Test and Evaluation Part II

SEAPOWER THROUGH ENGINEERING

TOPIC LEARNING OBJECTIVES

Upon successful completion of this topic, the student will be able to:

1. Given descriptions, identify the types of Development Test and Evaluation (DT&E), e.g., Production Qualification Tests and Production Acceptance Test and Evaluation.
2. Identify the characteristics and purposes of Operational Test and Evaluations (OT&E) and why independent agencies are involved.
3. Identify the prime source of testable parameters for OT&E.
4. Identify the characteristics and roles of Early Operational Assessment (EOA) and Operational Assessment (OA) in reducing program risk.
5. Recognize the purpose and objectives of Live Fire Test and Evaluation (LFT&E).
6. Identify the opportunities, risks, and benefits associated with Integrated Developmental Test & Operational Test (DT/OT).
7. Recognize how Technical Performance Measures are used to track progress in program risk areas during systems development.
8. Identify which organizations develop, coordinate, and approve Critical Technical Parameters (CTPs).
9. Identify which organizations develop, coordinate, and approve Critical Operational Issues (COIs).
10. Recognize how Measures of Effectiveness (MOE) and Measures of Suitability (MOS) are used throughout the Test and Evaluation (T&E) process.

STUDENT PREPARATION

Student Support Material

1. Department of the navy test & evaluation. Total training catalog and career guide

Primary References

1. DoD 5000 Series
2. SECNAV 5000.2
3. USD(R&E) and OPTEVFOR T&E Enterprise Guidebook
4. COMOPTEVFORINST 3980.2
5. Official Website for Director Operational Test and Evaluation (DOT&E) Website https://www.dote.osd.mil

Additional References

1. None

TOPIC LEARNING OBJECTIVES

Upon successful completion of this topic, the student will be able to:

11. Identify key issues regarding test and evaluation of commercial and non-developmental items (NDI).
12. Identify how T&E is integrated throughout the acquisition life-cycle.
13. Identify the primary T&E products required at each acquisition milestone.

STUDENT PREPARATION

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Additional References

1. None

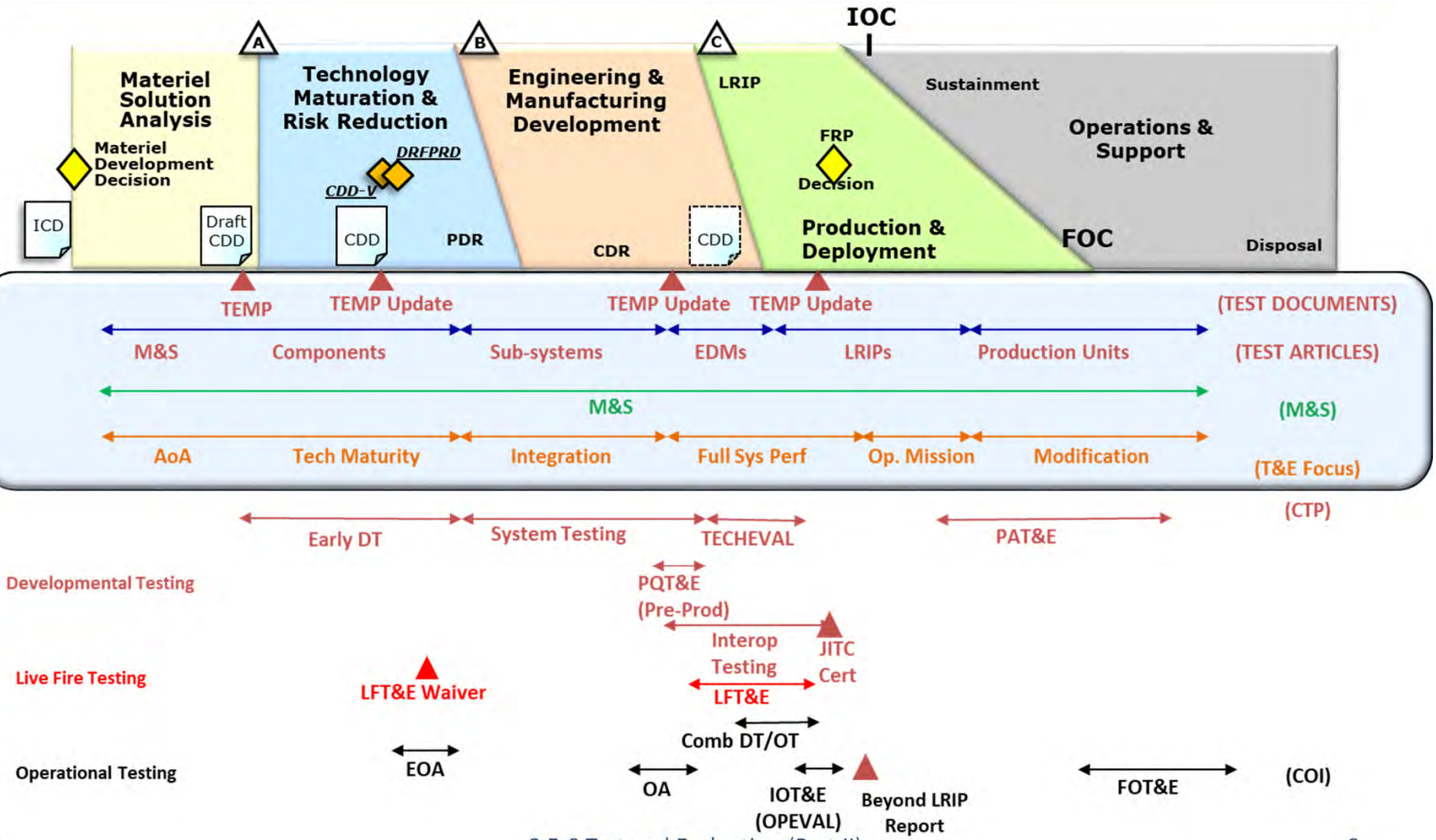
Overview

- Types of Developmental Testing
- Operational T&E Types
- Cybersecurity T&E
- Live Fire T&E
- T&E Terminology
- T&E Summary

