Capability Test Methodology (CTM) Measures Framework

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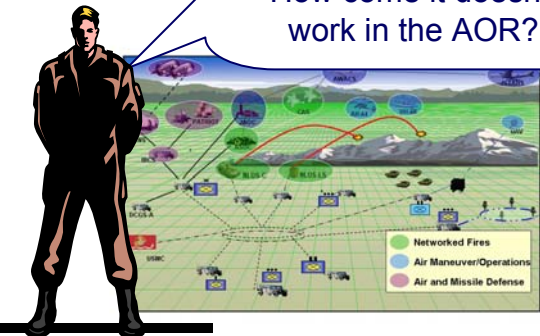**757.638.6079**
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Overview

- TiJE
- JTEM Overview
- Why Measures Framework ?
- CJI Construct
- CEM
- Measure Framework
  - Examples
- Way Ahead

Why Test in a Joint Environment?

It is a requirement . . .

Hey, this stuff passed its interoperability certs! How come it doesn't work in the AOR?

ENABLING THE JOINT FORCE

Test in a Joint Environment across the Acquisition Life Cycle

"Systems that provide capabilities for joint missions shall be tested in the expected joint operational environment ."

DoDI 5000.2, E.5
[Draft, August 2007]

Single Service Operational Test in a Realistic Environment

Interoperability Test/Certification

". . . any resultant materiel solution will be verified through testing in the expected joint operational environment to demonstrate joint interoperability . . ."
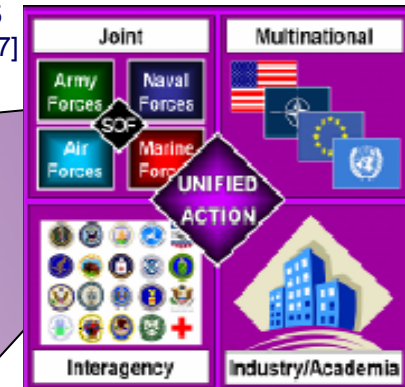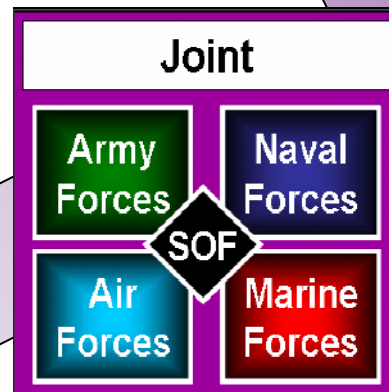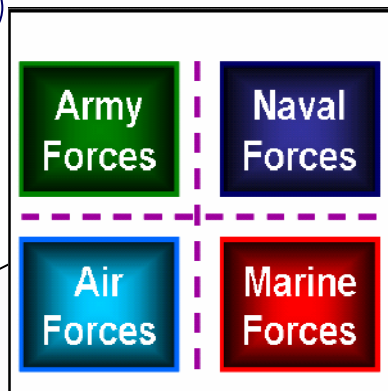
CJCSI 3170.01F, B.3
[May 2007]

"OT&E shall determine the operational effectiveness and suitability of a system under realistic operational conditions, including combat."

DoDI 5000.2, E.7
[May 2003]

JOINT CAPABLE FORCES

Interdependent

Joint

Army Forces | Naval Forces
SOF
Air Forces | Marine Forces

Integrated

The warfighter demands it!

Army Forces | Naval Forces
Air Forces | Marine Forces

Coordinated

Army Forces | Naval Forces
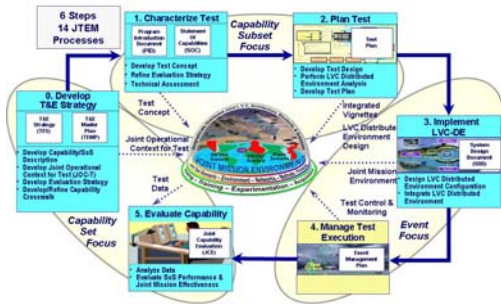Air Forces | Marine Forces

Deconflicted

Test like we fight

It is the right thing to do . . .

– Early discovery of problems, reduced rework costs

– Improved test data for milestone decision authorities

– Improved system characterization and limitations for Service and combatant commander planning

– Field proven joint capabilities to the combatant commander

Testing in a Joint Environment (TiJE) Methods and Processes Approach

Capability Test Methodology (CTM)

Capability Evaluation Metamodel (CEM)

Joint Mission Environment Foundation Model (JFM)
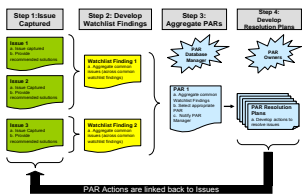
Process Anomaly Reports (PAR)

- **Best practices**

- **Consistent approach to joint mission environment (JME)**

- **Consistent joint capability assessments and evaluations**

- **Application across the acquisition life cycle**

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Why Measures Framework?

- For consistent answers on SoS, need standard methodologies across:
  - Services
  - Domains
- Need standard instrumentation
- Need joint tasks measured by test organizations
- Need measures rooted in JCIDS, AA, etc.

