. It provides focus to the staff and helps subordinate and supporting commanders take actions to achieve the military objectives or attain the end state without further orders, even when operations do not unfold or result as planned. While there is no specified joint format for the commander's intent, a generally accepted construct includes the purpose, end state, and risk.

3.A.1.A. Purpose and End State.

Description:

The purpose explains why the military action is being conducted. The purpose can help the force pursue the mission in the absence of further orders, even when actions do not unfold as planned. Thus, if an unanticipated situation arises, commanders understand the purpose of the action and can act decisively and within the higher commander's intent.

A military end state describes conditions that define mission success. It also describes how reaching the JFC's military end state supports higher headquarters' national objectives. The military end state normally represents a period in time or set of conditions beyond which the President does not require the military instrument of national power to achieve remaining national objectives. Commanders and planners constantly assess the stated military end state against the OE, resources, or policy.

Reference: DOD Dictionary, Pg 41; JP 5-0 Pg IV-18, I-19, I-20, A-5

MNC-I Example:

3.A. (U) Commander's Intent.

3.A.1. (U) Purpose. MNC-I continues operations to neutralize the insurgency, leadership and organizations, while developing the capacity for ISF to assume battlespace and conduct independent COIN operations. MNC-I must transfer battlespace to ISF accepting a moderate level of tactical risk while the Corps retains sufficient forces to allow ISF to mature. We must place emphasis on developing effective Iraqi Police Services (IPS) to assume the security lead in designated urban areas and to provide domestic law and order. MNC-I establishes the security environment to develop local economies, governance, and the rule of law. Finally, MNC-I must transition both battlespace and basing in a manner that postures CF in operational overwatch.

3.A.3. (U) End State.

(a) ISF have assumed battlespace and are capable of effective COIN operations
(b) Iraq's borders are under Iraqi control with ISF layered in-depth supported by CF enablers
(c) The insurgency is neutralized
(d) Al Qaida in Iraq is defeated
(e) Conditions are set for Provincial Iraqi Control (PIC)
(f) Coalition Forces and bases are smaller and postured for overwatch

3.A.1.B. (U) Objectives.

Description*:*

Objectives. Objectives and attainable goals are clearly defined, toward which operations are directed. They are specific, measurable, achievable, relevant, and time bound. Objectives are markers used to assess the strategy and develop decision points.

(a) At the operational level, CCDRs identify, prioritize, and sequence intermediate objectives that support the achievement of the national-level objectives and associated conditions to support attainment of military end states. Intermediate objectives help assess progress toward the longer-range objectives established by the NDS, NMS, or JSCP. As intermediate objectives are achieved, commanders and their staffs reassess their vision of the military end state (for contingencies), their progress toward the longer-range objectives, and the need to change or alter the objectives or methods. Intermediate objectives also represent multiple actions that occur between initiation of a CCP and the

achievement of campaign objectives. Intermediate objectives should identify discrete, identifiable, and measurable conditions or effects.

(b) At the tactical level, forces are arranged and employed to execute specific immediate tasks or missions. Although tactical tasks may not directly achieve operational or strategic objectives, the cumulative effects of the tactical events, coupled with operational and strategic events, should achieve those objectives. Both desired and undesired effects should be evaluated.

Reference: JP 5-0 Pg I-19

MNC-I Example:

3.A.1.B. (U) Objectives.

(1) Battle space transitioned

(2) ISF in the lead (Main Effort).

(3) Insurgency Neutralized, AQI Defeated

(4) Iraqis control the borders

3.A.1.C. (U) Effects.

Description:

Effects. An effect is a physical and/or behavioral state of a system that results from an action, a set of actions, or another effect. A desired effect can be thought of as a condition that can support achieving an associated objective and an undesired effect is a condition that can inhibit progress toward an objective.

Reference: JP 5-0 Pg IV-27

MNC-I Example:

3.A.4. (U) MNC-I Effects.

(1) Assured CF mobility. Defined as AIF is unable to prevent CF movement along MSR/ASR or disrupt CF sustainment operations

(2) IA battalions and brigades assume battlespace.

Defined as IA battalions and brigades at TRA Level 2 or higher plan and conduct COIN operations in assumed battlespace.

(3) AIF Leadership disrupted. Defined as: T&FF leadership is incapable of coordinating and employing foreign fighters and cannot effectively mass effects in space and time; SDM leadership is unable to receive financial support for operations; and IZR leadership is influenced to cooperate with GOI/ CF by improvement in basic services, increased employment, and overall quality of life improvements.

(4) Roads leading to the interior are controlled by ISF. Vehicle Check Points (VCPs) are established on the roads that lead from the border to the major urban areas in central Iraq; AIF movement to the Iraqi interior is disrupted by VCP.

3.A.2. (U) Courses of Action.

Description*:*

A COA is a potential way (solution, method) to accomplish the assigned mission. Staffs develop multiple COAs to provide commanders with options to attain the military end state. A good COA accomplishes the mission within the commander's guidance, provides flexibility to meet unforeseen events during execution, and positions the joint force for future operations. It also gives components the maximum latitude for initiative. All COAs must be suitable, feasible, acceptable, distinguishable, and complete.

3.B. (U) Tasks.

Description:

(1) List the tasks assigned to each subordinate commander in separate, numbered subparagraphs. Tasks are listed in order of priority or accomplishment. Tasks may be listed by phase. Designation of main effort or supporting effort is noted in tasking.

(2) Some actions are so critical that the commander may assign them as missions. These should be assigned as task and purpose (in order to . . .). Other actions are assigned simply as tasks because the purpose is understood. The commander assigns subordinate commanders tasks he deems necessary to fulfill his concept of operations.

(3) Unit or element task assignments are listed in the following order:

(a) Offensive operations: ground combat units or elements (infantry first followed by artillery and combat support units numerically or alphabetically), aviation combat units or elements (aircraft units, combat support, combat service support), combat service support units or elements.

(b) Defensive operations: units or elements closest to the enemy are listed first, ground and aviation combat units in the forward defense area are then listed in numerical order, other units are then listed alphabetically.

(4) Each task assignment may begin with the assets (attached or in support) available to the unit or element.

Reference: MCWP 5-10, Pg 139; CJCSM 3130.03A, G-C-5

MNC-I Example:

3.C. (U) Tasks.

3.C.1. (U) MNF–NW.

3.C.1.A. (U) O/O support MND-NC consolidation of MND-N NLT 30 DEC 05.

3.C.1.B. (U) Employ Weapons Intelligence Team (WIT) teams to assess infrastructure attacks as required.

3.C.2. (U) MND–B.

3.C.2.A. (U) Assume responsibility for Babil, Najaf, and Karbala Provinces NLT 5 Jan 06.

3.C.2.B. (U) Continue operations to protect the Iraqi Council of Representatives (COR).

3.C.2.C. (U) Assume security force tasks IAW MNC-I SECFOR Realignment Plan NLT 08 JAN 05. (See Appendix 13, Annex C).

3.C.2.D. (U) Provide Middle Ring Security for UNAMI operations in Baghdad until relieved.

3.C.3.E. (U) Employ Weapons Inspection Teams (WIT) to assess infrastructure attacks as required.

3.C. (U) Coordinating Instructions.

Description:

List the instructions applicable to the entire command or two or more elements of the command that are necessary for proper coordination of the operation but are not appropriate for inclusion in a particular annex. Explain terms pertaining to the timing of execution and deployments. Also explain other operational terms that are not defined in Joint Staff publications.

Reference: JP 5-0 Pg A-7

MNC-I Example:

3.D. (U) Coordinating Instructions.

3.D.1. (U) Tasks Common to All.

3.D.1.A. (U) Continue partnership to develop ISF units to TRA Level 2 IOT transition battlespace and security lead.

3.D.1.B. (U) Conduct IO to drive a wedge between the AIF and the Iraqi population (See Appendix 11, Annex C).

3.D.1.C. (U) Establish security conditions ISO provincial elections as required.

3.D.2. (U) Commander's Critical Information Requirements (CCIR). (See Appendix 2, Annex C).

3.D.3. (U) Definitions.

3.D.3.A. (U) Neutralize the Insurgency. Neutralization is achieved when insurgent capability to conduct and sustain operations is degraded to the point the Iraqi Army (IA) can plan and conduct counter-insurgency (COIN) operations in their own battlespace with coalition forces in overwatch providing required enablers

3.D.3.B. (U) Control of the Iraqi Border. The following five conditions define Iraqi control of the IZ border:

1 (U) DBE forces deployed in border forts along the entire Iraqi border enforcing border laws and disrupting the cross-border transit of T&FF.

2 (U) IA postured in-depth, integrated with DBE forces and prepared to respond to DBE requests for assistance.

3 (U) Roads leading to the Iraqi interior are controlled with ISF using vehicle checkpoints to disrupt T&FF freedom of movement.

4 (U) Accommodation with local tribes.

5 (U) Official Ports of Entry (POE) are open and effectively enforce Iraqi border and immigration laws. (MNSTC-I has the lead for POE).

3.D.3.C. (U) Denied Sanctuary. Enemy sanctuary is denied if a commander assesses that the enemy benefits of sanctuary as defined above no longer exist and a coalition force platoon can operate in that area at moderate risk.

4. (U) Force Sustainment.

Description:

Provide a statement of the administrative and logistic arrangements or requirements. Include transportation, marshaling, billeting, clothing, equipment, and special operational funds as appropriate.

4.A. (U) Concept of Sustainment.

Description:

This should provide broad guidance for the theater strategic sustainment concept for the campaign or operation, with information and instructions broken down by phases. It should cover functional areas of logistics, transportation, personnel policies, and administration.

4.B. (U) Logistics.

Description:

This paragraph addresses the CCDR's logistics priorities and intent: basing, combat, general, and geospatial engineering requirements, HNS, required contracted support, environmental considerations, mortuary affairs, and Service responsibilities. Identify the priority and movement of logistic support for each option and phase of the concept.

4.C. (U) Personnel. Refer to annex E (if published).

Description*:*

Identify detailed planning requirements and subordinate taskings. Assign tasks for establishing and operating joint personnel facilities, managing accurate and timely personnel accountability and strength reporting, and making provisions for staffing them. Discuss the administrative management of participating personnel, the reconstitution of forces, command replacement and rotation policies, and required capabilities and functions to command headquarters and other operational requirements.

4.D. (U) Public Affairs. Refer to Annex F.

Description*:*

Identify key public affairs considerations. Otherwise, provide a summary and include the details in Annex F.

4.E. (U) Civil–Military Operations. Refer to Annex G.

Description:

Identify key civil affairs considerations. Otherwise, provide a summary and include the details in Annex G.

4.F. (U) Meteorological and Oceanographic Services. Refer to Annex H.

Description:

Identify key METOC considerations. Otherwise, provide a summary and include the details in Annex H.

4.G. (U) Geospatial Information and Services. Refer to Annex B.

Description*:*

Identify key geospatial considerations. Otherwise, provide a summary and include the details in Annex B, Appendix 7, Tab A.

4.H. (U) Health Service Support. Refer to Annex Q.

Description*:*

Identify planning requirements and subordinate taskings for joint health services functional areas. Address critical medical supplies and resources to include military working dog patient and movement. Assign tasks for establishing joint medical assumptions and include them in a *subparagraph. Otherwise, provide a summary and include details in Annex Q.*

Reference: JP 5-0 A-7, CJCSM 3130.03A, F 8,9;

MNC-I Example:

4. (U) Administration and Logistics.

4.A. (U) Logistics. MNC-I develops sustainment plans, policies and procedures, and postures logistics assets across Iraq in order to support the development of Iraqi Security Forces, while retaining flexibility to support counterinsurgency operations. Key to success is gaining efficiencies in fixed site operations through contracts and LOGCAP support, while retaining expeditionary capability to support operations as required throughout Iraq without loss of momentum. Also critically important is development of concepts to support transition teams arrayed across Iraq while minimizing the logistics footprint. While tactical level logistical support remains a service responsibility, every effort should be made to maximize efficiencies gained through common item support.

4.A.1. (U) Concept of Coalition Support. CFLCC provides EAC CSS, JRSOI, and Title X support to MNC-I through service channels. COSCOM provides general common item support to all services and Coalition Forces as required, IAW acquisition and cross servicing agreements (ACSA)…

4.A.2. (U) Support to Iraqi Security Forces. MNC-I develops IA logistics capability through partnership and doctrine development while providing direct support as required preventing mission failure. Development of institutional and higher-echelon logistics capability in the ISF is critical to Iraqi self-sufficiency...

4.A.3. (U) Support to Other US Agencies. Coalition Forces and United Nations. MNC-I may be required to provide common item support, if available, to other US agencies or the United Nations, in accordance with applicable MOUs…

4.B. (U) Personnel. (See Annex E.)

4.C. (U) Public Affairs. (See Annex F)

4.D. (U) Civil Affairs. (See Annex G)

4.E. (U) Meteorological and Oceanographic Services. (See Annex H).

5. (U) Command, Signal, and Communications.

Description*:*

Summarize the command arrangements to be employed on execution. Include agreements in place or planned with other government agencies and summarize their respective roles and responsibilities.

5.A. Command.

5.A.1. (U) Command Relationships.

Description*:*

State the organizational structure expected to exist during plan implementation. Indicate any changes to major C2 organizations and the time of expected shift. Identify all command arrangement agreements and memorandums of understanding used and those that require development.

5.A.2 (U) Command Posts.

Description*:*

List the designations and locations of each major headquarters involved in execution. When headquarters are to be deployed or the plan provides for the relocation of headquarters to an alternate command post, indicate the location and time of opening and closing each headquarters.

5.A.3. (U) Succession to Command.

Description:

Designate in order of succession the commanders responsible for assuming command of the operation in specific circumstances.

5.B. (U) Command, Control, Communications, and Computer Systems.

Description:

Provide a general statement concerning the scope of communications systems and procedures required to support the operation. Highlight any communications systems or procedures requiring special emphasis.

Reference: JP 5-0, A-8, CJCSM 3130.03A, D-A-4, F-10

MNC-I Example:

5. (U) Command and Control.

5.A. (U) Command. The Commanding General of MNC-I exercises OPCON or TACON of designated forces. MNC-I is OPCON to MNF-I and is headquartered at Camp Victory.

5.A.1. (U) Command Relationships. (See Annex J). MNC-I will establish a partnering relationship at the Division, Brigade, and Battalion levels to advise and support Iraqi Army units at the appropriate echelon. MNC-I also establishes partnership with the Iraqi Police Services at the Provincial Police Headquarters, District Police Headquarters and Police Station level to develop IPS capacity. Police Transition Teams (PTT) are TACON to the MSC to train, coach and mentor IPS. The IPLO assigned to PTT are TACON to the MSC through the PTT and ADCON to MNSTC-I (CPATT) for administration of all personnel matters with the IPLO contractor…

5.A.2. (U) Succession of Command. CG, MNC-I then the senior US MSC CG.

5.B. (U) Control. (See Annex K.) MNC-I will continue to conduct coalition coordination and command through CENTRIX. Communications support will now transition to cross domain solutions and the installation of FusionNet down to the BDE level. The IAG will conduct administration and coordination of the transition teams over CENTRIX / SIPR and NIPR data networks…

(U) OFFICIAL:

Signature block of Approving Officer

APPENDIX A: ESC 1

7 Test Design Development

During the Test Design phase, the test team derives a test design(s) based on the test objectives established in the Test Strategy. Table 7-1 provides the most common tests designs based on test objectives and actions.