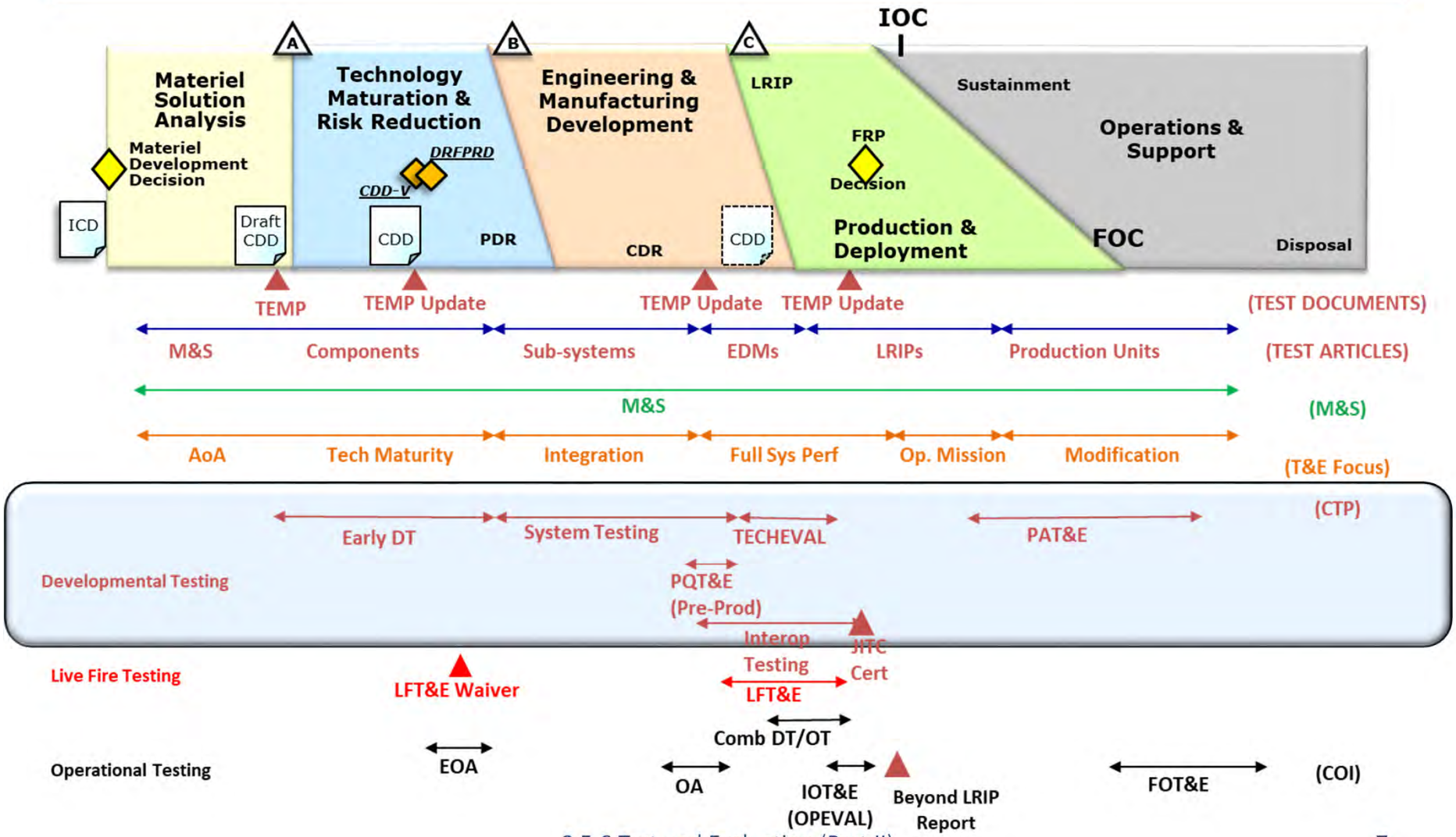
Test and Evaluation Review

- T&E Types and Organizations
- Test and Evaluation Master Plan (TEMP)
- TEMP Considerations
- Modeling and Simulation

Test & Evaluation



Test & Evaluation



Developmental T&E (DT&E)

- DT&E – Developmental Test and Evaluation
  - Controlled by Program Manager
  - Performed (typically) by Labs (e.g., NSWC) and/or Contractor team(s)
  - Warfighter or Operational Test Agency (OTA) insight is beneficial during DT&E
  - Weapons System Acquisition Reform Act of 2009 (WSARA 2009)
    - Director of Developmental Test and Evaluation appointed by Secretary of Defense and is the principal advisor to Secretary of Defense and USD (AT&L) on DT&E in DoD. Role names have changed
    - Director shall periodically review and assess technical maturity and integration risk of critical technologies of major defense acquisition programs and report to the USD (AT&L)

- DT&E Types:
  1. System Testing (verifying performance requirements)
  2. PQT&E: Production Qualification T&E
     a. Pre-production (prior to M/S C)
     b. 1st Article (between M/S C and FRP)
  3. PAT&E: Production Acceptance T&E