Relationship between CEM and CTM

Capability Test Methodology (CTM) Lexicon

provides underlying conceptual definitions

Capability Evaluation Metamodel (CEM)

provides underlying business rule relationships

6 Steps 14 JTEM Processes

0. Develop T&E Strategy
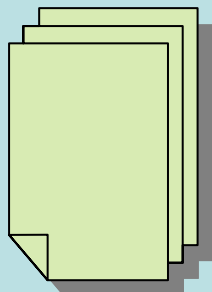- T&E Strategy (TES)
- T&E Master Plan (TEMP)
- Develop Capability/SoS Description
- Develop Joint Operational Context for Test (JOC-T)
- Develop Evaluation Strategy
- Develop/Refine Capability Crosswalk

1. Characterize Test
- Program Introduction Document (PID)
- Statement Of Capabilities (SOC)
- Develop Test Concept
- Refine Evaluation Strategy
- Technical Assessment

Capability Subset Focus

2. Plan Test
- Test Plan
- Develop Test Design
- Perform LVC Distributed Environment Analysis
- Develop Test Plan

3. Implement LVC-DE
- System Design Document (SDD)
- Design LVC Distributed Environment Configuration
- Integrate LVC Distributed Environment

4. Manage Test Execution
- Event Management Plan

Event Focus

5. Evaluate Capability
- Joint Capability Evaluation (JCE)
- Analyze Data
- Evaluate SoS Performance & Joint Mission Effectiveness

Capability Set Focus

Test Concept

Joint Operational Context for Test

Test Data

Integrated Vignettes

LVC Distribute Environment Design

Joint Mission Environment

Test Control & Monitoring

Capability Evaluation Metamodel (CEM)

- JTEM is designing a Capability Evaluation Metamodel (CEM)
  - Metamodel definition
    - An explicit model of the constructs and rules needed to build specific models within a domain of interest
    - A meta-model can be viewed from three different perspectives:
      - as a set of building blocks and rules used to build models
      - as a model of a domain of interest, and
      - as an instance of another model
  - CEM purpose
    - Provide an underlying structure for CTM evaluation methods and processes (for example, CTM evaluation-related template content and relationships)
    - Provide business rule relationships for the CTM evaluation thread
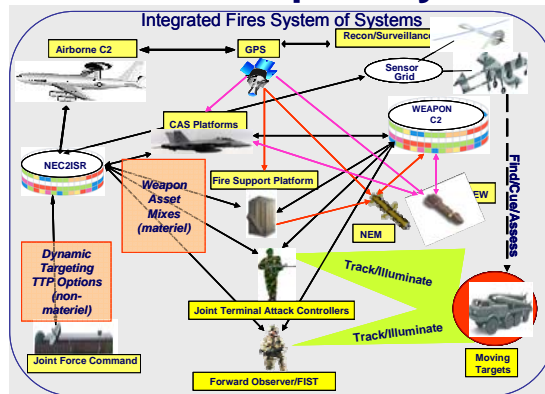
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CEM Key Relationships

Joint Mission Desired Effects

- Disrupt Red Combat forces moving in battle area.
  - Attrite Red Combat forces in the battle area.
  - Support Blue maneuver in the battle area.
  - Protect Blue forces in the battle area.
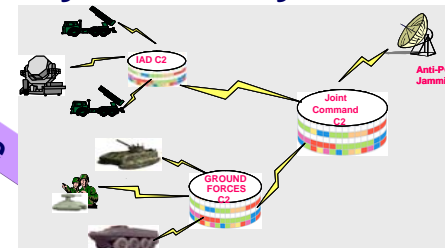
Mission MOEs

Analytic Agenda → Provide COCOM

Joint Tasks

SN 1, "Conduct Strategic Deployment and Redeployment"

OP 1, "Conduct Operational Movement and Maneuver"

TA 1, "Deploy/Conduct Maneuver"

Achieve

UJTL → List

Task MOPs

Joint Capability

Integrated Fires System of Systems

Perform

System of Systems

Describe

SoS Attributes

Address Capability Gaps

JCIDS Acquisition

JCAs → List

CTM establishes the M&P to test SoS ability to provide the means and ways to perform a set of tasks in order to achieve the set of desired effects that lead to mission success

CEM – Capability Evaluation Metamodel
JCIDS – Joint Capabilities Integration and Development System
MOP – Measure of Performance
CTM – Capability Test Methodology
M&P – Methods and Processes
SoS – System of Systems
JCA – Joint Capability Area
MOE – Measure of Effectiveness
UJTL – Universal Joint Task List