Table 7-1. Types of Tests per DAFI 99-103

Test Objectives	Action	Test Design
Characterize a System or Process over a Region of Interest	To measure the response across a design space *or battlespace*.	**System Characterization**
Detect Problems (Errors, Faults, SW Bugs, Cybersecurity vulnerabilities)	To determine what combinations and levels of factors create undesirable responses.	**System Error Identification**
Comparing System or process functionality	To determine if two systems perform similarly or if a system meets required thresholds	**System Comparison**
Process System Optimization	To find the factor levels that result in a desired response.	**System Optimization**
Screening for Important Factors	To learn which factors have the most influence on the response.	**Factor Screening**
Confirm system functionality	To verify the system behavior is consistent with theory or experience.	**Function Confirmation**

7.1 Inputs from Test Strategy

- Test Strategy
- Test Objectives: GTOs and STOs
- Evaluation Summary Chart II (ESC II)

7.2 Output

- Test design
- Scenarios
- Evaluation Summary Chart III (ESC III)

Figure 7-1. Test Design phase with scenario development as input

7.3 Responsibilities

7.3.1 Test Project Officer

- Affirms the test design based on the test objectives in the Test Strategy

- Ensures resource are available and accessible (i.e., digital twin, simulation data, etc.)

7.3.2 Test Engineers and Analysts

- Based on guidance in DAFI 99-103, determine appropriate test design (see Table).
- TOs from Battlespace Development and Test Strategy drive test type(s)
- Plans for al test types that may be required for evaluation the SUT
- Software testing will usually require error identification

NOTE: Some teams may develop experimental designs as a part of this phase depending on how well their test objectives are established. The caution is NOT to leap to a DOE before determining the objectives of the test. When this is the case, refer to the Methodology Phase for details.

Correspondence to Five-Paragraph OPLAN: Paragraph 3.B.2. Objectives

8 Test Measures Development

During this phase, the test team finalizes measures, thresholds, objectives, etc. Given the Evaluation Summary Charts (ESCs) from previous phases, produce a Final ESC, which becomes the Operational Evaluation Framework (OEF).

Figure 8-1. Test Measures development phase model with inputs from Test Design

8.1 Inputs

- Test Design (combinatorial, factorial, paired t-tests)
- Test scenarios
- Evaluation Summary Chart III (ESC III)

8.2 Output

- Data Elements
- MOPs with Thresholds
- OEF

8.3 Responsibilities

8.3.1 Test Project Officer

- Schedules a measures workshop
- Coordinates the workshop with relevant stakeholders, i.e., DT, SMEs (FFRDC), SPO, DOT&E, etc.
- Conducts or delegates the authority to conduct the measures workshop

Correspondence to Five-Paragraph OPLAN: Paragraph 3.B.2. Objectives

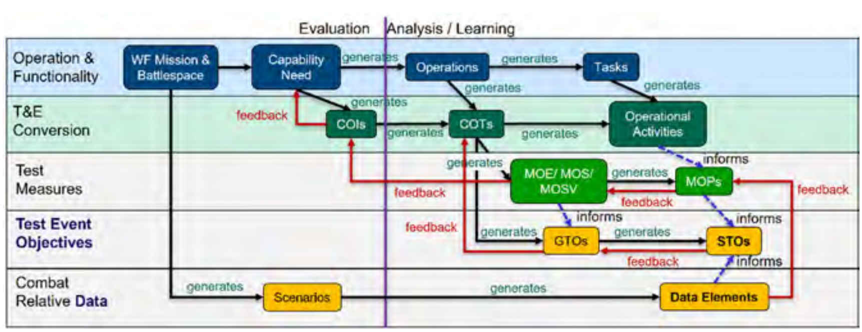

Figure 8-2. Evaluation and Learning MOMs under the CTF

8.4 STARCOM T&E Framework.

An effective evaluation framework is a logical and efficient way to plan test events and report on results, and a consistent application of the basic structure will better frame the narrative on system performance and capabilities for our customers. As seen in ***Figure 8-3***, test teams will use a dendritic approach to design tests, with a decomposition of the higher tiers into constituent parts in the tier directly below. When reporting, the results within each tier will roll up to the next level in the hierarchy. DEL 12 may add additional tiers and measure types within tiers as desired, but they must do so with an eye on the objective of efficiently determining and reporting on the system's performance for the decision authorities and warfighting customers of STARCOM's T&E event reports.

- **Tier 1 – Operational Effectiveness, Suitability, and Survivability** (ES&S) determinations, for effectiveness, suitability, and survivability, are dependent on expected system performance under operationally realistic threat conditions and environments. Operational ES&S determinations will support the Overall Mission Capability determination when used.
- **Tier 2 – Critical Operational Issues** are evaluated by identifying measures of effectiveness, suitability, and survivability for analysis and using their associated ratings. Critical Operational Issue evaluations will support Operational ES&S determinations.

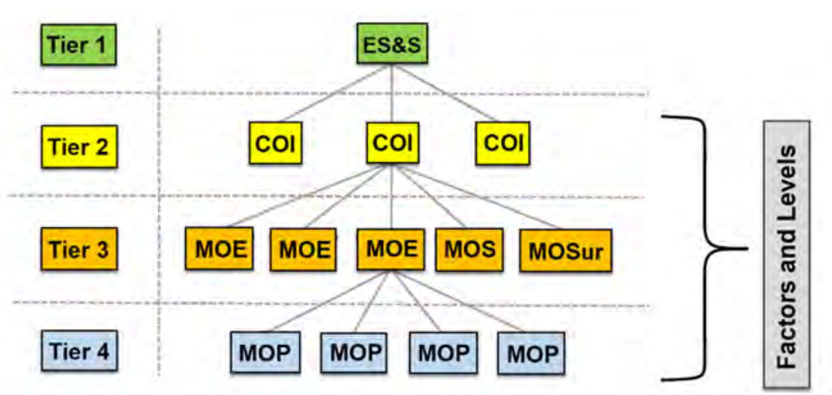

Figure 8-3. Dendritic approach to ES&S decomposition by tiers

- **Tier 3 – Measures of Effectiveness**, Suitability, and Survivability are rated by identifying Measures of Performance for analysis; alternatively, they may be measured, analyzed, and rated directly. Measure of Effectiveness, Suitability, and Survivability ratings will support Critical Operational Issue evaluations.
- **Tier 4 – Measures of Performance** generally support Tier 3 ratings, but sometimes also Tier 2 ratings

8.5 STARCOM T&E Rating Taxonomy.

Use the following T&E rating taxonomy in ***Figure 8-4*** to rate any supporting test measures, evaluate COIs, and determine system ES&S. The rating taxonomy applies to measures rated against identified objective and threshold criteria as part of a test campaign and identified in the test strategy. This rating taxonomy does not prevent test teams from reporting on combat system characterization data. Characterization will occur at every level of the reporting process. Additionally, it is important to note that the colored bubbles are a visualization indicator for test team use to easily convey system performance and are not the system rating.

Rating		Definition
B	No operational impact	No effectiveness or suitability shortfalls identified that impact capability
G	Minimal operational impact	Effectiveness or suitability shortfalls identified with minimal impact on capability
Y	Substantial operational impact	Effectiveness or suitability shortfalls identified with substantial impact on capability
R	Severe operational impact	Effectiveness or suitability shortfalls identified with severe impact on capability
	Not evaluated	Insufficient information to support an evaluation

Figure 8-4. T&E Ratings and Visual Indicators

A mission capable (MC) determination is an optional rating provided to accompany the ES&S rating and is intended to indicate the system under test's overall capability to execute or support the tasked mission. An MC determination is most useful during operational acceptance of a system by the operational community. If an MC rating is provided, the rating taxonomy in ***Figure 8-5*** will be used.

8.6 STARCOM Rating Decision Flow Guidance.

The figure below provides guidance on how to reach the ratings defined in ***Figure 8-6*** in a combined decision flow chart. As seen in Figure 4, the foundation for all test reporting starts with the measures for the system under test. The ratings of test measures, with consideration given to open deficiency reports (DR), experience, and judgment, contribute to the COI evaluation, and inform the test team evaluation of how the system under test performs within each COI. The combined COI evaluations will then help the test team to determine whether the system under test is Effective, Suitable, and Survivable.

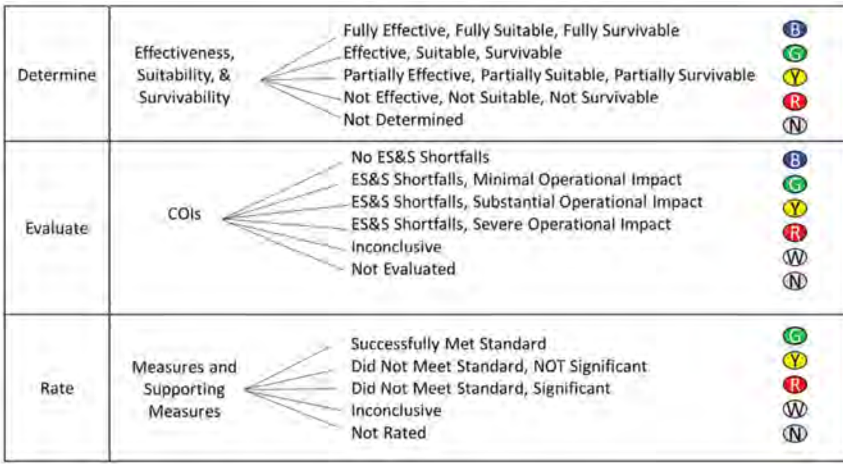

Figure 8-5. Mission Capable T&E Rating Taxonomy and Visual Indicator

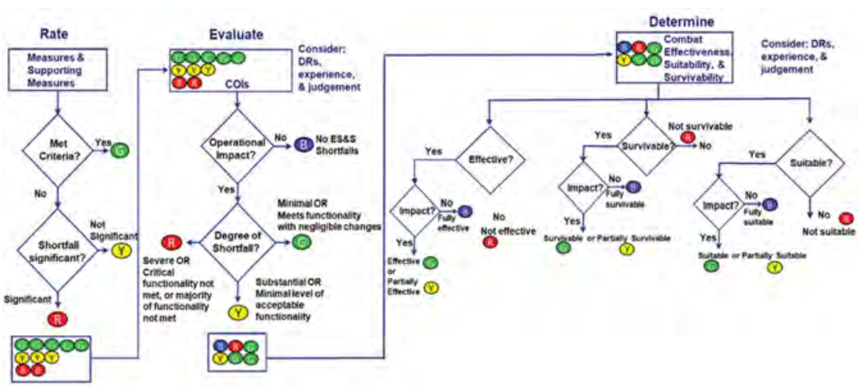

Figure 8-6. Rate, Evaluate, and Determine Decision Flow Chart

8.7 Anatomy of a Measure

With Table 8-1 as a basis, we will now explain how measures are developed, related, decomposed, and so on. There are two parts to measures: (1) measures that are evaluated (Measures of Merit), and (2) Measures for learning or test objectives.

Table 8-1. The Anatomy of Measures

Test Campaign Measures	**Test Event Objectives**
Does the System Under Test (SUT) provide capability as intended?	What can we learn about the SUT's combat operational capabilities
1. Capability Needs/Gaps • Capability Needs Statement • Initial Capabilities Document (ICD) • Capabilities Development Document (CDD) • Minimal Viable Product (MVP) - Agile • Minimal Viable Capability Release (MVCR) – Agile • SW-ICD	A. Same as Measures + • CONOPS OPLANS • INTEL
2. Critical Operational Issues • Can the SUT **effectively** provide the needed capability? • Is the SUT **sufficient** in providing the needed capability? • Is the SUT capability **survivable**?	B. Characterize the capability delivery. • Why is it effective? • Why is it suitable? • What is it survivable?
3. Combat Operational Threads (COTs) or Mission Threads • What operations/missions must the system perform to be combat effective? • Agile 101 Primer	C. General Test Objectives (GTOs) • Subject/Objective Verb/Expected Outcome • The Test Team will investigate the capability delivery to characterize its operation
4. MOEs/MOSs/MOSVs • Correlates to COTs • Disaggregated by MOPs	D. Operational Activities • What activities are required to perform the operation/mission?
5. MOPs • Performance metric • Single calculation, outcome, action • Aggregated to Assess MOEs	E. Specific Test Objectives (STOs) • Derived from operational activities. • Stated as objectives (like GTOs) • Aggregated to accomplish GTOs
6. Data Element	F. Scenarios • Defined by the battlespace.

• Single element that provides evidence for specific performance • Output of a combat scenario • E.g., State vector, orbit shape, object type, etc.	• Provide data for operational activities ⇦

8.8 Test Campaign Measures (left column)

When we plan for operational testing of software systems, we plan a test campaign (OUE, OA, etc.) comprised of multiple test events based on capability delivery and program objectives. At the campaign-level, we want to know whether of not the SUT provides the needed capability.

8.8.1 (1) Capability Need Process

The capability need is provided by the Capability Needs Statement (CNS), resulting from the Joint Requirements Oversight Council (JROC).

Programs executing the software acquisition pathway are not subject to the Joint Capabilities Integration and Development System (JCIDS) and will be handled as specifically provided for by the Vice Chairman of the Joint Chiefs of Staff, in consultation with Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) and each service acquisition executive. Software development will be done in active collaboration with end users, representing key user groups, to ensure software deliveries address their priority needs, maximize mission impact, and undergo regular assessment of software performance and risk. (OUSD (A&S), 2020, p. Section 1.2)

MVP: An early version of the software to deliver or field basic capabilities to users to evaluate and provide feedback on. Insights from MVPs help shape scope, requirements, and design. (OUSD (A&S), 2020)

MVCR: The initial set of features suitable to be fielded to an operational environment that provides value to the warfighter or end user in a rapid timeline. The MVCR delivers initial warfighting capabilities to enhance some mission outcomes. The MVCR is analogous to a minimum marketable product in commercial industry. (OUSD (A&S), 2020)

SW-ICD: SWP programs that Joint Staff views as having "Joint Equities" are required to use a Software Initial Capabilities Document (SW-ICD) to capture high level needs. Those that don't have Joint Equities can use the Capability Needs Statement (CNS) via their Service/Agency requirements process.

8.8.2 (2) Critical Operational Issues.

Critical Operational Issues (COIs) are key operational effectiveness or suitability issues that must be examined in operational test and evaluation to determine the system's capability to perform its mission.

- COIs must be relevant to the required capabilities and of key importance to the system being operationally effective, operationally suitable, and survivable, and represent a significant risk if not satisfactorily resolved.
- A COI/COIC is normally phrased as a question that must be answered in the affirmative to properly evaluate operational effectiveness (e.g., "Will the system detect the threat in a combat environment at adequate range to allow successful engagement?") and operational suitability (e.g., "Will the system be safe to operate in a combat environment?).
- COIs/COICs are critical elements or operational mission objectives that must be examined, are related to Measures of Effectiveness (MOE) and Measures of Suitability (MOS) and are included in the Test Campaign Strategy.
- System effectiveness, suitability, and survivability are evaluated at the COI level.