Ensures the producibility of the system's design and the effectiveness of the manufacturing process

DT&E Example

Pre-production Qualification Testing and Evaluation of the Enhanced Position Location Reporting System (EPLRS)

1. System Testing & Evaluation

- Testing performed during development that verifies performance
  - Typical development process is design-build-test and repeat
- Identifies & controls design technical risk
  - Assess progress toward resolving critical technical and operational issues, mitigation of tech risk, achievement of manufacturing process requirements, and system maturity
- Provides feedback to SE Process
  - Verifies requirements and validates functions
  - Supports cost, schedule and performance trade-offs with data
- Provides data and analysis to confirm the system is ready for OT&E
  - Want reasonable assurance of success before committing resources for OT

Commercial & Non-Development Items (NDI)

- Adequate testing is still required for Commercial Off-The-Shelf (COTS) & NDI
- Key issues:
  - Undefined COTS/NDI architecture
    - May impose additional risk due to lack of technical data
  - System suitability
    - Drive to maximize advantages of COTS/NDI may ignore legal requirements and suitability concerns
- Considerations:
  - Intended environment of the NDI
  - Additional integration testing
  - Potential modifications required to conform to new system
  - Take advantage of previous testing
  - Involve the Services' DT&E and OT&E agencies
  - Thoroughly document COTS & NDI testing in TEMP

2. Production Qualification T&E

- Pre-Production Qualification tests
  - Conducted prior to M/S C
  - Confirms system design integrity over specified operational & environmental range (e.g., thermal & vibration)
  - Usually on prototype or pre-production hardware (e.g., Engineering Development Model (EDM))
  - Includes contractual reliability & maintainability demonstration tests
- 1st Article Tests
  - Conducted between M/S C and Full Rate Production. (Ships are different)
  - Ensures effectiveness of manufacturing processes, equipment & procedures on items from the first production lot
  - PMO conducts additional 1st Article Tests when manufacturing process or system design changes significantly or a second source starts production

Production Qualification T&E verifies the design and the manufacturing processes prior to FRP

3. Production Acceptance T&E (PAT&E)

- Conducted during production, fielding/deployment, and operational support
  - Responsibility of the developer (Contractor)
  - May be accomplished by Quality Assurance sampling
- Checks that production units meet requirements/specifications

Reduces production risk

Technical Evaluation (TECHEVAL)

- Navy conducts additional DT&E for IOT&E cert called technical evaluation (TECHEVAL)

- TECHEVAL**:** The study, investigations, or Test and Evaluation (T&E) by a developing agency to determine the technical suitability of materiel, equipment, or a system, for use in the Military Services
  - DT&E controlled by the program office in a more operationally realistic test environment

The schedule should allow sufficient time between DT&E and IOT&E for rework, reports, analysis, and developmental testing of critical design changes

Technical Evaluation (TECHEVAL) (Cont.)

- Objectives:
  - To assist the developers by providing information relative to technical performance, qualification of components, compatibility, interoperability, vulnerability, lethality, transportability, reliability, affordability, maintainability, manpower and personnel, system safety, integrated logistics support, correction of deficiencies, accuracy of environmental documentation, and refinement of requirements
  - To ensure the effectiveness of the manufacturing process of equipment and procedures through production qualification testing
  - To confirm ***readiness for IOT&E***

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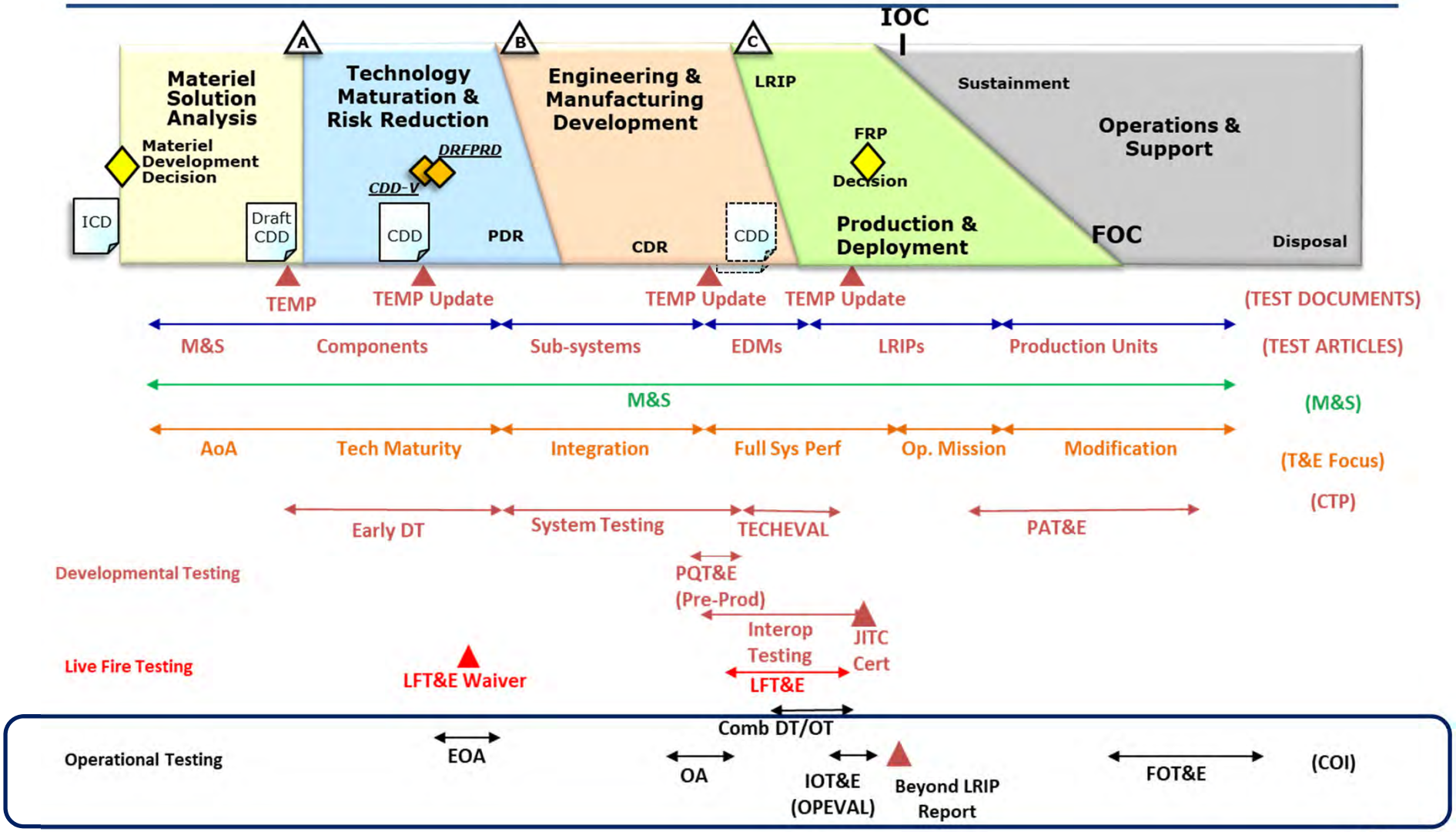
Test and Evaluation