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Capability Evaluation Metamodel (CEM): Test Plan Design
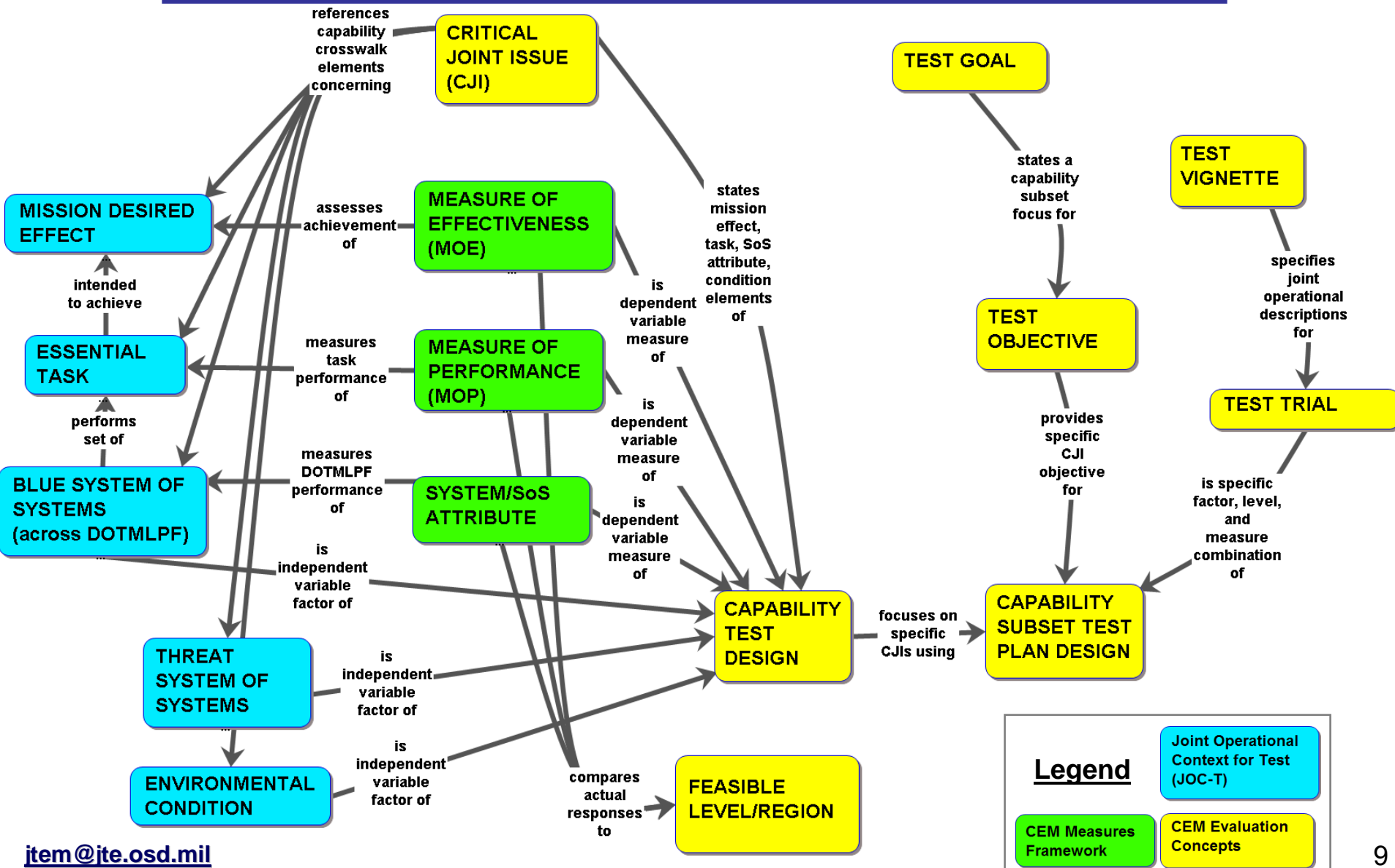
Capability Evaluation Metamodel (CEM): DOD Context for CEM JOC-T