8.8.3 (3) Combat Operational Thread

Definition: A series of operational tasks that relate initiatives and/or improved infrastructure systems to one or more C2 processes (Hamilton, Euker, Solterbeck, & Wright, 2002)

Characteristics

- A design feature of the experiment; used by Capability Development Teams to assess contribution of potential solutions to capability gaps.

- Should be represented by an operational architecture and supporting systems views
- Facilitates transition within the Joint Capabilities Integration and Development System (JCIDS) (OV-6C)
- Observable and measurable; defines specifically what the assessment team will examine.

8.8.4 (4) Measures of Effectiveness (MOEs)

Measure of Performance (MOP) — A criterion used to assess friendly actions that are tied to measuring task accomplishment. (Curtis E. Lemay Center, 2016)

At their most basic level, MOEs should be developed to measure those items of information within the operational environment that give signs of progress toward creating the conditions described in the commander's endstate. MOEs are evaluated using subordinate measurement tools called indicators, which are items of information related to the MOE. Each of the conditions may be measured by one or more MoEs, while each MOE may be informed by one or more indicators (MOPs). (Westphal & Guffey, 2019)

Measures of Effectiveness (MOEs) assess changes in system behavior, capability, or operational environment that is tied to measuring the attainment of an end state, achievement of an objective, or creation of an effect. (Andress & Winterfeld, 2014)

- They do not measure task performance.
- MOEs are assessed using the aggregate of multiple measures of performance (MOPs)
- When evaluating a COI or combat assessment we need to evaluate it based on the impact the MOE will have.
- MOEs should use assessment metrics that are relevant, measurable, responsive, and resourced so there is no false impression of task or objective accomplishment.

8.8.5 (5) Measures of Performance

Measures of Performance (MOPs) are indicators that are used to inform the evaluation of MOEs. This is another task that is simple in theory but difficult in practice, especially in complex operational environments. (HQDA, 2019)

- Joint and Army doctrine defines and use indicators in different ways, and Army doctrine's guidance is fragmented throughout several manuals.
- Understanding doctrine's approach to developing indicators is critical to the success of assessment efforts.
- ADRP 5-0 recommends that a mix of quantitative and qualitative indicators are used to evaluate MoEs to mitigate the risk of misinterpretation and overcome the limits of raw data in understanding complex situations.
- The data satisfying a measure should be observable, or at least inferable.
- The measurements can be quantitative (numerical) or qualitative (non-numerical).
- In general, the more objectively measurable the better, but commanders and planners should avoid "the numbers trap:" blindly using rates, numbers, and other quantitative metrics, especially in assessing effects.

8.8.6 (6) Data Elements

A basic unit of information that has a unique meaning and subcategories (data elements) of distinct value. Examples of data elements include gender, race, and geographic location. A data element is the smallest named item of data that conveys meaningful information. (OSD, 1991)

- Describe the means to satisfy all data requirements.
- Provide the data required for answering the indicators.
- Includes data elements and data values that are required to be unique to the operation of equipment and software that are an integral part of a planned acquisition.
- Generate data with appropriate combat relevant scenarios.
- Take advantages of the efficiency and speed of data pipelines.

8.9 Test Event Objectives (right column)

When we plan for operational testing of software systems, we plan a test campaign (OUE, OA, etc.), that is comprised of one or more test events. Test Events can serve two purposes:

1. Evaluate partial capability deliveries when "just-in-time" operational data is generated
2. Learn about the SUT when used in a Combat Relevant Environment or a Digital Twin

The second goal is represented by the Right column.

8.9.1 (A) Capability Needs:

The sources of capabilities are the same as they are for test campaign measures.

MVP: An early version of the software to deliver or field basic capabilities to users to evaluate and provide feedback on. Insights from MVPs help shape scope, requirements, and design. Reference Source: DODI 5000.87 Glossary

MVCR: The initial set of features suitable to be fielded to an operational environment that provides value to the warfighter or end user in a rapid timeline. The MVCR delivers initial warfighting capabilities to enhance some mission outcomes. The MVCR is analogous to a minimum marketable product in commercial industry. (OUSD (A&S), 2020)

8.9.2 (B) Characterize the capability delivery.

This is where we tell the warfighter what we've learned the system will do or not do. Example, the sensor can be pointed by the down-angle limit is too restricted.

8.9.3 (C) General Test Objectives (GTOs)

GTOs are stated test objectives at the level of a COT

- GTOs are comprised of a subject (who), an objective verb (what) and an expected outcome (what); the When and Where are optional.

- Since GTOs are at the COT-level, each one also corresponds to an MOE.
- GTOs are learning objectives and are written in the operator /warfighter vernacular.

8.9.4 (D) Operational Activities

Operation Activities are those activities that are required to perform an operation. Operational activities may be thought of a sub-thread of the COTs.

8.9.5 (E) Specific Test Objectives (STOs)

STOs are stated objectives at the level of an MOP

- An STO is not required for all MOPs associated with and MOE; rather, they are required for specific MOPs being measured in a test event.
- STOs are not used to make evaluations of measures.
- STOs are learning objectives.
- STOs are intended for learning about the operational activities, i.e.,
- Do we have the right operational activities for particular COT
- Are more or fewer operational activities adequately cover a COT

Note: When a SUT has one or two COTs, there may be a need to aggregate STOs to the GTO level. That is, there may be no STOs for a Test Event. Also, other tailoring may be required for some test events.

8.9.6 (F) Scenarios

Scenarios are design to provide the data elements required for evaluating the SUT.

- Scenarios must be combat relevant.
- Scenarios are developed to be inclusive of all MOPs within a COT
- An individual scenario may provide data elements for more than one COT.

8.10 Additional Supporting Information

8.10.1 CNS Details

The CNS initiates the capability requirements for an acquisition in the form of an Initial Capabilities Document (ICD) or Minimal Viable Product (MVP) in the case of DevSecOps programs. The Initial Capabilities Document (ICD) documents the results of JCIDS analysis (commonly a CBA or other study) that the appropriate authority validates prior to the Materiel Development Decision (MDD). The operational attributes identified in the ICD are **mission**, not system specific, and also inform the Analysis of Alternatives (AoA) conducted during the MSA phase.

The results of the AoA then inform the development of a draft Capabilities Development Document (CDD) to support Milestone A and inform the Request for Proposal (RFP) for the Technology Maturity and Risk Reduction (TMRR) phase contract. This draft CDD contains performance attributes, to include KPPs, KSAs and APAs that reflect the capability requirements for the solution selected at Milestone A. Toward the end of the TMRR phase, the prototyping and other activities (to include an AoA update, when appropriate) provide information to update the draft CDD that ultimately results in a validated CDD prior to the Development RFP Release Decision. This validated CDD in-turn informs the RFP for the EMD phase. Also, the KPPs from this validated CDD are inserted verbatim into the APB approved by the MDA at Milestone B.

The validated CDD then drives Engineering and Manufacturing Development (EMD) phase activities. After the system-level critical design review (CDR), this CDD is updated, which is then validated prior to Milestone C. For an incremental acquisition program, the CDD may contain performance attributes for more than one increment. CDD's may also contain annexes for variants of a base system, where the base CDD includes the common requirements, and the variations of the Family of Systems (FoS) are contained in the annexes. (OUSD (A&S), 2020)

Programs executing the software acquisition pathway are not subject to the Joint Capabilities Integration and Development System (JCIDS) and will be handled as specifically provided for by the Vice Chairman of the

Joint Chiefs of Staff, in consultation with Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) and each service acquisition executive. Software development will be done in active collaboration with end users, representing key user groups, to ensure software deliveries address their priority needs, maximize mission impact, and undergo regular assessment of software performance and risk. (OUSD (A&S), 2020)

Programs using the software acquisition pathway are not subject to JCIDS, except pursuant to a new process as discussed in Paragraph 2.8.a., but must be effective in capturing users' needs, priorities, and environment.

8.10.2 Test Campaigns versus Test Events

Definition of military campaigns:

Campaigning. The persistent conduct of related operations, activities, and investments that align military actions with the other instruments of national power, supporting global integration across the competition continuum in pursuit of strategic objectives. (Joint Force Development, 2022)

Campaigns seek to shape the OE and achieve national objectives. They establish operations, activities, and investments the command undertakes to achieve specific objectives (set conditions) in support of national policy and objectives. Combatant Command (CCMD) campaigns are proactive and rarely feature a single measure of military success implying victory in a traditional sense and may include operations across the competition continuum to include ongoing combat operation. (US Army War College, 2023)

8.10.3 MVP & MVCR Details

The PM and the sponsor will use an iterative, human-centered design process to define the minimum viable product (MVP) recognizing that an MVP's definition may evolve as user needs become better understood. Insights from MVPs help shape scope, requirements, and design. (OUSD (A&S), 2020)

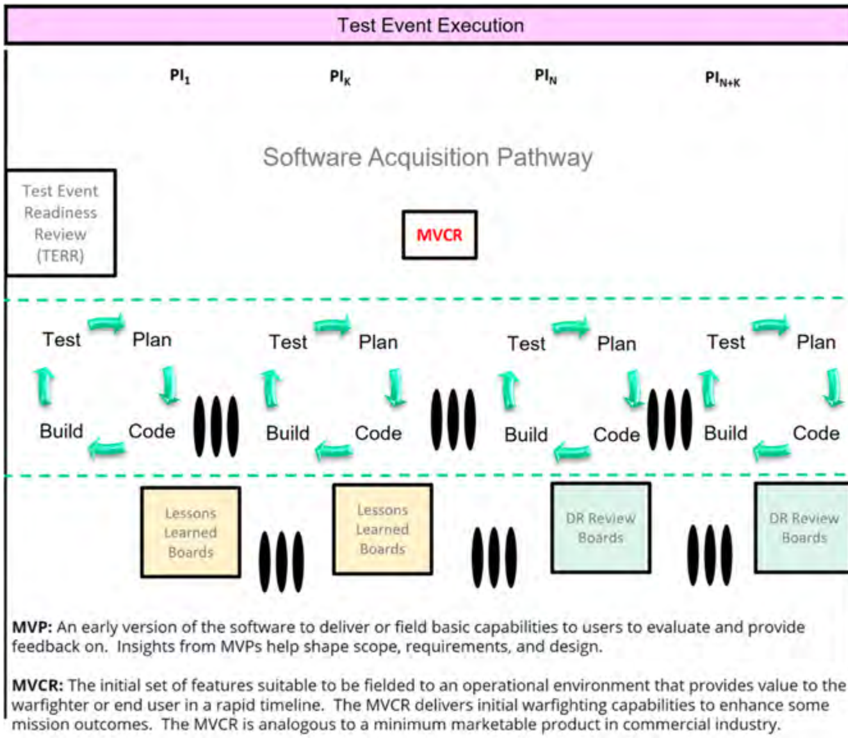

Figure 8-7. Test Campaign decomposed to multiple test events

The PM and the sponsor will use an iterative, human-centered design process to define a minimum viable capability release (MVCR) if the MVP does not have sufficient capability or performance to deploy into operations. The MVCR delivers initial warfighting capabilities to enhance mission outcomes. The MVCR for applications programs must be deployed to an operational environment within 1 year after the date on which funds are first obligated to acquire or develop new software capability including appropriate operational test. If the MVP version of the software is determined sufficient to be fielded for operational use, the MVP will become the MVCR. (OUSD (A&S), 2020)

MVP: An early version of the software to deliver or field basic capabilities to users to evaluate and provide feedback on. Insights from MVPs help shape scope, requirements, and design.

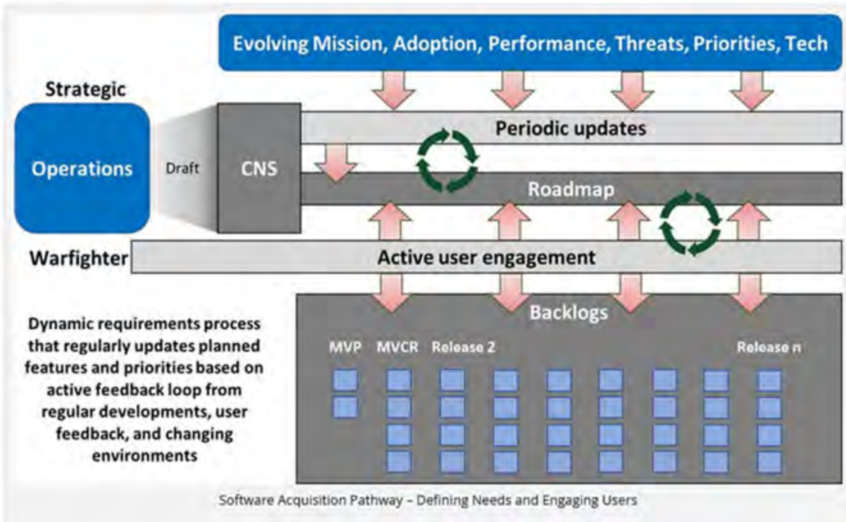

Figure 8-8. Dynamic requirements process with active warfighter engagement

MVCR: The initial set of features suitable to be fielded to an operational environment that provides value to the warfighter or end user in a rapid timeline. The MVCR delivers initial warfighting capabilities to enhance some mission outcomes. The MVCR is analogous to a minimum marketable product in commercial industry. (OUSD (A&S), 2020)

The PM and the sponsor will use an iterative, human-centered design process to define the minimum viable product (MVP) recognizing that an MVP's definition may evolve as user needs become better understood. Insights from MVPs help shape scope, requirements, and design.

The PM and the sponsor will use an iterative, human-centered design process to define a minimum viable capability release (MVCR) if the MVP does not have sufficient capability or performance to deploy into operations. The MVCR delivers initial warfighting capabilities to enhance mission outcomes. The MVCR for applications programs must be deployed to an operational environment within 1 year after the date on which funds are first obligated to acquire or develop new software capability including appropriate operational test. If the MVP version of the software is determined sufficient to be fielded for operational use, the MVP will become the MVCR.

8.10.4 SW-ICD Details

SW-ICD: SWP programs that Joint Staff views as having “Joint Equities” are required to use a Software Initial Capabilities Document (SW-ICD) to capture high level needs. Those that don’t have Joint Equities can use the Capability Needs Statement (CNS) via their Service/Agency requirements process. It is recommended SWP programs work with their Service/Agency requirements headquarters organizations to get an early “read” from Joint Staff on the Joint equities determination before proceeding with the SW-ICD or CNS. (Joint Staff, J-8, 2021)

The SW-ICD shall be constrained to 10 pages or less. Given the dynamic nature of modern software development, the capability needs/requirements will be iteratively defined, shaped, and prioritized via product roadmaps and program backlogs throughout the development lifecycle.

SWP programs that Joint Staff views as having “Joint Equities” are required to use a Software Initial Capabilities Document (SW-ICD) to capture high level needs. Those that don’t have Joint Equities can use the Capability Needs Statement (CNS) via their Service/Agency requirements process. It is recommended SWP programs work with their Service/Agency requirements headquarters organizations to get an early “read” from Joint Staff on the Joint equities determination before proceeding with the SW-ICD or CNS.