Operational T&E Types

OPERATIONAL Test Director's (OTD) Manual
COMOPTEVFORINST 3980.21

- EOA – Early Operational Assessment
  - Forecast and evaluate the potential operational effectiveness, suitability, and cyber survivability of the system during development using experimental models, prototypes, modeling, or simulation
    - Shines a light on potential risk areas through analysis of program's progress in identifying operational design constraints, developing system capabilities
  - Supports program initiation decision (prior to M/S B)
- OA – Operational Assessment
  - Validates system meets operational requirements (prior to M/S C)
    - Focuses on significant trends noted in development efforts, programmatic voids, risk areas, adequacy of requirements, and the ability of the program to support adequate Operational Testing (OT)
  - Large complex programs will often have multiple OAs during EMD phase
  - OAs are typically required to support a Low Rate Initial Production Decision

Testable parameters derived from CDD; assessments provide confidence to the MDA that risks have been reduced

Operational T&E Types

OPERATIONAL Test Director's (OTD) Manual
COMOPTEVFORINST 3980.21

- IOT&E – Initial Operational T&E
  - Statutorily required
  - Conducted on production-representative test articles
  - Prior to Full Rate Production decision
  - Validates production system meets operational requirements
  - OTF decides operational effectiveness, operational suitability, cyber survivability, and recommendation regarding Fleet introduction

- VCD – Verification of Correction of Deficiency
  - Typically, not a pre-planned phase of testing
  - Inserted after a formal phase of OT to verify specific deficiencies cited in a previous OT&E report have been corrected
  - Provides MDA independent assurance

- FOT&E – Follow-on Operational T&E
  - After significant change in system or requirements
  - Evaluate new capabilities, enhancements, and regression of capabilities
  - Validates improvements or deficiencies from IOT&E

Ship Program OT&E

- MDA and DOT&E will come to an agreement on how much testing is required and then the CNO has to fund it
  - Scheduled after ship is delivered
  - Portions of DT&E and OT&E may be combined with SECNAV concurrence
  - TECHEVAL and IOT&E will not be combined
  - DT&E and OT&E prior to M/S B shall address T&E of individual, new, or modified shipboard systems
    - For lead ship acquisition, T&E conducted on lead (LRIP) ship
    - For individual weapons systems, T&E conducted at land based training sites (best case scenario), use of M&S authorized if not able
    - For system prototypes on lead ship, T&E conducted on LRIP ship and individual systems

Ships are complex and require integrated testing of many systems, possibly in various stages of DT and/or OT