JOINT CAPABILITY AREA (JCA) —functionally tiers areas of→ **CAPABILITY**

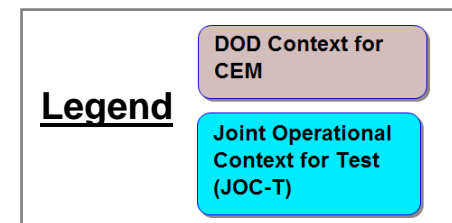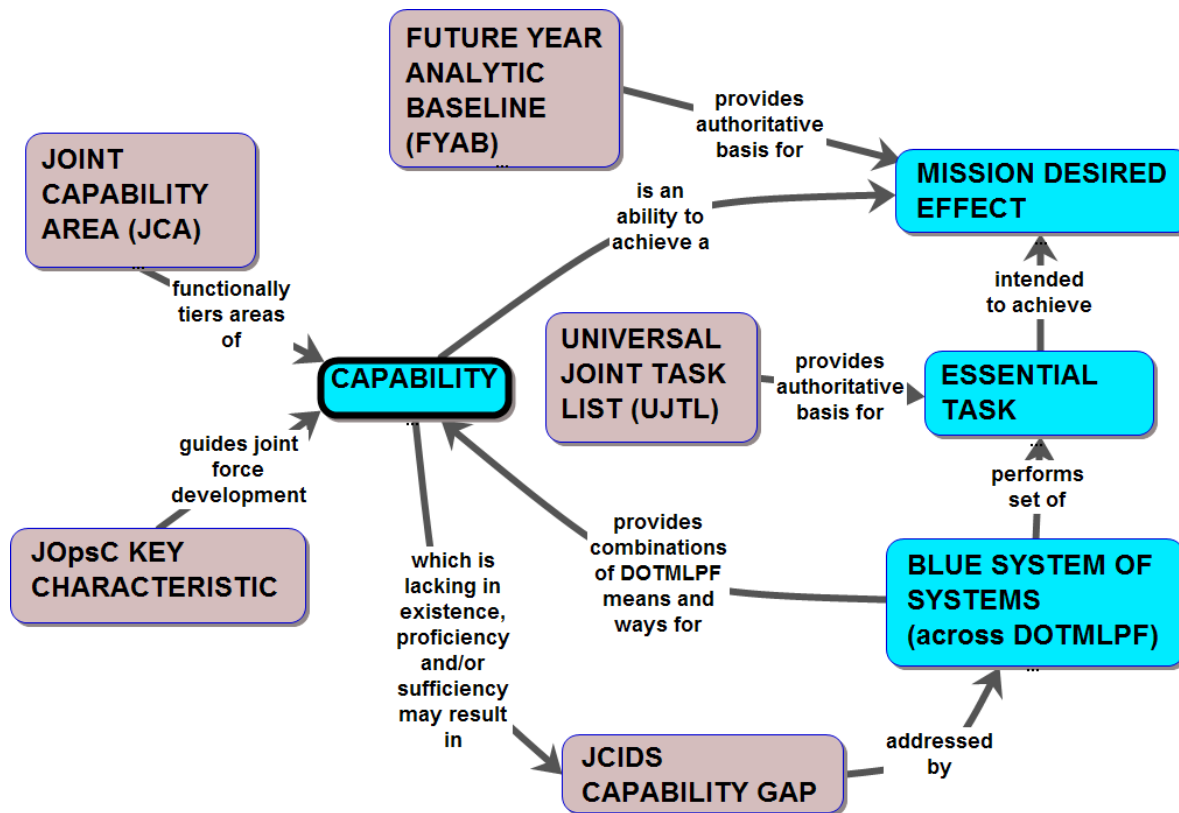**FUTURE YEAR ANALYTIC BASELINE (FYAB)** —provides authoritative basis for→ **MISSION DESIRED EFFECT**

CAPABILITY —is an ability to achieve a→ **MISSION DESIRED EFFECT**

JOpsC KEY CHARACTERISTIC —guides joint force development→ **CAPABILITY**

UNIVERSAL JOINT TASK LIST (UJTL) —provides authoritative basis for→ **ESSENTIAL TASK**

ESSENTIAL TASK —intended to achieve→ **MISSION DESIRED EFFECT**

BLUE SYSTEM OF SYSTEMS (across DOTMLPF) —performs set of→ **ESSENTIAL TASK**

BLUE SYSTEM OF SYSTEMS (across DOTMLPF) —provides combinations of DOTMLPF means and ways for→ **CAPABILITY**

CAPABILITY —which is lacking in existence, proficiency and/or sufficiency may result in→ **JCIDS CAPABILITY GAP**

JCIDS CAPABILITY GAP —addressed by→ **BLUE SYSTEM OF SYSTEMS (across DOTMLPF)**

Legend

DOD Context for CEM

Joint Operational Context for Test (JOC-T)

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Evaluation Strategy Overview

- **Critical Joint Issue (CJI) Checklist**
    - Is the CJI:
        - Used to assess performance as it pertains to capabilities supporting joint missions?
        - Structured as a question addressing joint capability areas described in Joint Capability Documentation?
        - Addressing the system of systems ability to perform joint operational tasks and/or the system of systems, system, or service attribute performance?
    - Does the CJI phrasing include SoS contribution to achieving the desired mission end state outcomes in terms of mission desired effects?
    - CJIs should be of primary importance to the decision authority in reaching a decision to allow the system of systems to advance into the next phase of development.

- **CJI Example Template:**

    Can the Capability perform Task X by SoS Configuration Y under Condition A to achieve Mission Desired Effect Z?

Measures Framework

Service-acquired capabilities

that perform joint tasks

CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

to accomplish a joint mission

Critical joint issues assess system and task performance pertaining to capabilities which support joint missions.

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Measures Framework

COIs & system/SoS attributes (KPP, CTPs)

CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

- Systems measure critical technical parameters (CTP) (attributes, that when achieved, allow attainment of desired operational capabilities) to resolve critical operational issues (COI) regarding task accomplishment

The program manager/OTA need to know if the SUT can accomplish the required task in the Joint Operational Context for Test.