The Joint Staff J8 gatekeeper is the determining official for Joint equities, with the general guidelines as follows:

- Combatant Command generated requirements
- Programs related to JADC2 per JROCM 074-20
- Programs related to Nuclear Command Control and Communications (NC3)
- Any explicit joint or joint-service requirements

Table 8-2. Comparison of Capability Needs Statement (CNS) and Software Initial Capabilities Document (SW-ICD). Source: USD(A&S) Guidance

	Capability Needs Statement (CNS)	Software Initial Capabilities Document (SW-ICD)
Applicability	Software development	Software development that Joint Staff determines has Joint equities
Approval	Service requirements board or other Service process	Service approval with expedited Joint Staff validation (≤ 40 days); JCB biennial reviews
Key Sections	Ops context/threat summary; capabilities needed; performance attributes; interoperability; requirements management	Ops context; threat summary; capability requirements and gaps/overlaps; interoperability; final recommendations
DODAF Views	Not required	8 views required
Page Count	5-10 pages	< 10 pages

The SW-ICD shall be constrained to 10 pages or less. Given the dynamic nature of modern software development, the capability needs/ requirements will be iteratively defined, shaped, and prioritized via product roadmaps and program backlogs throughout the development lifecycle.

Table 8-3. Software Initial Capabilities Document (SW-ICD) Contents

1. Operational Context	**How the software capabilities contribute to missions and activities.**
2. Threat Summary	Ensure software capability requirements are informed by current threat environment.
3. Capability Requirements and Gaps/Overlaps	Outline what the required capabilities must do and the operational effect. Cite current capabilities.
4. Interoperability	Describe governance process for interfaces and data to include enterprise architecture, standards, and software factories.
5. Final Recommendations	Outline the plan for sponsor, operational commands, users to capture, prioritize, refine lower-level needs.

8.10.5 COI Relations to MOE, MOS and MOSur

COIs must be examined and related to Measures of Effectiveness (MOE) and Measures of Suitability (MOS) and are included in the Test Strategy.

- Measures of Effectiveness (MOE)
- Measures of Suitability (MOS)
- Measures of Survivability (MOSur)
- Measures of Performance (MOP)

8.10.6 COI Examples

A COI is normally phrased as a question that must be answered in the affirmative to properly evaluate operational effectiveness. The following are four examples of critical operational issues statements in the Test Strategy:

- Will the platform/system (or subsystem/equipment) detect the threat in a combat environment at the adequate range to allow a successful mission?
- Will the system be safe to operate in a combat environment?
- Can the platform/system (or subsystem/equipment) accomplish its critical missions?
- Is the platform/system (or subsystem/equipment) ready for Joint and, if applicable, Combined operations?

8.10.7 MOPs versus MOEs.

A Simplified Example: A joint force air component commander (JFACC) working with the ground component attempting to stop a major enemy ground offensive might assess their forces' performance by measuring the number of interdiction sorties successfully flown against a crucial element of enemy follow-on forces. If the forces flew the planned number of sorties or more without loss, the JFACC can assess that forces are "doing things right." The JFACC might assess effectiveness 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, the JFACC may conclude that the forces' efforts were effective—that they "did the right thing." These are very different types of assessment, requiring different measures, and can lead commanders to very different conclusions. Too often, commanders may focus on MOPs (in part because they are more easily measured and yield empirical answers) and pay inadequate attention to MOEs. Both are necessary, but conceptually different.

8.10.8 TechFAR – Developing Requirements for Agile

Key Question: The Federal Acquisition Regulation (FAR) 15.203 requires agencies to identify requirements in their requests for proposals (RFPs). How does this requirement fit with Agile processes, which rely on refinement of system requirements based on testing and customer feedback after the contract is awarded?

Agile software development, as with any software development, requires thorough acquisition planning. Lack of proper acquisition planning and failure to follow FAR subpart 7.1 can be fatal to any procurement, but especially software development procurements. With Agile software development, requirements and priorities are captured in a high-level Product Vision, which establishes a high-level scope of the project, describes expected outcomes, and produces high level budgetary estimates. The government component of the agile team defines the core capabilities of the project which are required to meet the mission objective and provide business value, governed by the TechFAR.

Agile software development can satisfy core principles related to requirements development by writing a Product Vision and coupling it with an explanation of how the Agile process will be used to achieve the Product Vision. Rather than providing a set of "how to specifications" (or Requirements Traceability Matrix), the Product Vision focuses on desired outcomes, similar to performance-based contracting, which has been permitted by the FAR for many years.

Many agencies get caught up on requirements definition for agile development because what they traditionally think of as requirements are really system design specifications, like the blueprints of a house. In agile development, we think more about the end state of the house rather than the architectural diagrams. An agile requirements document would still comply with FAR provisions like FAR 15.203 without trapping the contractors into a waterfall methodology using a very familiar concept: performance-based contracting. For many years the FAR has provided for performance-based service contracts, where the Government issues a statement of objectives (SOO) defining its outcomes that allows for industry to provide innovative solutions that are measured under a quality assurance surveillance plan. This same approach is applied to contracts using an Agile software development methodology.

An agile requirement package that includes elements like a Product Vision, definition of done, and Product Roadmap would still comply with FAR provisions like 15.203(a)(1) without trapping the contractors into a waterfall methodology. Refer to this Sample Language for Government Contracts for Agile Software Development Services as a baseline for developing your requirements document.

Agile 101 Primer: https://aaf.dau.edu/storage/2023/05/Agile-101-Primer-v2.0_16May2023.pdf

Statutory Requirements: The Software Pathway intent is to reduce bureaucracy to maximize taxpayer investment and accelerate capability to our Warfighters. In turn, the intent is to reduce the documentation requirements and focus the program's efforts on planning and producing working software to enable rapid and continuous delivery. It is recognized that there are some statutory and regulatory information requirements that must be met such as a Component cost position, cybersecurity strategy, or bandwidth requirements review. *(Note: a hybrid pathway adoption may require statutory requirements for associated hardware of the parent program).* However, we take the view that many of the statutory requirements are information requirements that can be included in the Acquisition Strategy and not as stand-alone documents. *(The team has not assessed the distinction between application and embedded software acquisition/pathway use wherein certain safety requirements may apply, e.g., nuclear surety.)*

Regulatory Requirements: Regulatory documents should be developed only if deemed essential to program execution. Some document content will be combined. Many regulatory information requirements are covered in the CNS, User Agreement, Acquisition Strategy, and Cost Estimates. Some regulatory information may still be required on a case-by-case basis, based on capabilities being delivered (e.g., waveform assessment if delivering new or modified signal formats). Decision Authorities have discretion in the regulatory arena on what to require and when to require it.

8.10.9 Test Strategy

Software development testing, government developmental testing, system safety assessment, security certification, and operational test and evaluation will be integrated, streamlined, and automated to the maximum extent practicable to accelerate delivery timelines based on early and iterative risk assessments. Maximum sharing, reciprocity, availability, and reuse of results and artifacts between the various testing and certification organizations is encouraged. (OUSD (A&S), 2020)

The test strategy defines the streamlined processes by which capabilities, features, user stories, use cases, etc., will be tested and evaluated to satisfy developmental test and evaluation criteria and to demonstrate operational effectiveness, suitability, interoperability, and survivability, including cyber survivability for operational test and evaluation. (OUSD (A&S), 2020) The strategy will:

- Identify key independent test organizations and their roles and responsibilities and establish agreements on how they will be integrated early into the planning and development activities throughout the software lifecycle.
- Encourage and identify test artifacts that can and will be shared across the testing and certification communities (e.g., developmental test and evaluation, operational test and evaluation, system safety assessments, and security certification).
- Identify the tools and resources necessary to assist in data collection and transparency to support developmental test and evaluation and operational test and evaluation objectives.

- For programs executing the embedded software path, include a safety critical risk assessment and mitigation strategy, including any safety critical implications.
- Include a strategy to assess software performance, reliability, suitability, interoperability, survivability, operational resilience, and operational effectiveness.
- Programs using the embedded software path will align test and integration with the testing and delivery schedules of the overarching system in which the software is embedded, including aligning resources and criteria for transitioning from development to test and operational environments.

Automated testing and operational monitoring should be used as much as practicable for user acceptance and to evaluate software suitability, interoperability, survivability, operational resilience, and operational effectiveness. The DA will approve the test strategy and DOT&E will be the final approver on test strategies for programs on the DOT&E Oversight List. The test strategy should include information on the verification, validation, and accreditation authority, approach, and schedule for models and simulations in accordance with applicable modeling and simulation policies. Continuous runtime monitoring of operational software will provide health-related reporting (e.g., performance, security, anomalies), as well as additional data collection opportunities to support test and continuous operational test.

9 Test Methodology(ies) Development

During this phase, the Test Team establishes and runs experimental designs (DOEs) for known factors and levels and identifies/fills gaps. This may seem premature to some, but this is required to ensure all the data you need is collected. Moreover, these designs are developed agnostic of the responses/targets.

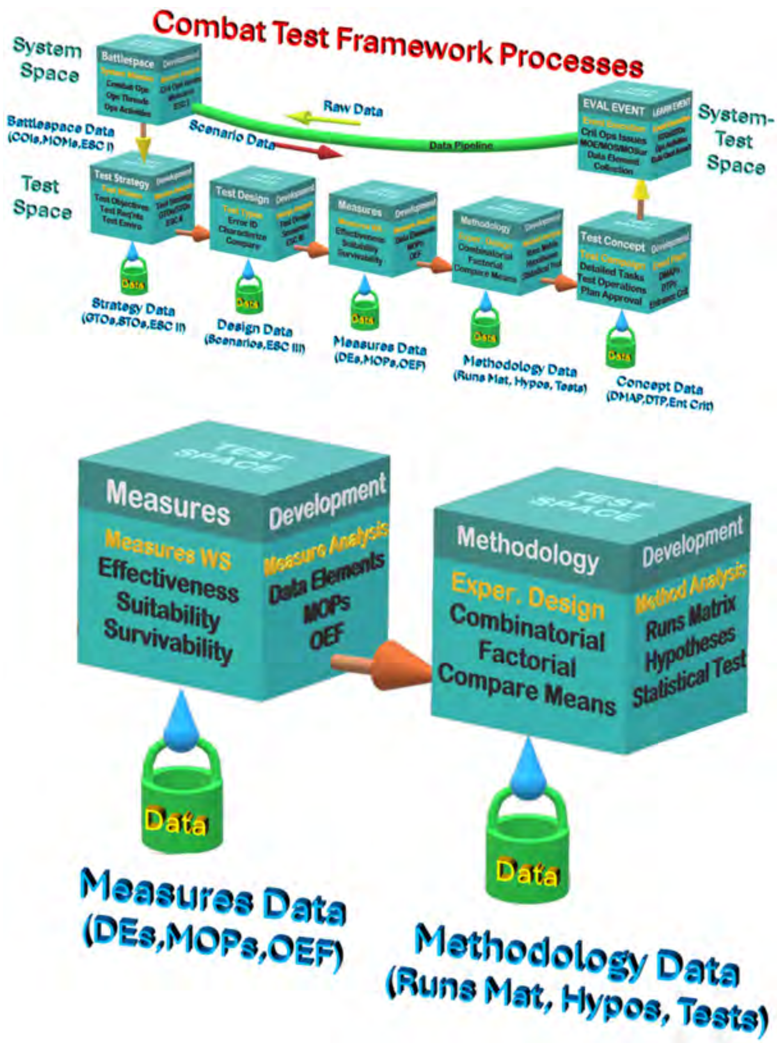

Figure 9-1. Test Methodologies development phase model

9.1 Inputs

- Operational Activities
- Measures of Merit (MOEs, MOSs, MOSURs, MOPs)
- Test design objectives.

9.2 Outputs

- Test methodologies
- Hypothesis tests,
- Data element requirements

9.3 Responsibilities

9.3.1 Test Project Officer

1. Provides resources, i.e., SMEs, Software, Computer Networks, etc.
2. Submit to TRB for approval.

9.3.2 Test Engineers and Analysts

1. Develops the experimental designs, i.e., D-Optimal Factorial, Fractional Factorial, etc.
2. Runs experimental design models.
3. These are based on the Measures Workshop outcomes.

9.4 Methodologies

9.4.1 Comparisons

In *Statistical Methods for Test and Evaluation, Volume 1: Machine Learning Primer*

- Two Sample t-Test
- Paired t-Test
- Welch Two Sample t-test
- Aspin-Welch Unequal-Variance test
- F test to compare two variances
- Sign Test (nonparametric)

9.4.2 Error Identification

In *Statistical Methods for Test and Evaluation, Volume 2: Combinatorial Design using R*

- Combinatorial Designs
- Covering Arrays (CAs)
- Incomplete and Confounded Block (ICB) design
- Balanced Incomplete Block (BIB) design
- Balanced Treatment Incomplete Block (BTIB) design
- Partially Balanced Incomplete Block (PBIB) design

9.4.3 Characterization Methods

In *Statistical Methods for Test and Evaluation, Volume 3: Experimental Design using R*

- Completely Randomized Designs (CRD)
- Factorial Designs (i.e., 2^k factorial design)
- Randomized Block Designs (RBD)
- Fractional Factorial Designs (FFD)
- Response Surface Designs (RSD)

9.5 Design of Experiments using R (doer)

Dr Jeffrey Strickland - 1st Test and Evaluation Squadron, 1/25/2022

9.5.1 About doer

Generate and evaluate test designs using the Shiny app, **doer** (Design of Experiments in R) based on the R package skpr (Morgan-Wall and Khoury 2021). Ee the screen shot in ***Figure 9-2***.

9.5.2 Features

- Full Factorial Design (Continuous Response)
- Full Factorial Design (Binary Response)
- Blocking designs
- D-Optimal designs
- I-Optimal designs
- A-Optimal designs

- Replications
- Randomization
- K-order Interactions
- Power Curve Generation
- Advanced Design Diagnostics
- R code Generation

Correspondence to Five-Paragraph OPLAN: Paragraph 3 Execution, subparagraph A.2. COAs

URL: https://stricje1.shinyapps.io/doer/

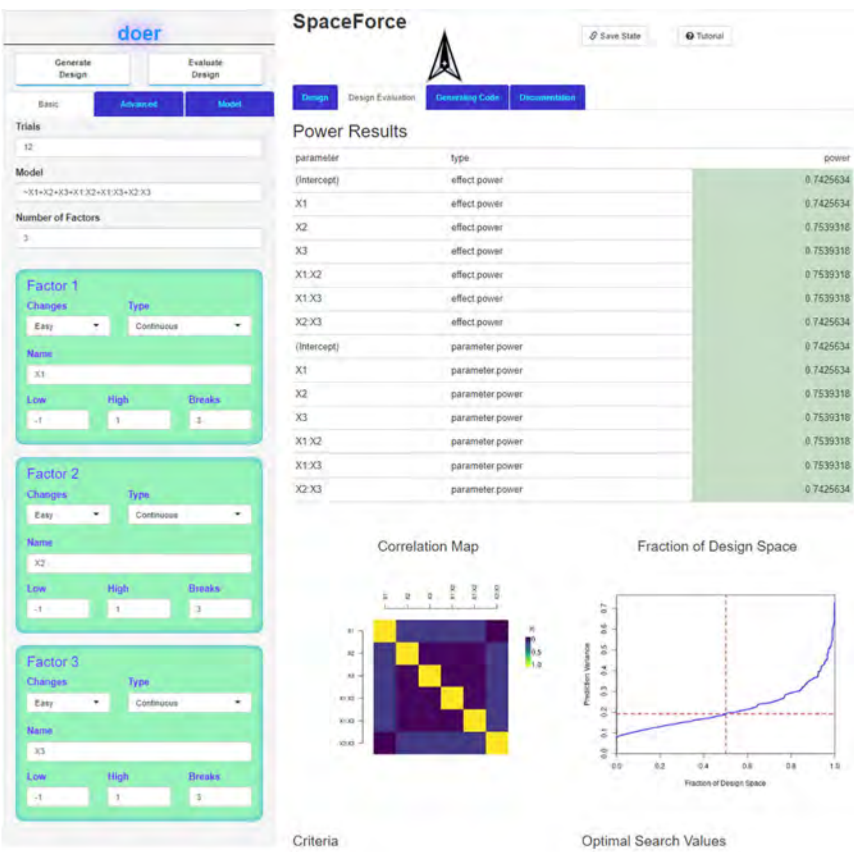

Figure 9-2. doer screen shot

10 Test Concept Development

During this phase, the test team develops the test campaign plan using artifacts of previous phases.