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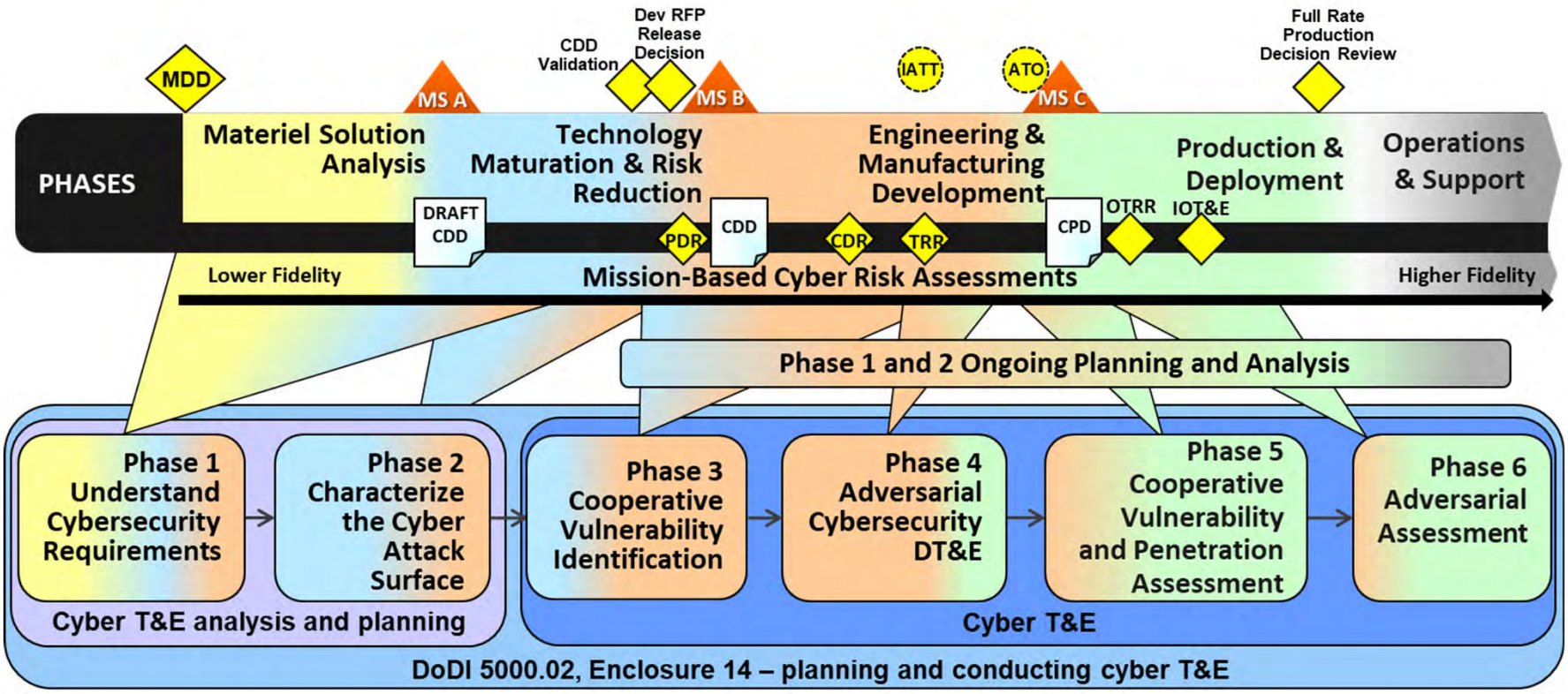
Cybersecurity T&E

- Six phases of cybersecurity T&E
  - Phase 1: Understand Cybersecurity Requirements – DT
  - Phase 2: Characterize the Attack Surface – DT
  - Phase 3: Cooperative Vulnerability Identification (CVI) – DT/IT
  - Phase 4: Adversarial Cybersecurity DT&E (ACD) – DT/IT
  - Phase 5: Cooperative Vulnerability and Penetration Assessment (CVPA) – OT
  - Phase 6: Adversarial Assessment (AA) – OT
- Cybersecurity T&E conducted early and often throughout a system's acquisition life-cycle
- For new acquisition platforms, conduct DT cybersecurity iteratively on systems, enclaves, and the end-to-end platform prior to OT

Six Phase Cyber T&E Process



DoD Cybersecurity T&E Guidebook Version 2.1
Download from https://ac.cto.mil/wp-content/uploads/2020/09/cyber-te-guide-v2c1.pdf

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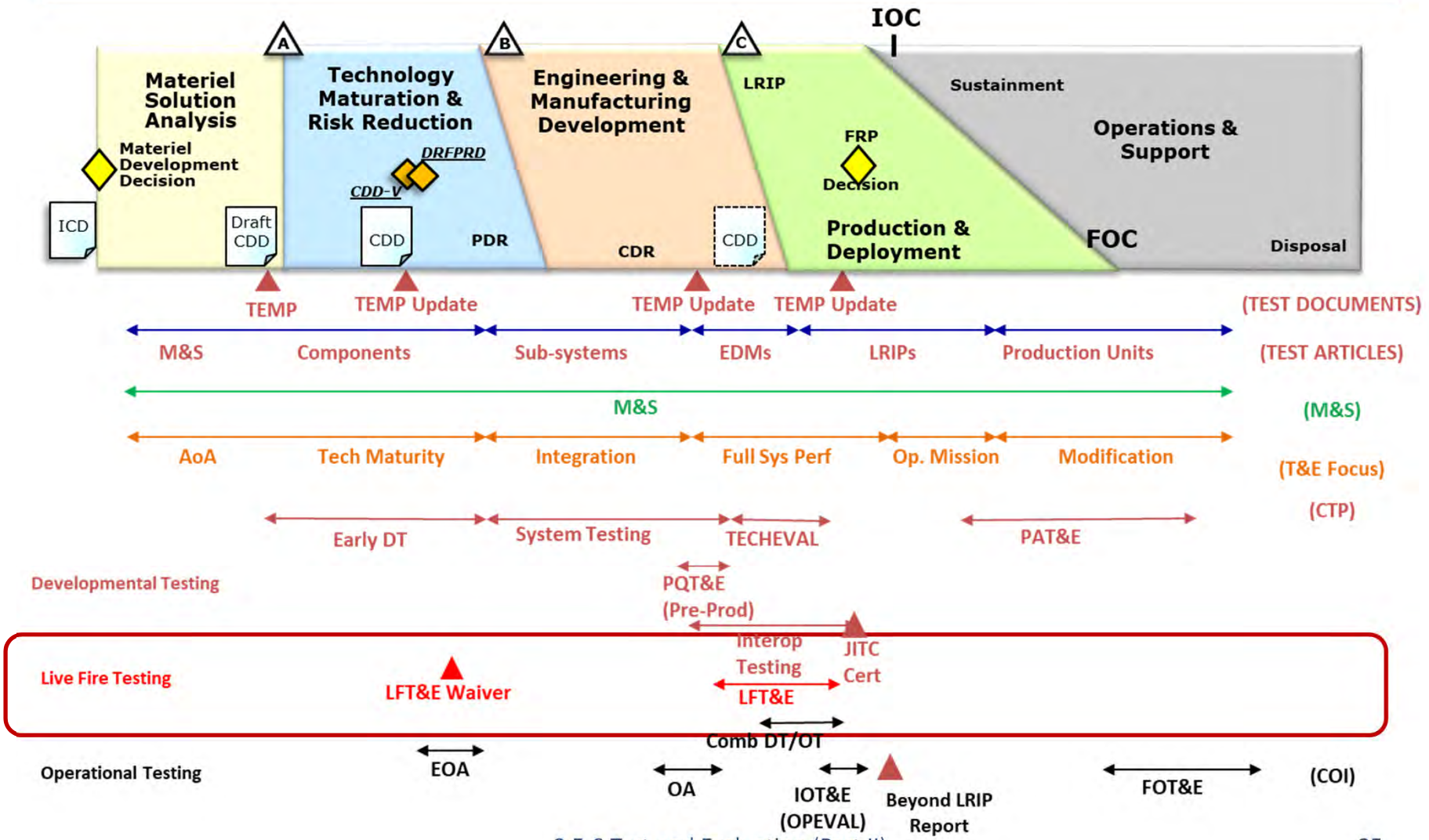