Measures Framework

```
┌─────────────────────┐        ┌─────────────────────┐        ┌─────────────────────┐
│  System/System      │  ←act→ │  System/System      │  → to  │  Joint Task(s)      │
│  of Systems         │   &    │  of Systems         │contribute│ Accomplishment    │
│                     │interact│                     │   to   │  (TMOP)             │
└─────────────────────┘        └─────────────────────┘        └─────────────────────┘
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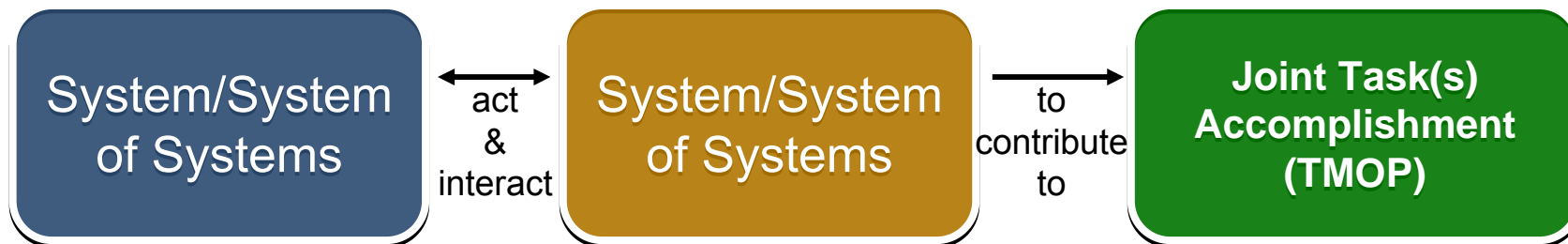
CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

- Systems are combined to accomplish Universal Joint Tasks which are measured at the System of Systems level (Services acting in concert to achieve a task)

Joint tasks are measured by a Task Measure of Performance derived from UJTL references (after Joint Capability Area analysis).

Measures Framework

System/System of Systems ← act & interact → System/System of Systems → to contribute to → **Joint Task(s) Accomplishment (TMOP)**

CJI: Can JBD2 perform to enable close air support by near-term networked fires SoS under a hostile threat environment to achieve destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)?

Mission Desired Effect (MMOE)

- One or more tasks contribute to desired effect(s)/end state

Mission Measure of Effectiveness (MMOE) measures desired end state(s) (desired effects) that result from task performance.

Integrated Fires Capability Operational Concept Graphic (OV-1)

Mission Statement

Blue Forces conduct Joint Forcible Entry Operations to expand lodgment and control key infrastructure in order to facilitate rapid force build-up in the Joint Operations Area (JOA)
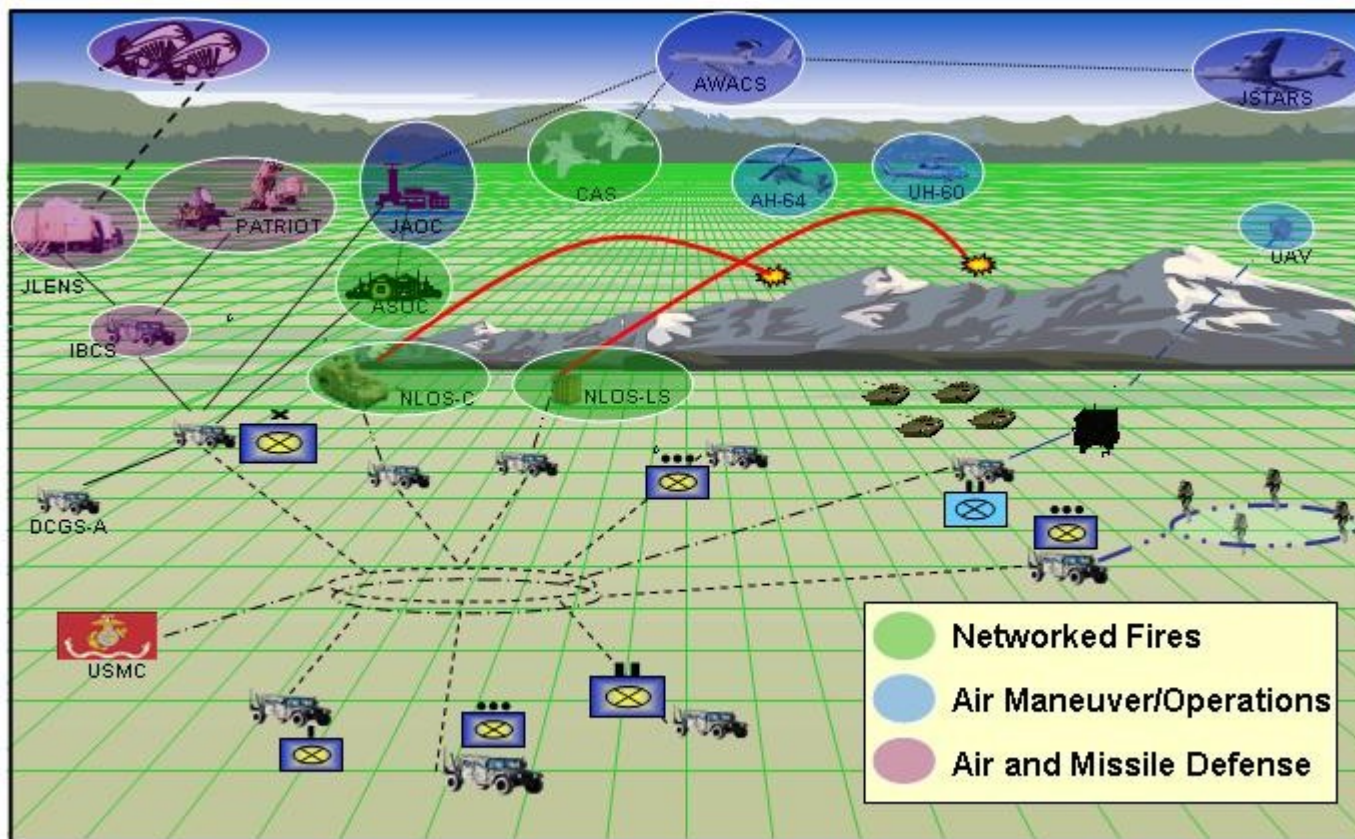
End State

- **Expand lodgment and control key infrastructure to facilitate rapid force build-up**
- **Preserve key infrastructure and prevent environmental contamination**
- **Secure LOCs to facilitate flow of forces needed to conduct regime change operations**

Desired Effects

- **Destroyed or neutralized Threat Forces (in Zone, moving into Zone, indirect fires, ADA)**
- **Blue unhindered in maneuver within the JOA**
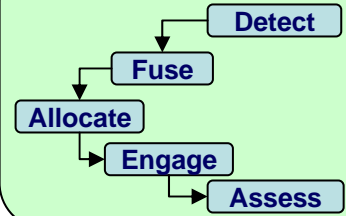- **Blue force survivability in the JOA**
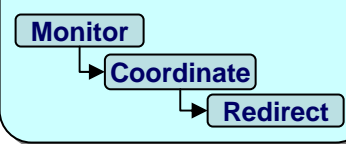
Integrated Fires System of Systems

Legend:
- Networked Fires
- Air Maneuver/Operations
- Air and Missile Defense

to help achieve

Tasks

Networked Fires
- Detect
- Fuse
- Allocate
- Engage