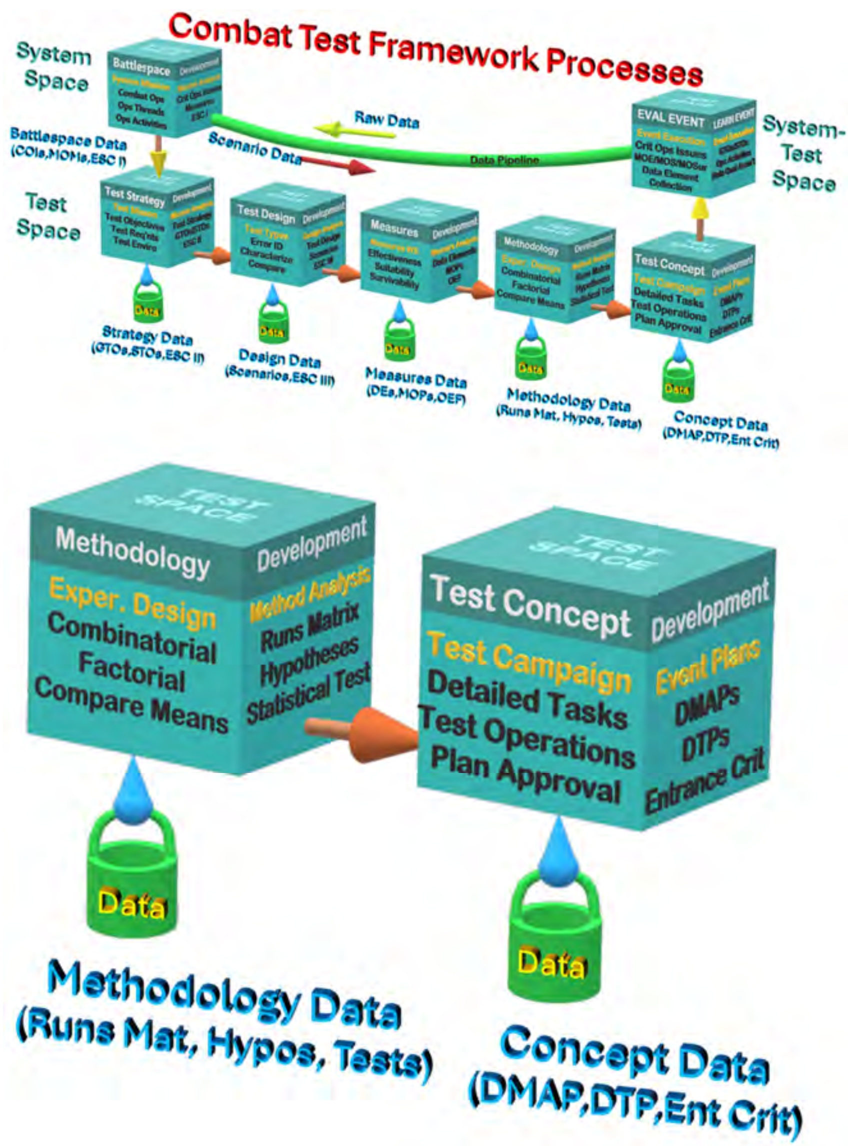

Figure 10-1. Test Concept model

10.1 Inputs

- Runs Matrix
- Test Hypotheses
- Applicable Statistical tests

10.2 Outputs

- Test Campaign Plan with OEF
- Data Management and Analysis Plan (DMAP)
- Detailed Test Procedures (DTP)
- Test event entrance criteria

10.3 Responsibilities

10.3.1 Test Project Officer

- Compiles inputs for the test campaign plan
- Coordinates test campaign plan completion and socialization
- Coordinates reviews with Delta 12, STARCOM, and DOT&E

10.3.2 Test Engineer and Analyst

- Finalizes ECS and OEF
- Prepares DMAPs and DTPs
- Begin entrance criteria checks and balances

Correspondence to Five-Paragraph OPLAN: Paragraph 3-Execution, subparagraph a, Concept of the Operation

11 Test Events: Test to Learn / Test to Evaluate

Now, we can execute test events. A test campaign is comprised of one or more test events. These test events may be either learning events or evaluation events. Testers have to decide which kind of test event they will execute, depending on test objectives, past test events, percentage of data collected for event data elements.

Learning events focus on GTOs and STOs, while evaluation events focus on MOEs, MOSs, MOSur, and MOPs. Thorough planning will avoid situation where data elements are not represented, and their data cannot be collected (see ***Figure 11-1***).

Poorly performed data analysis after a test event is recoverable, i.e., we can redo it correctly. However, a poorly design test can result in collecting the wrong data, answering the wrong questions, and wasting resources. This situation is unrecoverable and test events and possibly the test campaign must be replanned.

For this reason, tools like the evaluation summary charts (ESCs) and the OEF are vital test artifacts that ensure rigorous testing. Moreover, a properly planned test campaign plan may provide combat relevant scenarios that ensure data we planned for will be collected.

One of the purposes of test learning events is to discover what we can get from a properly planned test, but they may also demonstrate a poorly planned test campaign. We should use these learning events to

- Validate our campaign planning
- Validate MoMs (i.e., MOEs, MOSs, and MOSurs)
- Demonstrate rigorous data collection
- Discover additional aspects of the SUT
- Inform the warfighter on capability delivery progress

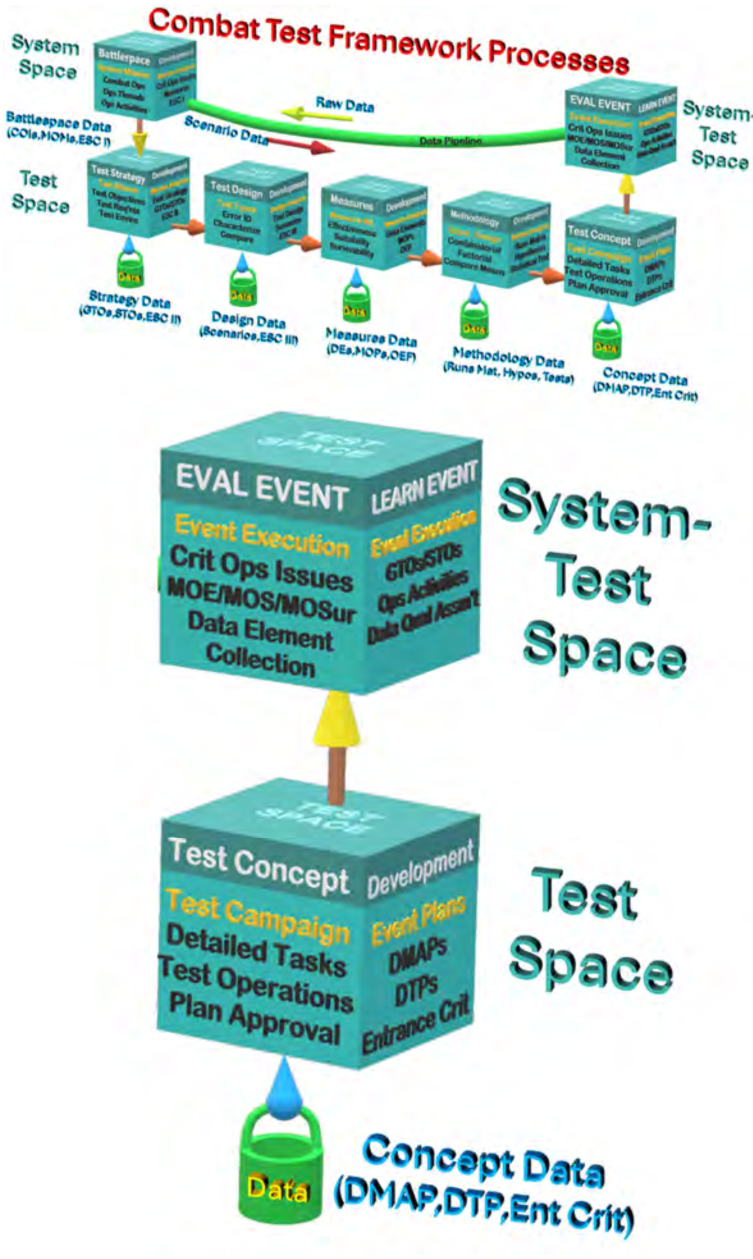

Figure 11-1. Test Event execution model

11.1 Inputs

- Data Management and Analysis Plan (DMAP)
- Detailed Test Procedures (DTP)s
- Test Cases

11.2 Evaluation Event Outputs

- Critical Operational Issue (COI) measures
    - o MOEs, MOSs, MOSurs, MOPs
- Data elements

11.3 Leaning Event Outputs

- Objective Assessments
- Lessons Learned
- Data Quality Assessment

11.4 Responsibilities

11.4.1 Test Director:

- Conduct Test Readiness Review (TRR) prior to test execution
- Ensures test objectives are met
- Resources test execution

11.4.2 Test Engineer and Analyst

- Ensure all data elements and associated data are collected
- Ensure scenarios run as planned
- Ensures MOMs are addressed
- Implements DTP
- Ensure ALL data is collected & stored in a common data lake

Correspondence to Five-Paragraph OPLAN: Paragraph 3-Execution, subparagraph b, Tasks

12 It's All About Data

12.1 Data Assurance

We define data assurance as the process, or set of processes, that increase confidence that data we collect will meet a specific need, and that when collecting, accessing, using and sharing data we are doing so in trustworthy ways. Naturally, data assurance depends on the quality of the data and the quality of the methods we use to acquire it.

12.2 Data Quality

Data quality is the measure of how well suited a data set is to serve its specific purpose. Measures of data quality are based on data quality characteristics such as accuracy, completeness, consistency, validity, uniqueness, and timeliness.

12.2.1 Six Criteria for Measuring Data Quality

Data quality can be measured. It is complex, but certainly not impossible. The following aspects are used as criteria to measure data quality:

- **Accuracy**: consider, for example, old addresses or spelling errors in names and addresses.
- **Completeness**: has all the data been entered completely and correctly? Your processes will also benefit from this and run more smoothly.
- **Format**: does the data comply with the rules? Consider the formatting of phone numbers or bank accounts.
- **Consistency**: is the data consistent across internal databases? For example, is an address in the bookkeeping solution identical to the one in the CRM system?
- **Duplication**: customers often appear multiple times in files. Often, the information in various records is different.
- **Integrity**: is the data linked with the relevant information? Consider orders that "float" in the system and aren't attached to any customers.

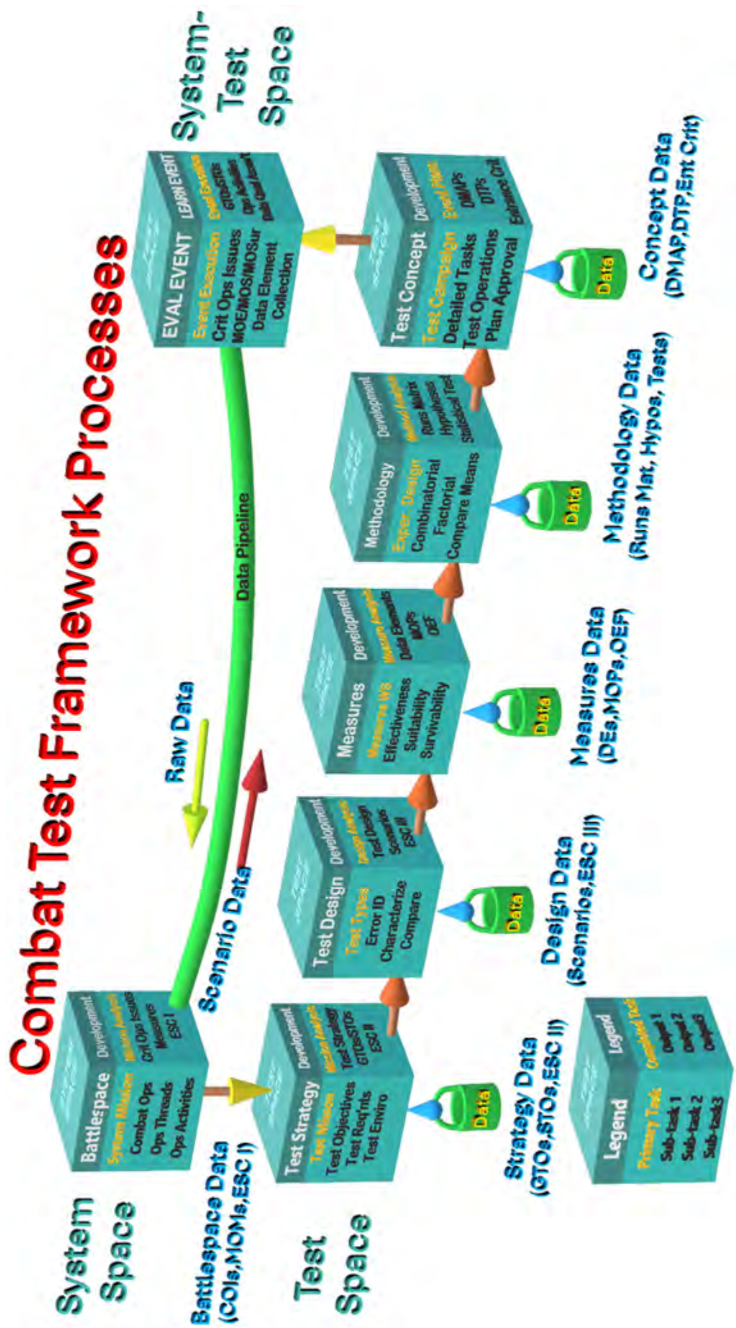

Figure 12-1. The data assurance process model

12.3 Extract, Transform, and Load

Extract, transform, and load (ETL) is the process of combining data from multiple sources into a large, central repository called a data warehouse. ETL uses a set of business rules to clean and organize raw data and prepare it for storage, data analytics, and machine learning (ML).

12.4 Data Defined

Data comes in many shapes and sizes. The most prominent kind is Big Data. This is a very large and complex volume of data that no longer fits in a standard database of columns and rows. But you also have to pay attention to open data and zero data.