Covered Systems

- LFT&E is a statutory requirement for systems that are covered under the law (10 U.S.C. 4712), these include:
  - Any major system that provides some degree of protection to its occupants in combat
  - Any major conventional munitions or missile program; or one that will acquire 1M rounds or more
  - A modification to a covered system that is likely to significantly affect the survivability or lethality of such a system
  - Full Up System Level testing may be waived but Secretary of Defense shall include with any certification under paragraph (1) or (2) [the waiver] a report explaining how the Secretary plans to evaluate the survivability or lethality of system or program and assessing possible alternatives to realistic survivability testing of the system or program

Live Fire Test & Evaluation (LFT&E)

- Purpose/Objective:
  - ***Demonstrate lethality & survivability***
    - Systems requiring LFT&E are known as covered systems
    - ***Covered systems*** must submit a LFT&E Waiver at M/S B to support any decisions to perform less than full-up system level Live Fire Testing when it would be unreasonably expensive and impractical (an alternative vulnerability and lethality LFT&E program must still be accomplished)
      - e.g., Ships always have some form of LFT&E waiver
- Responsibilities
  - Services - Planning/Funding/Event Execution
  - DOT&E - Oversight and submits final LFT&E report
  - SECDEF - Approve LFT&E Waivers (delegated to USD(A&S) or ASN(RDA))

Live Fire Test Report due to Congress prior to FRP

Lethality & Survivability

Lethality Testing:
*Countermine Counter Obstacle (CMCO)**

Survivability Testing:
Blast Mitigation and Thermal Suppression
Protective VBIED Barrier Evaluation

- *Fired from a 5”/54 Barrel Modified to a 5”/62 Barrel

Examples of Live Fire Test & Evaluation

LFT&E Examples

- Early
  - Component testing
  - Lethality effects
  - Strength of system materials under fire
- Mature System
  - Full up system live-fire testing
    - Ship-level Shock Trials
    - Aircraft crew survivability
    - Vehicle crew survivability
    - Missile lethality

LFT&E Example

OT&E Review

Early Operational Assessment (EOA)	Performed on prototypes to help decision makers assess the proposed concepts. Assists the Program Manager with identifying and reducing risk.
Operational Assessment (OA)	Conducted during the EMD Phase to assess the system's potential to meet mission requirements. ***Supports a M/S C and Low Rate Initial Production (LRIP) decision.***
Initial Operational Test and Evaluation (IOT&E)	Conducted on production or production representative articles to ***support a Full Rate Production Decision Review (FRPDR)***. Purpose will always be to determine the operational effectiveness, operational suitability, and cyber survivability of the system.
Follow-on Operational Test and Evaluation (FOT&E)	Conducted after the system is in production and may continue throughout the life-cycle. Evaluates new capabilities, enhancements, and regression of capabilities.

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T&E Terminology

- Generic terminology for “metric”
  - TPM - Technical Performance Measure
- Developmental testing terminology
  - CTP - Critical Technical Parameter
- Operational testing terminology
  - COI – Critical Operational Issue
  - MOE – Measure of Effectiveness
  - MOS – Measure of Suitability
  - CBTE – Capabilities Based Test & Evaluation
  - MBTE – Mission Based Test & Evaluation
  - PMT – Platform Mission Task
  - IEF – Integrated Evaluation Framework

Technical Performance Measure (TPM)

- PMs must manage 3 basic program elements: cost, schedule, and performance
  - TPMs provide the mechanism for management of technical performance risk
- TPM is an umbrella term that covers Critical Technical Parameters (CTPs) and Critical Operational Issues (COIs)
  - CTPs and COIs are derived from KPPs
- Technical Performance must be tracked throughout system development
  - Results are compared to predicted values
  - Provides early detection of performance problems
  - Includes risk thresholds – when do we "pull the trigger"? (e.g., switch to alternative design or technology)

Essential to risk management

Critical Technical Parameters (CTPs)