- Assess

Air Maneuver/Ops
- Monitor
- Coordinate
- Redirect

Air & Missile Defense
- Detect
- Fuse
- Allocate
- Engage
- Assess
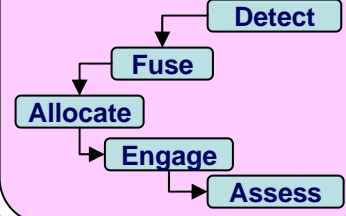
Provides the ability to perform

Mission MOE: Threat Systems Combat Ineffectiveness
(Percentage of threat systems rendered ineffective
[killed, damaged, dislocated] compared to Blue desired value)

Mission Statement
Blue forces conduct joint forcible entry operations to expand lodgment and control key infrastructure in order to facilitate rapid force build-up in the joint operations area (JOA)

End State
Expand lodgment and control key infrastructure to facilitate rapid force build-up

Desired Mission Effect
Destroyed or neutralized threat forces (in zone, moving into zone, indirect fires, ADA)

Networked Fires
Air Maneuver/Operations
Air and Missile Defense

t_0
Trial Start

Joint Mission Time Horizon

t_n
Trial End

Sequence of Events

1. Mission start at time t_0. Threat forces in JOA or moving into JOA. Blue forces conducting joint forcible entry operations.
2. Blue forces employ Networked Fires task thread to prosecute threat targets.
3. Threat systems killed, damaged, or dislocated.
4. Mission complete at time t_n

Mission MOE: Threat Systems Combat Ineffectiveness
(Percentage of threat systems rendered ineffective
[killed, damaged, dislocated] compared to Blue desired value)

Data Elements

1. **Blue Desired Fraction of Threat Systems in JOA Combat Ineffective at Mission End State (threshold value)**
2. **Cumulative count Threat Systems in zone over time (System Type, Time, Location)**
3. **Cumulative count Threat Systems Killed (System Type, Time, Location)**
3. **Cumulative count Threat Systems Combat Damaged (System Type, Damage Type, Time, Location)**
3. **Cumulative count Threat Systems Dislocated (System Type, Dislocation Type, Time, Location)**

Key Terms

1. **Threat Mounted Systems**: Those threat mounted systems that either are in the JOA at trial start or enter the JOA during the trial period. System does not have to still be in JOA at trial end to be counted. A system will also not be counted more than once (if enters JOA more than once). (**System Type**: identifying type; **Time**: Time at which entered JOA; **Location**: Positioning data at time which entered the JOA. If in JOA at trial start, then position at trial start time)