12.5 Data quality improvement

12.5.1 Big Data

Big data is data that contains greater variety, arriving in increasing volumes and with more velocity. This is also known as the three "Vs." Put simply, big data is larger, more complex data sets, especially from new data sources. These data sets are so voluminous that traditional data processing software just cannot manage them. But these massive volumes of data can be used to evaluate SUTs when they contain combat relevant data. Searching for such data is the process called data mining.

Data mining is the process of searching and analyzing a large batch of raw data in order to identify patterns and extract useful information. This data is often unstructured, making it ripe for the use of ML as a means of mining.

12.5.2 Open data

Open data is freely available data that can be pulled from countless sources. Governments and knowledge institutes are producing data non-stop. The goal of open data is reuse. Although we are not likely to find combat relevant data here, we should not reject it as a source when test data is limited. Open data might come from government organizations that are involved with similar testing, like NASA.

12.5.3 Zero data

Zero data is data that we already have in a database. If we test a system today, it is worthwhile to keep the data as referent data for future retesting or comparison testing for similar systems.

12.6 Operational Evaluation Framework

The Operational Evaluation Framework (OEF) is a DOT&E requirement that really does aid in the planning and execution of testing, especially when a test campaign is comprised of multiple test events. The OEF should contain the hierarchical taxonomy in some form. The Space C2 OEF contains an overall framework of Combat Operations, Operational Threads (activities), MOEs and MOPs. The data elements required are continued in the MOE tabs of the workbook (see ***Figure 12-2***).

12.7 Learning Event Framework

The Learning Event Framework (LEF) is a tool to implement the Combat Testing Framework and is derived from the test campaign OEF. Regardless of the format, the LEF should contain:

- The Operational Activities, GTOs, and STOs that will be used for learning assessments
- The alignment of GTOs and STOs from MOEs, MOSs, MOSurs, and MOPs in the OEF
- The tracing of GTOs and STOs from Operational Activities

The LEF and OEF can be combined in the OEF.

A system begins development based on the MVP. Testing provides information for developing the MVCRs, The test that are performed before MVCR are Learning Events and we do not use them for evaluation of the SUT. Rather, they are used to learn about the SUT as it is being developed. After MVCR, the campaign plan's Evaluation Events can be executed, and an evaluation can be performed (see ***Figure 12-3***).

The key documents and processes of an Evaluation Event include (see ***Figure 12-3***):

- MVP = Minimal Viable Product
- MVCR = Minimum Viable Capability Release

- TRR = Test Readiness Review
- TERR = Test Event Readiness Review
- DR = Deficiency Report

COI	COT/GTO	MOE_S_Sur/STO
Under what conditions does SET4D evaluate environmental effects for spacecraft?	**COT 1.1. External Data Sources Ingestion** GTO 1.1 Analyze the Ingestion of External Data Sources	**MOE 1.1.1. System Processing** STO 1.1.1. Analyze SET4D's System Processing Capabilities while Ingesting External Data Sources
		MOS 2.1.1. Operational Effectiveness STO 1.1.2. Examine SET4D's Operational Effectiveness while Ingesting External Data Sources
		MOS 4.1.1. Adaptability STO 1.1.3. Examine SET4D's Adaptability across Enclaves while Ingesting External Data Sources
		MOSur 1.1.1. Security Coverage STO 1.1.4. Validate SET4D's Security Coverage while Ingesting External Data Sources
		MOSur 4.1.1. Data Retention STO 1.1.5. Appraise SET4D's Data Retention while Ingesting External Data Sources
	COT 1.2. Integration GTO 1.2. Examine the Integration of Data Sources	**MOE 1.1.2. System Processing** STO 1.2.1. Analyze SET4D's System Processing Capabilities while Integrating Data Sources
		MOS 2.1.2. Operational Effectiveness STO 1.2.2. Examine SET4D's Operational Effectiveness while Integrating Data Sources
		MOS 4.1.2. Adaptability

COI 1 | COI 2 | COI 3 | COI 4

Figure 12-2. Excerpt of an OEF from SET4D

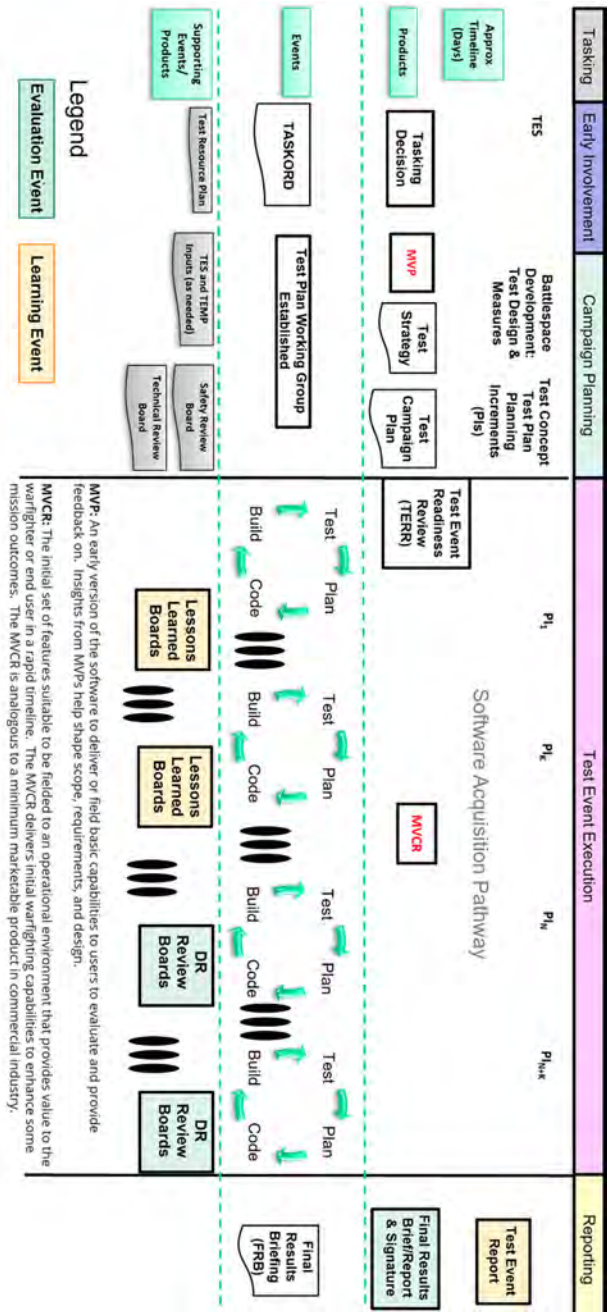

Figure 12-3. Campaign planning and test event execution illustration in SWP

12.8 Structured and Unstructured Data

When collecting data from a test event, the data does not need to be structured. While structured data is preferred, unstructured data placed in a data lake can be extracted and structured using machine learning algorithms before we perform analysis. Therefore, cloud storage is the preferred repository for test data.

- Clouds are customized to meet system/test requirements
- Variable number of data servers and storage space (terabytes of storage)
- Data as a Service (DaaS)
- Data Lakes for unstructured combat data
- Data Warehouses for structured routine data
- Variable number of processors (gigabytes of RAM)
- Software as a Service (SaaS)
- Multiple Apps with Containers as a Service (CaaS)

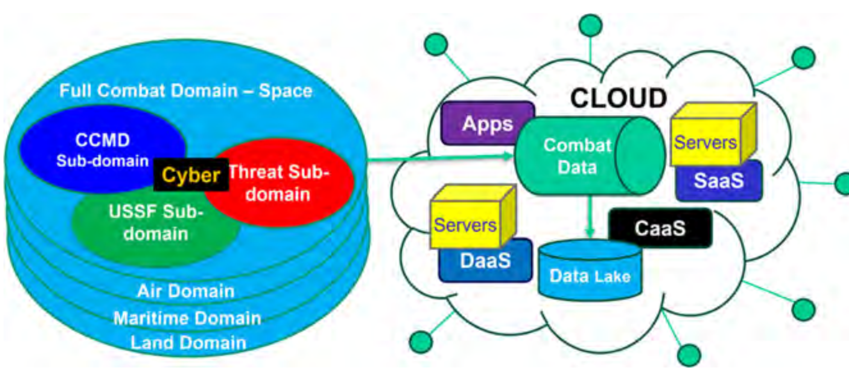

Figure 12-4. Illustration of combat relevant data in the cloud-based data lake

12.9 Data Terms of Reference

A **data lake** is a centralized repository that allows you to store all your structured and unstructured data at any scale.

A **data warehouse**, also called an enterprise data warehouse (EDW), is an enterprise data platform used for the analysis and reporting of structured and semi-structured data from multiple data sources.

A **data pipeline** is a method where raw data is ingested from data sources, transformed, and then stored in a data lake or data warehouse for analysis.

13 Example: SET4D

13.1 Battlespace Development

During SET4D Battlespace Development, we perform functions that will inform testers about the System Under Test (SUT). There are three essential tasks that the test team must be initiated:

13.1.1 System Under Test Description

(U) SYSTEM UNDER TEST (SUT) DESCRIPTION. (U) The Space Domain Awareness Environmental Toolkit for Defense (SET4D) product is the cloud architecture modernization of the Space Weather Analysis and Forecast System (SWAFS). The Government is designing the SET4D system to address current and emerging space environment requirements for DoD and Intelligence Community (IC) operations. This toolkit is an integrated software suite of space environment data, models, and applications to provide mission impacts and SDA for DoD warfighters and IC operations (see ***Figure 13-1)***. Two Minimum viable products (MVPs) are expected to construct the first Minimum Viable Capability Release (MVCR) that the Test Team will perform a field test on from August 2024 to November 2024 to produce an Operational Assessment (OA) of the MVCR. A fielding decision must occur No Later Than (NLT) 31 December 2024. (Andorka, Cox, & Fraizer, 2021)

13.1.2 Area of Concern Description

(U) AREA OF CONCERN. (U) Space is contested, congested, and competitive. Competitors are developing technologies that contest U.S. and allied space systems and services. Reduced costs of space technologies and launch services have supported explosive growth in the number of objects in space and enabled numerous countries to acquire advanced technologies, boosting their own space industries and countering U.S. competitive advantage. To combat this security environment, the USAF and USSF are focused on space superiority through SDA which includes characterizing the space environment and its impact on DoD missions. The SET4D capability provides this imperative knowledge of the space environment and the impacts on the orbital and link regimes of SDA (see ***Figure 13-2***).

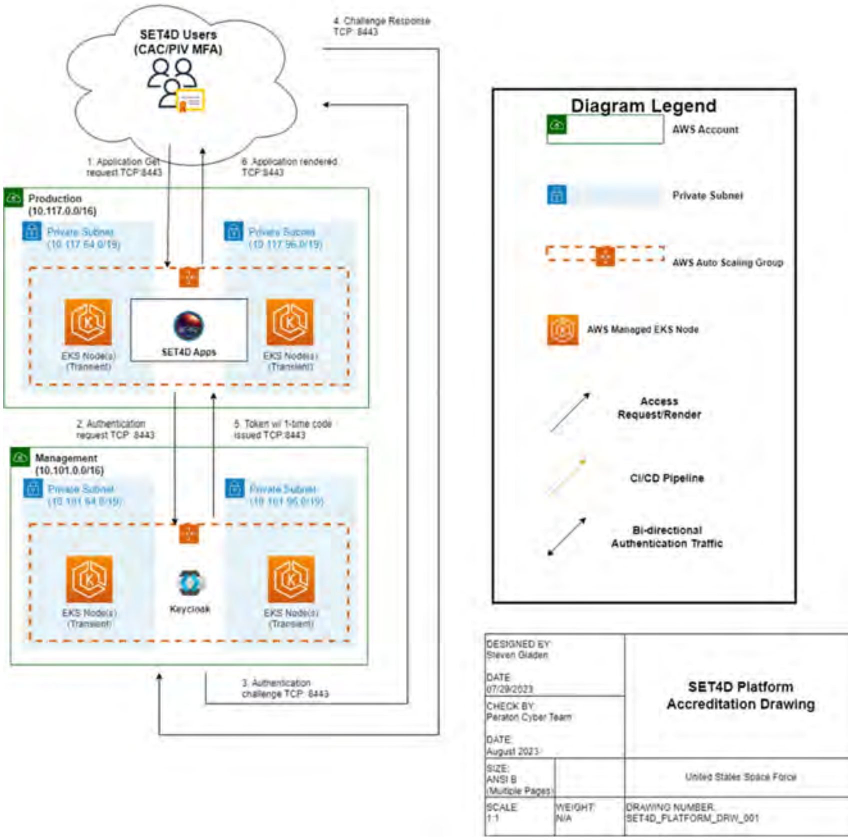

Figure 13-1. SET4D Platform Accreditation Architecture Drawing

SET4D modernization work will provide the USAF and USSF with an enhanced ability to evaluate space environmental data and greater situational awareness of threats as it navigates this increasingly important strategic and tactical environment. 1 TES will conduct T&E on the initial MVCR consisting of two capabilities: *Energetic Charged Particle – Hazard Assessment System (ECP – HAS)* and *Electromagnetic Interference – Hazard Assessment System (EMI – HAS)*. These two capabilities are currently funded. REF D lists 49 MVPs with the first two (*ECP – HAS* and *EMI – HAS*) funded and developed.

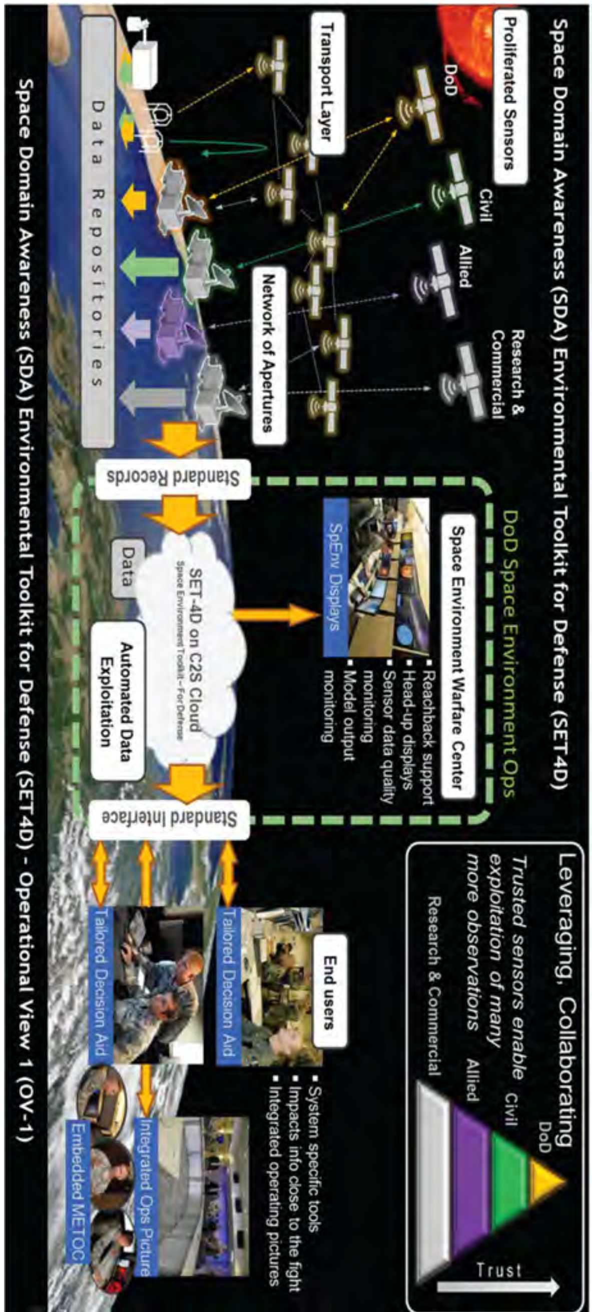

Figure 13-2. SET4D OV-1

SET4D shall ingest and store space environment data from a variety of data sources, from both ground-based and space-based sensors. These data originate from operational USAF, USSF, DoD, U.S. Government, allied, research and development (R&D), and commercial sources. SET4D shall be capable of operating without non-DoD data and degrade gracefully when data are limited. Data from trusted sources (e.g., DoD, U.S. government, and allied sources) shall be used to validate R&D and commercial sources.