- CTPs are ***design parameters*** critical to ensuring system ***meets operational thresholds*** (i.e., speed, range, lethality)
  - CTPs listed in matrix format in Part I of TEMP
- CTPs are TPMs derived from:
  - Capability Documents (ICD and CDD)
  - System Specifications
  - Acquisition Program Baseline (APB)
  - Systems Engineering documents
- CTPs are listed in a matrix, along with performance objectives and thresholds, in Part III of the TEMP
- CTPs are stated as specific numerical values and may change as the system matures during development; the system should show improvement over time

PMO develops & coordinates; MDA approves

Critical Operational Issues (COIs)

- COIs are the top level operational issues that must be examined during OT&E to determine the system's capability to perform its mission
- COIs are TPMs derived from
  - Capability documents (ICD and CDD)
  - Primarily derived from the CDD
- Two categories:
  - Effectiveness (E) and Suitability (S)
- Typically phrased as questions, for example:
  - (E) Will the system detect the threat in a combat environment at an adequate range to allow successful engagement?
  - (S) Will the system be supportable in the intended combat environment?
- COIs are included in Part III of the TEMP

OTA develops; PMO coordinates; MDA approves

MOEs and MOSs

- Measures of Effectiveness and Measures of Suitability are metrics that assess COIs. These measures are derived from the performance capabilities and characteristics identified in the CDD and AoA

- MOE: Measure of Effectiveness
  - Measures of operational capabilities in terms of engagement or battle outcome
    - Probability of kill
    - Lethality
    - Maximum effective range
    - Kills per unit time

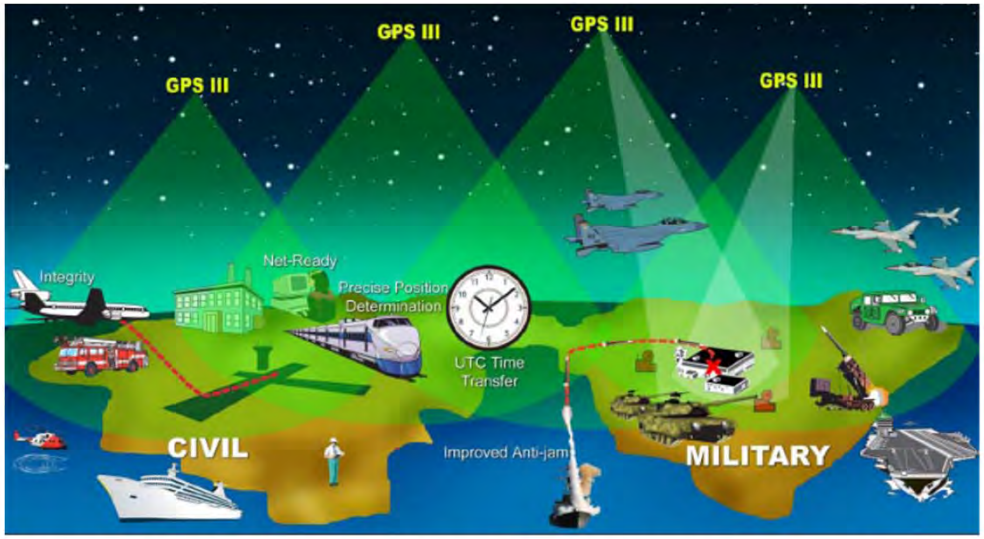
- MOS: Measure of Suitability
  - Measures of operational capabilities in terms of logistics, system supportability, and usability
    - Appropriate for environment
    - User training & maintenance
    - RAM

MOEs and MOSs assessed throughout development to help ensure successful Operational Test

Top-Level Evaluation Framework

Key Requirements and T&E Measures				Test Methodologies/ Key Resources (M&S, SIL, MF, ISTF, HITL, OAR)	Decision Supported
Key Reqs	**COIs**	**Key MOEs/MOSs**	**CTPs & Threshold**		
KPP #1:	COI #1. Is the XXX effective for...	MOE 1.1.	Engine Thrust	Chamger measurement Observation of performance profiles OAR	PDR CDR
	COI #2. Is the XXX suitable for...		Data upload time	Component level replication Stress and Spike testing in SIL	PDR CDR
	COI #3. Can the XXX be...	MOS 2.1.			MS-C FRP
		MOE 1.3.			Post-CDR FRP
		MOE 1.4.	Reliability based on growth curve	Component level stress testing Sample performance on growth curve Samlpe performance with M&S augmentation	PDR CDR MS-C
KPP #2		MOS 2.4.	Data link		MS-C SR
KSA #3	COI #4 Is training...	MOE 1.2.		Observation and survey	MS-C FRP
KSA #3.a	COI #5 Documentation	MOS 2.5			MS-C FRP

COI's – Operational Mission "Chunks" Informing Operational Decisions



Mission: GPS provides precise information to properly equipped users in support of specific mission objectives

Can GPS ***broadcast PNT*** data that supports the mission of properly equipped users?

Can the ***warfighter employ*** PNT data?

Does GPS ***command, control, and monitoring*** support all functions of GPS operations?

Does GPS provide MP in ***EW environments*** to properly equipped users?

Does GPS ***sustainment*** support mission operations?

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GPS OT Evaluation Framework

Assume the GPS system calls for a backup ground station in Fairbanks, Alaska. Operators there frequently complain about difficulty of pressing buttons with PPE (i.e., gloves). Is this an issue of Effectiveness or is it an issue of Suitability? Where might it be assessed?