2. **Threat Mounted System kill**: Those threat systems that can no longer move, shoot, and sense. System no longer possesses a capability. Assumes cannot be fixed and remains a kill until trial end. (**System Type**: identifying type; **Time**: Time at which killed; **Location**: Positioning data at time which killed)

3. **Threat Mounted System damaged**: Those threat systems that can no longer shoot but are not killed. System is combat ineffective but still retains some capability to move or sense. (**System Type**: identifying type; **Damage type**: S – unable to shoot, SM – unable to shoot and move, SS – unable to shoot and sense; **Time**: Time at which entered damaged state. Must remain in damaged state to trial end to be counted. If later attacked and killed, then counted as a kill. If moves out of JOA or goes into hiding, still considered damaged and not dislocate; **Location**: Positioning data at time which entered damaged state)

4. **Threat Mounted System dislocated**: Those threat systems that are not combat effective in the JOA at trial end. System either leaves the JOA and remains outside the JOA until trail end, or system is in the JOA and hiding at trial end to avoid attack. Hiding assumes it is unable to move, shoot, or sense. A system is only counted as dislocated if in that state at trial end. (**System Type**: identifying type; **Dislocation type**: departed, denied, hidden; **Time**: Time at which entered dislocated state. Reset if system goes out of dislocated state before trial end; **Location**: Positioning data at time which entered dislocated state. Assumes does not move if remains in dislocated state until trial end)

Calculation

$$\frac{\left(\dfrac{\sum \text{Threat Systems Combat Ineffective (killed} \vee \text{damaged} \vee \text{dislocated) in JOA at trial end}}{\sum \text{Threat Systems in/newly entered JOA by trial end}}\right)}{\left(\text{Blue Desired Fraction of Threat Systems Combat Ineffective in JOA at Mission End State}\right)}$$

Success Criteria

MMOE ≥ 1.0

Task MOP: Percentage targets attacked IAW requests for fires
(Number of targets attacked compared to total number of requests for fires)

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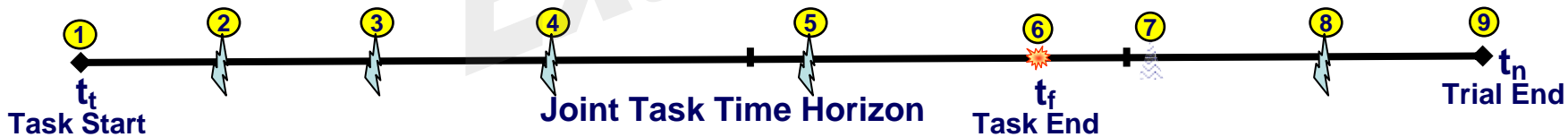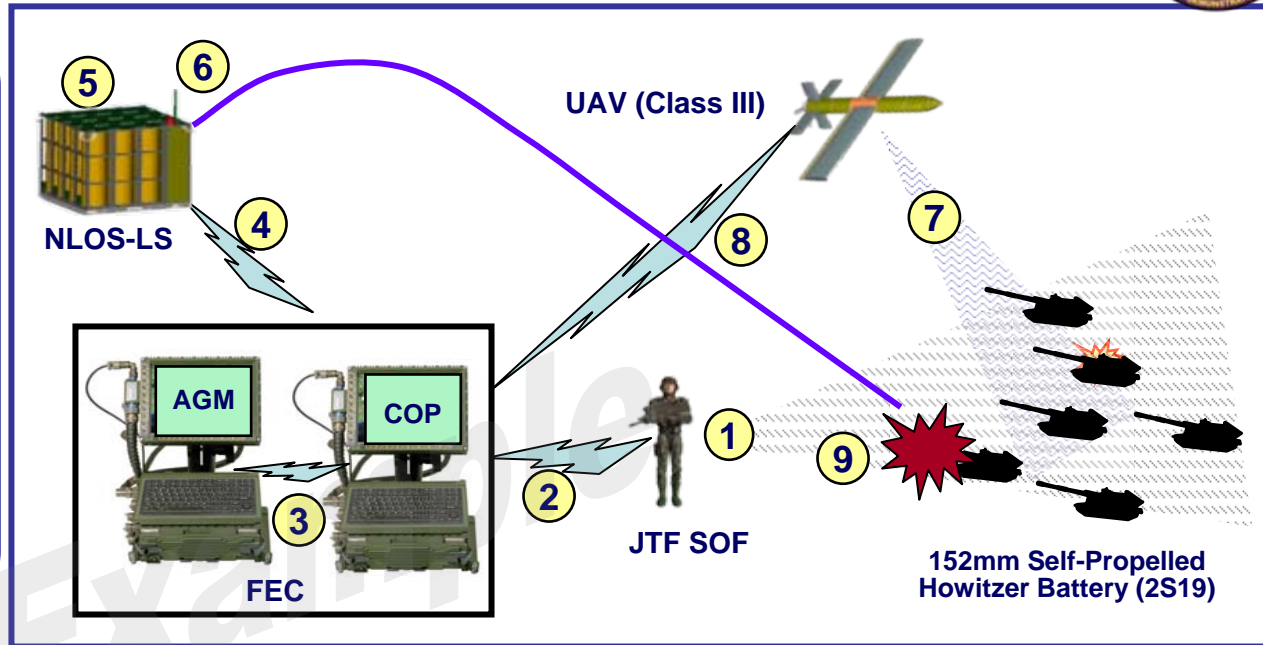
Joint Task
TA 3.2.1 Conduct Joint Fires:
Employ Fires that support land, maritime, amphibious, and special operation forces to engage enemy forces, combat formations, and facilities in pursuit of tactical and operational objectives.

MOP (M1)
Percentage targets attacked IAW requests for fires