13.1.3 Intelligence Preparation of the Battlefield (IPB)

(U) ADVERSARY (ENEMY) COURSE OF ACTION. (U) SET4D will be a DOD Authorized environment that will streamline information exchange through role-based access by securely providing products and services across Multiple Security Enclaves, on multilevel security networks across the DoDIN to include Unclassified, Collateral SECRET, and TOP SECRET-SCI (TS//SCI) levels. Active Logging and Monitoring will enable Internal and External Threats to be mitigated timely. All SET4D Services, Users, and Systems, whether "trusted" or not will be verified, regardless of location.

(U) INTERNAL THREATS. (U) SET4D Internal threats come from individuals unwittingly introducing malicious computer code, threatening the reliability of the SET4D capabilities. Internal threats also come from "trusted" individuals damaging SET4D capabilities by deliberately modifying and manipulating system components, introducing malware, or using malicious components (e.g., hardware, firmware, and software); accessing or obtaining information without appropriate need to-know; expanding authorized access to system without appropriate authorizations; destroying information; or making unauthorized disclosure of information. Internal threats also present a risk to supply chain operations by those with access to components or networks and undermining production of hardware, software, or firmware.

(U) EXTERNAL THREATS. (U) SET4D External threats come from foreign adversaries, terrorists, cybercriminals, or hackers conducting cyberspace operations with the intent of exploiting weaknesses in system networks and cloud services, injecting malware (viruses, worms, and Trojan Horses), corrupting data, or denying operations. External threats could gain access to SET4D capabilities or information and modify or manipulate system operations or information, physically destroy the system and information, digitally destroy data, or create a denial-of-service situation, severely impacting the SET4D's ability to function properly.

(U) OTHER THREATS. (U) Threats can also come from use of removable media (e.g., universal serial bus devices, data transfer devices, compact discs) as they could introduce new threats to firmware and software. New threats can then be transferred from terminal to the cloud architecture during data transfer process. While not all threats can be removed, it is important the SET4D operations community understands the risk of corrupt data from any source. DoD has few, if any, ways to ensure non-DoD sourced data feeds are intact, cyber-secure, and valid but understands data gained from the DoD Information Network (DoDIN) may be affected by disruption or corruption, as well.

13.1.4 Friendly Force Analysis

(U) FRIENDLY FORCE DESCRIPTION (WARFIGHTERS AND OPERATORS). (U) SET4D mission users require an improved capability to analyze sensor data related to solar flares, solar winds and other space environmental conditions that may affect high-altitude aircraft, and space- and ground-based systems. The SET4D system will impact all DoD operations and will be employed by all services of the DoD; however, the primary user of SET4D is the Space Force and Intelligence Community Operation Users for mission-specific environment impacts. The Space Weather Operations Center (SpaceWOC), the operational space environment center staffed by the 2nd Weather Squadron (2 WS) at the 557th Weather Wing (557 WW) provides a team of officers, enlisted, civilians, and contractors for 24/7 reach-back support to DoD units and IC activities. Specific use cases have been identified as follows: the Joint Task Force – Space Defense (JTF-SD) at the National Space Defense Center (NSDC) mission of space superiority requires rapid characterization, prediction, and assessments of the space environment hazards; the Joint All Domain Command and Control (JADC2) mission of connecting distributed sensors, warfighters, and data from and in all domains to all forces to enable distributed mission command at the scale, tempo, and level to accomplish the mission requires characterization, prediction, and assessments of the space environment hazards; the Advanced Battle Management System (ABMS), allows a joint force to use cutting-edge methods and technologies to rapidly collect, analyze, and share information and make decisions in real time. Part of this decision calculus is the characterization, prediction, and assessments of the space environment hazards.

13.1.5 Terrain Analysis

(U) SPACE TERRAIN DESCRIPTION. (U) The complex Sun-Earth space environment is formed by a steady stream of solar particles and energy, e.g., the solar wind, with an embedded magnetic field. The resulting effect on the near-Earth environment drives the natural space environment of the magnetosphere, ionosphere, thermosphere, and weather of the troposphere. Numerical simulations and physics models of these environments are key to understanding the space environment conditions and impacts. SET4D shall integrate and execute space environment models to characterize the space environment sufficiently to determine the impacts on DoD warfighters and IC activities. The coverage, resolution, refresh, accuracy, and timeliness of these space environment models will be determined by the mission needs. Every effort to incorporate the latest technology and improved modeling will be made to improve SET4D performance; therefore, the architecture and design must support rapid integration of new models in a continuous integration and delivery construct. Space environment models will range from climatological empirical relationships to complex data-assimilation routines, along with machine learning/artificial intelligence (ML/AI) capabilities.

(U) OPERATING ENVIRONMENT DESCRIPTION. (U) The SET4D capabilities shall be deployed in a cloud environment and deploy a Data-as-a-Service (DaaS) interface, so that users get more direct access to near-real-time data. Use of this data collection model will allow the DoD and other government organizations to increase the number of data sources available to the SET4D program and upgrade its capacity to collate and correlate data. Supporting programs that feed into SET4D architecture are the following: Space Domain Awareness (SDA) - Military Application of the Space Environment (MASE) and Unified Data Library (UDL); Ground-Based Space Environment Sensing 4 CUI - Ionospheric Ground System (IGS) and Solar Electro-Optical Network (SEON); Space-Based Environmental Sensing - Defense Meteorological Satellite Program (DMSP), Constellation Observing System for Meteorology Ionosphere and Climate - 2 (COSMIC2) and Weather System Follow-on – Microwave

(WSF-M). 1.E.2. (U) TEST SITE DESCRIPTION. (U) SET4D will be deployed across three enclaves (NIPR, SIPR, and JWICS) to support diverse mission sets, operations centers, and organizational constructs. 1 TES will conduct T&E events using a combination of enclaves at various office centers using a layered approach of test and operations personnel. Due to the vast warfighter community, the initial field test will be conducted in the local area for 1 TES and will expand out as more MVPs and MVCRs are funded, developed, and ready for testing.

13.2 SET4D Initial Capability Fielding - December 2024

Two Minimum viable products

13.2.1 Mission Research

13.2.1.1 Warfighter Capability Need:

Space is contested, congested, and competitive. Competitors are developing technologies that contest U.S. and allied space systems and services. Reduced costs of space technologies and launch services have supported explosive growth in the number of objects in space and enabled numerous countries to acquire advanced technologies, boosting their own space industries and countering U.S. competitive advantage. To combat this security environment, USSF is focused on space superiority through space domain awareness which includes characterizing the space environment and its impact on DoD missions. The SET4D capability provides this imperative knowledge of the space environment and the impacts on the orbital and link regimes of SDA. SET4D modernization work will provide USSF with an enhanced ability to evaluate space environmental data and greater situational awareness of threats as it navigates this increasingly important strategic and tactical environment - (CNS Page 8).

13.2.1.2 Warfighter Mission

SET4D is an integrated software suite of space environment data, models, and applications to provide mission impacts and SDA for DoD warfighters and IC operations. (SET4D CNS, 2023, p. 6)

13.2.1.3 Operational Capabilities:

Energetic Charged Particle – Hazard Assessment System (ECP-HAS) This tool is designed to provide satellite operators, space operations centers, and environmental providers a single application that can evaluate environment effects to spacecraft in any orbit. (SET4D Overview Briefing, 2024, p. 6)

Electromagnetic Interference – Hazard Assessment System (EMI-HAS)

This tool will allow spacecraft operators and engineers the ability to tailor interface to a specific "threshold of pain" as well as display environmental information that would be required to conduct satellite anomaly assessments. (SET4D Overview Briefing, 2024, p. 9)

13.2.1.4 Operational Mission:

SET4D shall provide space environmental impact products and capabilities for the other DoD services, IC, and allied partners, e.g., North Atlantic Treaty Organization (NATO) and Five Eyes (FVEY) partners. SET4D shall:

- Provide access to ECP models and applications such as the Space Environment Anomaly Resolution (SpEAR) and ECP-HAS flow charts that address the DoD warfighter and IC activity needs. (SET4D CNS, 2023, p. 8)
- Provide access to ionospheric density and scintillation models and applications such as Space Environment Electro-Magnetic Interference (EMI) Flow Charts. (SET4D CNS, 2023, p. 9)

13.2.1.5 Mission Threads

SET4D will have two mission threads with the delivery of the initial capabilities based upon two funded MVPs: ECP-HAS and EMI-HAS.

ECP-HAS mission is to provide satellite operators, space operations centers, and environmental provides a single application that can evaluate environment effects to spacecraft in any orbit. This will be a web-based application enabling tailored products for a specific user or user groups to input parameters and receive detailed reports. ECP-HAS will be a 4-D visualization tool with the following capabilities: decision aids, flow charts, space environment support data, and environmental model data (SET4D Overview Briefing, 2024, pp. 6-7). EMI-HAS mission is to allow spacecraft operators and engineers the ability to tailor interface to a specific "threshold of pain" as well as display environmental information that would be required to conduct satellite anomaly assessments. This will be a web-based application supporting either ECP-HAS follow-up analysis or independent assessment for EMI troubleshooting or diagnosis of mission systems. (SET4D Overview Briefing, 2024, pp. 8-9)

13.2.1.6 Critical Operational Issues (COIs)

- **COI 1:** Under what conditions does SET4D evaluate environment effects for spacecraft? (SET4D CNS, 2023, pp. 12-19)
- **COI 2**: Under what conditions does SET4D produce environmental effect products for spacecraft? (SET4D CNS, 2023, pp. 12-19)
- **COI 3:** Under what conditions does SET4D tailor the interfaces for thresholds of pain for environmental information? (SET4D CNS, 2023, pp. 12-19)
- **COI 4:** Under what conditions does SET4D provide troubleshooting diagnosis for specified mission systems? (SET4D CNS, 2023, pp. 12-19)

13.2.1.7 Combat Operational Threads (COTs)

- **COI 1** (SET4D CNS, 2023, pp. 12-19):
- **COT 1.1:** External Data Sources Ingestion
- **COT 1.2:** Integration
- **COT 1.3:** Model Processing
- **COT 1.4:** Mission Utilities
- **COT 1.5**: Data Storage
- **COT 1.6:** System Management
- **COI 2** (SET4D CNS, 2023, pp. 12-19)**:**
- **COT 2.1:** Hazard Indexes
- **COT 2.2:** Stoplight/Threshold Assessments
- **COT 2.3:** Space Impacts
- **COT 2.4:** Global Disruption
- **COT 2.5:** Regional Disruption

- **COT 2.6:** Space Environment Anomaly Attribution
- **COT 2.7:** Space Asset Safety of Flight
- **COT 2.8:** Space Environment Event Notification
- **COT 2.9:** UI/UX GUI
- **COT 2.10:** Central Operational Picture
- **COT 2.11:** Help Guides
- **COI 3** (SET4D CNS, 2023, pp. 12-19)**:**
- **COT 3.1:** Hazard Indexes
- **COT 3.2:** Stoplight/Threshold Assessments
- **COT 3.3:** Space Environment Event Notification
- **COT 3.4:** UI/UX GUI
- **COT 3.5:** Central Operational Picture
- **COT 3.6:** Help Guides
- **COI 4** (SET4D CNS, 2023, pp. 12-19)**:**
- **COT 4.1:** Terrestrial Impacts
- **COT 4.2:** Space Impacts
- **COT 4.3:** Fixed Asset Impacts
- **COT 4.4:** Ground Moving Asset Impacts
- **COT 4.5:** Regional Disruption
- **COT 4.6:** Radiation Exposure Specification
- **COT 4.7:** Space Environment Anomaly Attribution
- **COT 4.8:** Space Asset Safety of Flight
- **COT 4.9:** Radio Frequency Signal Performance
- **COT 4.10:** EMI Attribution

13.2.1.8 Measure of Effectiveness (MOE)

- **MOE 1.** System Processing
- **MOE 2.** System Dissemination
- **MOE 3.** System Display

13.2.1.9 Measure of Suitability (MOS)

- **MOS 1.** User Training Program
- **MOS 2.** Operational Effectiveness
- **MOS 3.** User's Guide
- **MOS 4.** Adaptability

13.2.1.10 Measure of Survivability (MOSur)

- **MOSur 1.** Security Coverage
- **MOSur 2.** Report Retention
- **MOSur 3.** Model Retention
- **MOSur 4.** Data Retention

13.2.1.11 Measures of Performance

- Measure of Effectiveness (MOE)
- **MOE 1.** System Processing
- **MOP 1.1.** Alerts Processing
- **MOP 1.2.** Warnings Processing
- **MOP 1.3.** Scheduled Model Processing
- **MOP 1.4.** Ingest Processing
- **MOP 1.5.** Storing Processing
- **MOP 1.6.** On-Demand Model Processing
- **MOE 2.** System Dissemination
- **MOP 2.1.** Dissemination Processing
- **MOE 3.** System Display
- **MOP 3.1.** Display Processing
- Measure of Suitability (MOS)
- **MOS 1.** User Training Program
- MOP 1.1.
- **MOS 2.** Operational Effectiveness
- **MOP 2.1.** Availability
- **MOP 2.2.** Mean Time to Restore Functions
- **MOS 3.** User's Guide
- MOP 3.1.
- **MOS 4.** Adaptability
- **MOP 4.1.** Configured for NIPR
- **MOP 4.2.** Available on NIPR
- **MOP 4.3.** Configured for SIPR
- **MOP 4.4.** Available on SIPR
- **MOP 4.5.** Configured for JWICS
- **MOP 4.6.** Available on JWICS
- Measure of Survivability (MOSur)
- **MOSur 1.** Security Coverage

- **MOP 1.1.** Security Scan Coverage
- **MOSur 2.** Report Retention
- **MOP 2.1.** Application Output
- **MOSur 3.** Model Retention
- **MOP 3.1.** Model Output
- **MOSur 4.** Data Retention
- **MOP 4.1.** Observation Output

13.3 SET4D Test Design

13.3.1 Initial Capability Fielding - December 2024

System **comparison testing** will be conducted for SET4D for the Initial Capability Fielding testing period from August 2024 to November 2024. Comparison testing is the most appropriate for SET4D's initial capability fielding for the following reasons:

- SET4D has specified requirement standards listed in the Capability Needs Statement (CNS) that provide the baseline for operational acceptance criteria and test measures of performance.
- The SET4D CNS standards and operational configuration do not allow for factors and levels to be built for the Initial Capability Fielding; however, that can change with future releases/deliveries.
- SET4D will not be compared to the legacy system (SWAFS) but against the CNS performance standards in a operational relevant environment.
- SET4D testing is not seeking to identify system issues to meet minimum performance standards.
- SET4D specified standards in units of time and as such cannot have negative values.
- SET4D specified standards require the performance to be under a limit, not within two limits, threshold, or boundaries.