GPS provides precise information to properly equipped users in support of specific mission objectives.					
Operational Capabilities	COI 1: Can GPS broadcast PNT data that supports the mission of properly equipped users?	COI 2: Can the warfighter employ PNT data?	COI 3: Does GPS command, control, and monitoring support all functions of GPS operations?	COI 4: Does GPS provide MP in EW environments to properly equipped users?	COI 5: Does GPS sustainment support mission operations?
System Autonomy	MOE 1.1				
Position Accuracy	MOE 1.2* - 1.3	MOE 2.1* - 2.2.1*			
Timing Accuracy	MOE 1.4*, 1.4.1*	MOE 2.3*, 2.3.1			
Signal Integrity			MOE 3.1 - 3.2*, 3.3 - 3.4*, 3.5 - 3.8		
Jam Resistance				MOE 4.1* - 4.1.2	
Signal Accessibility		MOE 2.4, 2.4.1		MOE 4.2	
NAVWAR		MOE 2.5*, 2.5.1	MOE 3.9, 3.25, 3.25.1	MOE 4.3 -4.4*, 4.5 - 4.7, 4.8*, 4.9	
Signal Security		MOE 2.8*	MOE 3.10		
E3 Compatibility		MOE 2.6	MOE 3.11		
Constellation Management			MOE 3.12* - 3.18		
Interoperability		MOE 2.7*			
IA			MOE 3.19*, 3.20*, 3.21*, 3.22*		
Operations Continuity			MOE 3.23 - 3.24		
Usability					MOS 5.1 - 5.3
Reliability					MOS 5.4
Maintainability					MOS 5.5 - 5.6
Availability					MOS 5.7*
SV Readiness/ Disposal					MOS 5.8
Training Quality					MOS 5.9 - 5.14
Documentation					MOS 5.15 - 5.18
Logistics Supportability					MOS 5.19 - 5.21
UE Survivability					MOS 5.22
Training Compliance					MOS 5.23 - 5.26

Which MOE assesses the warfighter's ability to employ PNT through Signal Accessibility?

A certain user of GPS is concerned that the extreme heat in the operational environment will cause critical equipment failures. Where might you find an applicable metric for assessment of this risk?

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Timing of T&E Products Review

- EOA
- LFT&E Waiver
- TEMP

- OA
- PQT&E (Pre-production)

- Interoperability Cert
- PQT&E (First Article)
- IOT&E
- LFT&E Report
- BLRIP Report

- PAT&E

T&E throughout the Acquisition Life-cycle

- The fundamental purpose of T&E is to
  - Provide essential information to decision makers
  - Verify and validate performance capabilities documented as requirements
  - Assess attainment of technical parameters
  - Determine whether a system is operationally effective, suitable, survivable, and safe for intended use
- T&E used throughout the acquisition life-cycle
  - During early phases of development, T&E demonstrates feasibility of
    - Conceptual approaches, evaluates design risk, identifies design architectures, compares and analyzes trade-offs, and estimates satisfaction of operational requirements
  - Early emphasis is on DT&E
  - Later emphasis is on OT&E as the design becomes more stable
  - ***Both types of testing can occur throughout the life-cycle***

Integrated DT/OT

- Satisfies one or more objectives of both DT and OT by the same test
  - ***IOT&E must be independent and cannot be combined***
- Benefits:
  - Saves time and money
  - Earlier feedback from Warfighters
  - Early identification of operational issues (before IOT&E)
- Risks:
  - Test events may be longer and more complex
  - Test failures can have larger ramifications
    - Increased number of test events may need to be redone/rescheduled
  - Independent testers see the system while it is immature
  - Contractor negative influence of Operational Test results

Critical T&E Procedures

- Cybersecurity
  - All programs will execute cybersecurity DT and OT throughout the program's life-cycle as part of the cybersecurity strategy
- Interoperability
  - All programs that exchange data will incorporate testing in DT and OT
  - Require certification from Joint Interoperability Test Command (JITC) (updated every three years) which is validated by Joint Staff J6
- Navigation Warfare Compliance
  - All programs using or producing positioning, navigation, and timing (PNT) must incorporate the Survivability KPP and conduct system T&E
- NAVSEA Navigation Certification (NAVCERT)
  - Conducted prior to and during Sea Trials to verify proper operation of navigation systems
- Weapons System Accuracy Tests (WSAT)
  - Conducted concurrently after ship delivery to verify performance

Key Differences between DT&E and OT&E

DT&E	OT&E
Controlled by Government PM	Controlled by COTF with input from DOT&E
Sys Operating (lab) environment	Combat Environment
Developer involved	No Contractor involvement
Measure Performance against design	Measure Effectiveness and Suitability
Critical Technical Parameters	COIs (MOEs and MOSs)
Any development article (component, sub-sys, EDMs)	Production representative article (LRIP)
Contractor/developer personnel do testing	Warfighters do the testing
Realistic environment	Combat environment/Realistic Threats

Summary

- Which statement accurately reflects what occurs during Developmental Test & Eval (DT&E)?
- Which is conducted on production items to demonstrate that those items meet the requirements and specifications of the procuring contracts or agreement?
- Which is conducted prior to M/S C and also between M/S C and FRP?
- Which is a type of OT&E that assesses the system's potential to meet mission requirements and supports a M/S C decision?
- EOA and OA provide for:
- Prime source of testable parameters for OT&E:

Summary

- Purpose and objectives of LFT&E?
- What is a major advantage of integrating DT & OT?
- An indicator of the overall degree to which a system can be placed satisfactorily in the Fleet, with consideration given to utilization factors
- An indicator of the overall degree of mission accomplishment when the system is used by representative personnel in the expected operational environment
- Critical system characteristics and technical performance measures derived from the CDD & CPD and evaluated during DT&E