13.4 SET4D Test Methodology

Three types of comparison testing methodologies are provided in the Test Design Phase (1 TES T&E Guidebook, 2022): paired t-test, sign testing, and equivalency testing. Paired t-test and sign testing are not appropriate for SET4D comparison testing due to not having a baseline to compare to (paired t-test, legacy system is not similar to SET4D and sign testing, system is not parametric). Equivalency testing is most appropriate due to the need to compare system performance (requirement standards as detailed in the CNS (SET4D CNS, 2023) and SET4D's ESC II (SET4D Evaluation Summary Chart II, 2024) in an operationally realistic and combat relevant environment.

SET4D will use a One-Sided Test due to the performance requirements listed in the CNS (SET4D CNS, 2023) and SET4D's ESC II (SET4D Evaluation Summary Chart II, 2024) being time-based and only specify maximum values to be under, not within a time-range. Additionally, since time cannot be negative, SET4D will not conduct a Two One-Sided Test (TOST) due to the reasons above and based upon the standard deviation from the mean, the upper limit is the focus area (from +2 to +3 standard deviation from the mean).

For more information, see the report on Equivalency Testing (AFIT, 2022) and Statistics Training (DAU, 2022). These documents will form the basis of equations used for SET4D's Initial Capability Fielding testing.

13.4.1 Hypothesis Breakdown

For this comparison testing, SET4D will have null and alternate hypothesizes for the following MOPs:

13.4.2 Measure of Effectiveness (MOE)

- **MOE 1.** System Processing
- **MOP 1.1.** Alerts Processing
- **MOP 1.2.** Warnings Processing
- **MOP 1.3.** Scheduled Model Processing
- **MOP 1.4.** Ingest Processing
- **MOP 1.5.** Storing Processing
- **MOP 1.6.** On-Demand Model Processing
- **MOE 2.** System Dissemination
- **MOP 2.1.** Dissemination Processing
- **MOE 3.** System Display

- **MOP 3.1.** Display Processing

13.4.3 Measure of Survivability (MOSur)

- **MOSur 2.** Report Retention
- **MOP 2.1.** Application Output
- **MOSur 3.** Model Retention
- **MOP 3.1.** Model Output

13.4.4 Measure of Suitability (MOS)

1 TES will report on the following MOPs without null or alternate hypothesizes due to the nature of the requirement:

- **MOS 2.** Operational Effectiveness
- **MOP 2.1.** Availability
- **MOP 2.2.** Mean Time to Restore Functions
- **MOS 4.** Adaptability
- **MOP 4.1.** Configured for NIPR
- **MOP 4.2.** Available on NIPR

13.4.5 Measure of Survivability (MOSur)

- **MOSur 1.** Security Coverage
- **MOP 1.1.** Security Scan Coverage

The Test Team will not report on the following MOPs due to limitations of the current system:

13.4.6 Measure of Suitability (MOS)

- **MOS 4.** Adaptability
- **MOP 4.3.** Configured for SIPR
- **MOP 4.4.** Available on SIPR
- **MOP 4.5.** Configured for JWICS
- **MOP 4.6.** Available on JWICS

13.4.7 Measure of Survivability (MOSur)

- **MOSur 4.** Data Retention
- **MOP 4.1.** Observation Output

13.4.8 Test Methodology

The Test Team will either reject or fail to reject the null hypothesis statements. Accepting the null hypothesis statement is the default position due to the nature of equivalence testing. Either the null hypothesis is rejected, thereby proving the alternate hypothesis, or the null hypothesis fails to be rejected.

13.4.9 Hypotheses Statements

The Test Team has the following hypothesizes for the performance requirements listed above:

- **Null Hypothesis 1 (H_{O1}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will not meet the performance requirements for alerts and warnings (less than 1 second).

- **Alternate Hypothesis (H_{A1}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will meet the performance requirements for alerts and warnings (less than 1 second).

- **Null Hypothesis 2 (H_{O2}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will not meet the performance requirements for start scheduled model/application runs (less than 1 second).

- **Alternate Hypothesis (H_{A2}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will meet the performance requirements for start scheduled model/application runs (less than 1 second).
- **Null Hypothesis 3 (H_{O3}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will not meet the performance requirements for dissemination (less than 5 seconds).

- **Alternate Hypothesis (H_{A3}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will meet the performance requirements for dissemination (less than 5 seconds).

- **Null Hypothesis 4 (H_{O4}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will not meet the performance requirements for displays (less than 5 seconds).

- **Alternate Hypothesis (H_{A4}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will meet the performance requirements for displays (less than 5 seconds).

- **Null Hypothesis 5 (H_{O5}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will not meet the performance requirements for ingest and store (less than 10 seconds).

- **Alternate Hypothesis (H_{A5}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will meet the performance requirements for ingest and store (less than 10 seconds).

- **Null Hypothesis 6 (H_{O6}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will not meet the performance requirements for application execution - run on-demand (less than 60 seconds).

- **Alternate Hypothesis (H_{A6}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will meet the performance requirements for application execution - run on-demand (less than 60 seconds).

- **Null Hypothesis 7 (H_{O7}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will not meet the performance requirements for keeping model and application output (for at least 30 days).

- **Alternate Hypothesis (H_{A7}):** When SET4D transitions from the developer environment to the operationally realistic and combat relevant environment, it will meet the performance requirements for keeping model and application output (for at least 30 days).

From the notional example, T-Stat (left side of equation in Figure 5 below) is 2.444 and T-Crit (right side of equation in Figure 5 below) is 1.677. Therefore T-Stat > T-Crit and we can reject the Null Hypothesis (Ho1) and accept the Alternate Hypothesis (Ha1) for MOP 1.1.

For the required confidence, we can see from the Standard Deviation Charts that all of the data is within the -3 to +2 range and since +2 standard deviation is 0.999 and there are no values above that, we can conclude that at least 98% of our data is within +2 standard deviation and under the MOP 1.1. threshold.

For rating MOP 1.1., due to the above points, the rating would be Successfully Met Standard (Green G).

13.4.10 Statistical Tests

One-Sided Equivalence Testing Formulas

1 TES will reject each Null Hypothesis (H_O) using the following formulas:

Equation 2. One-Sided Equivalence Test Formula.

$$\text{Reject } H_0 \text{ if: } \frac{|\bar{y}_1 - \bar{y}_2| + \Delta}{SE} > t_{\alpha, n_1 + n_2 - 2}$$

Equation 3. Standard Error Formula.

$$SE = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

Equation 4. One-Sided Equivalence Test and Standard Error Formulas Legend.

$$\bar{y}_1 = Test\ 1\ Sample\ Mean$$

$$\bar{y}_2 = Test\ 2\ Sample\ Mean$$

$$\Delta = Equivalence\ Acceptance\ Criterion$$

$$t_{\alpha,n_1+n_2-2} = Critical\ Value$$

$$\alpha = Type\ I\ Risk$$

$$n_1 = Test\ 1\ Sample\ Size$$

$$n_2 = Test\ 2\ Sample\ Size$$

$$SE = Standard\ Error$$

$$s_1 = Test\ 1\ Sample\ Variance$$

$$s_2 = Test\ 2\ Sample\ Variance$$

The Equivalence Acceptance Criterion will be considered insignificant (as determined by the 1 TES Technical Director) and can be set to a zero (0) value. The adjusted equations for rejection of the Null Hypothesis are the following formulas:

Equation 5. Adjusted One-Sided Equivalence Test Formula.

$$\text{Reject } H_0 \text{ if: } \frac{|\bar{y}_1 - \bar{y}_2| + \Delta}{SE} > t_{\alpha,n_1+n_2-2}$$

Equation 6. Standard Error Formula.

$$SE = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

<u>Sample Mean Formulas</u>

Equation 7. Sample Mean Formula.

$$\bar{y} = \frac{1}{n}\sum_{i-1}^{n} y_i = \frac{y_1 + y_2 + \cdots + y_n}{n}, i = 1,2, \ldots, n.$$

Equation 8. Sample Mean Formula Legend.

$$\bar{y} = Sample\ Mean$$

$$n = Sample\ Size$$

$$i = Sample\ Counter$$

Sample Variance Formulas

Equation 9. Sample Variance Formula.

$$s^2 = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}, i = 1,2, \dots, n.$$

Equation 10. Sample Variance Formula Legend.

$$s^2 = Sample\ Variance$$

$$y_i = Sample\ i$$

$$\bar{y} = Sample\ Mean$$

$$n = Sample\ Size$$

$$i = Sample\ Counter$$

Standard Deviation Formulas

Equation 11. Standard Deviation Formula.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n}}, i = 1,2, \dots, n.$$

Equation 12. Standard Deviation Formula Legend.

$$\sigma = Standard\ Deviation$$

$$y_i = Sample\ i$$

$$\bar{y} = Sample\ Mean$$

$$n = Sample\ Size$$

$$i = Sample\ Counter$$

The only values desired are to be under the maximum values. Furthermore, when analyzing the Standard Deviation from the Mean to determine frequency of data, only the values from +2 to +3 standard deviations from the mean are the areas of concern. All other values (from -3 standard deviations to +2 standard deviations) will be the data sample.

13.5 SET4D Test Concept Development

The SET4D Test Concept is comprised of the previous phases outputs and will constitute the SET4D Test Campaign and test event plans. The outline/template for the five-paragraph OPLAN in ***Section 5.3*** is the proper format for the campaign plan.

The SET4D Campaign Plan will be executed by a series of test events in accordance with the SPO timeline.

References

1 TES T&E Guidebook. (2022). Retrieved from https://usaf.dps.mil/sites/ussf-starcom/stardelta/1tes/guide/SitePages/Develop-Test-Design.aspx

AFIT. (2022). *Equivalency Testing*. Retrieved from https://usaf.dps.mil/:b:/r/sites/ussf-starcom/stardelta/1tes/ITF1_01/E_CTT/SET4D/Shared Documents/06. Test Methodology/Equivalency Testing - AFIT.pdf?csf=1&web=1&e=ZhfdRa

Andress, J., & Winterfeld, S. (2014). *Cyber Warfare* (Second ed.). New York: Elsevier Inc. doi:https://doi.org/10.1016/C2013-0-00059-X

Curtis E. Lemay Center. (2016, November 4). *Assessment Measures.* Retrieved from Air Force Doctine Publication (AFDP) 3-0 Operations and Planning: https://www.doctrine.af.mil/Portals/61/documents/AFDP_3-0/3-0-D27-OPS-Assessment-Measure.pdf

DAU. (2022). *CLE035 Statistics*. Retrieved from DAU: https://usaf.dps.mil/:b:/r/sites/ussf-starcom/stardelta/1tes/ITF1_01/E_CTT/SET4D/Shared Documents/06. Test Methodology/CLE035_L2_Print.pdf?csf=1&web=1&e=WQGp7A

Faulconbridge, G. (2023). Russia's first lunar mission in 47 years smashes into the moon in failure. *Reuters*, Online. Retrieved from https://www.reuters.com/business/aerospace-defense/russias-moon-mission-falters-after-problem-entering-pre-landing-orbit-2023-08-20/

Hamilton, S., Euker, B., Solterbeck, W., & Wright, J. (2002, May 1). Operational Thread Development. *Military Operations Research Society Symposium (75th)*, *June 12-14*, pp. 1-29. Annapolis, Maryland. Retrieved from Defense Technical Information Center: https://apps.dtic.mil/sti/citations/ADA488597

HQDA. (2019, July 31). *Army Doctrine Publication, No. 5-0: The Operations Process.* Retrieved from Department of the Army ePubs: https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN18126-ADP_5-0-000-WEB-3.pdf

Joint Force Development. (2022, June 18). *JP 3-0, Joint Campaigns and Operations.* Retrieved from Defense Acquisition University: https://www.dau.edu/sites/default/files/webform/documents/25566/JP%25203-0%252C%2520Joint%2520Campaigns%2520and%2520Operations.pdf

Joint Staff, J-8. (2021, October 39). *JCIDS Manual.* Retrieved from Joint Capabilities Integration and Development System (JCIDS): https://www.dau.edu/sites/default/files/Migrated/CopDocuments/Manual - JCIDS Oct 2021.pdf

Kuthunur, S. (2023). India's Chandrayaan-3 lunar lander barely kicked up any moon dust. Here's why that matters. *Space.com*, Online. Retrieved from https://www.space.com/india-chandrayaan-3-lunar-lander-moon-dust

Lea, R. (2024). Watch China's Chang'e 6 probe land on far side of the moon in dramatic video. *Space.com*, Online. Retrieved from https://www.space.com/china-chang-e-6-lunar-far-side-video

OSD. (1991, September 26). *DoD Directive 8320.1 Data Administration.* Retrieved from Defense Acquisition University: https://www.dau.edu/sites/default/files/Migrated/CopDocuments/DoDD83201 Data Admin.pdf

OUSD (A&S). (2020, October 2). *DOD Instruction 5000.87: Operation of the Software Acquisition Pathway.* Retrieved from Executive Services Directorate: https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/500087p.PDF

SET4D CNS. (2023). Retrieved from https://usaf.dps.mil/:b:/r/sites/ussf-starcom/stardelta/1tes/ITF1_01/E_CTT/SET4D/Shared

Documents/01. Early Involvement/Space Environment Toolkit 4 Defense (SET4D) Capability Needs Statement (CNS) v1.3.pdf?csf=1&web=1&e=Hmjqup

SET4D Evaluation Summary Chart II. (2024). Retrieved from https://usaf.dps.mil/:x:/r/sites/ussf-starcom/stardelta/1tes/ITF1_01/E_CTT/SET4D/Shared Documents/05. Test Measures/SET4D Evaluation Summary Chart (ESC) II.xlsx?d=w3d1ad2aa7fd147afb3dd0fa5b0a30725&csf=1&web=1&e=gHT2yy

SET4D Overview Briefing. (2024). Retrieved from https://usaf.dps.mil/:b:/r/sites/ussf-starcom/stardelta/1tes/ITF1_01/E_CTT/SET4D/Shared Documents/01. Early Involvement/SWAFS 2023 Overview Brief_5_22_23 .pdf?csf=1&web=1&e=iGM6Scp

US Army War College. (2023). *Campaign Planning Handbook (2023).* Retrieved from My Army Publications: https://www.myarmypublications.com/general-army-subjects-c-43/campaign-planning-handbook-2023-big-size-p-1101.html

Westphal, T., & Guffey, J. (2019, February 28). Measures of Effectiveness in Army Doctrine. *eARMOR*, Online. Retrieved from https://www.moore.army.mil/armor/earmor/content/issues/2014/oct_dec/Westphal.html

Yamaguchi, M. (2024). Japan’s moon lander wasn’t built to survive a weekslong lunar night. It’s still going after 3. *Associated Press*, Online. Retrieved from https://apnews.com/article/japan-jaxa-moon-probe-slim-78edbd90fd46837d272277700431ed95

Index

C

D

J

L

M

P

Q

R

S

T

U

V

W

Z