NLOS-LS

UAV (Class III)

AGM   COP

FEC

JTF SOF

152mm Self-Propelled Howitzer Battery (2S19)

t_t
Task Start

Joint Task Time Horizon

t_f
Task End

t_n
Trial End

Sequence of Events
1. JTF SOF soldier detects 2S19 Battery at start time t_d
2. JTF SOF soldier reports 2S19 target information to the FEC to populate the COP.
3. Decision is made to engage the 2S19s with PAM. Request for fires is made.
4. NLOS-LS receives fire mission
5. NLOS-LS processes the target acquisition information and is prepared to fire PAM.
6. NLOS-LS fires PAM at time t_f
7. Class III UAV detects effects.
8. BDA report is sent to FEC for COP update and potential re-targeting/re-attack.
9. Ground truth of target effects.

Data Elements

1. **Blue Target Engagement Objective Value**
3. **Number of requests for fire**
6. **Number threat systems attacked from requests for fire**

Key Terms

1. **Threat Systems (TS$_d$) detected in JOA** : Those threat systems **(TS$_d$)** that are detected in the JOA and a request for fires is executed. (**System Type**: identifying type; **Detection time**: Time at which TS was first detected (t_d.), Request for Fires time: Time at which request for fires on TS was executed (t_r.)

6. **Threat Systems (TS$_k$) targeted in JOA** : Those threat systems **(TS$_k$)** that are targeted and attacked in the JOA during the trial period. (**System Type**: identifying type; **Fires time**: Time at which TMP was fired on (t_f.)

Calculation

$$TMOP = \frac{\dfrac{\sum \text{Threat Systems Attacked from Requests for Fire}}{\sum \text{Requests for Fire}}}{\text{BlueTargetEngagementObjectiveValue}}$$

Success Criteria

TMOP ≥ 1.0

SoS Attribute: Rapid Fires Engagement
(Average time to engage targets from networked fires)
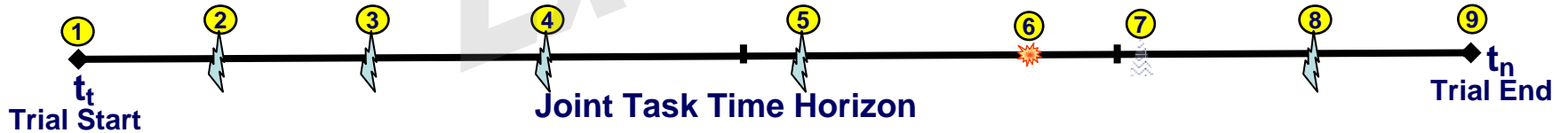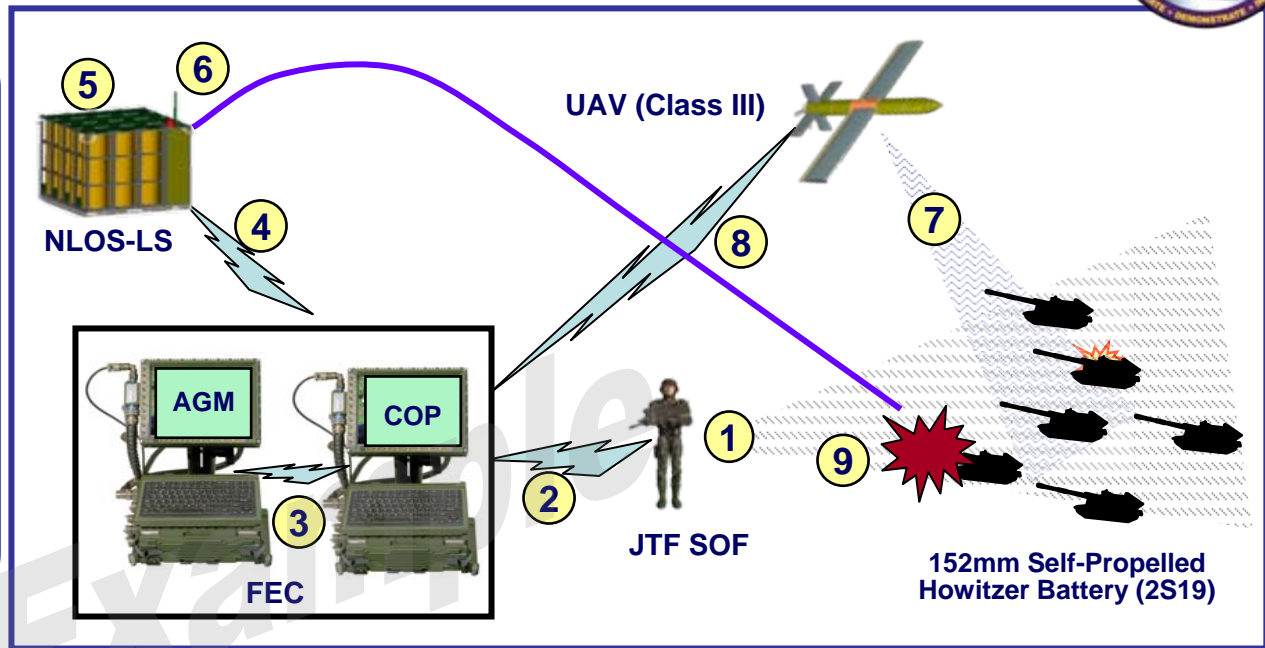
Mission Statement
Blue Forces conduct joint forcible entry operations to expand lodgment and control key infrastructure in order to facilitate rapid force build-up in the joint operations area (JOA)

System of Systems (SoS)
Networked Fires

SoS Performance Areas
Doctrine
Organization
Training
Materiel
Leadership
Personnel

NLOS-LS

AGM

COP

FEC

UAV (Class III)

JTF SOF

152mm Self-Propelled Howitzer Battery (2S19)

t_t
Trial Start

Joint Task Time Horizon

t_n
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SoS Attribute: Rapid Fires Engagement

(Average time to engage targets from networked fires)

Data Elements

1. BlueDesiredEngagementTime
1. Cumulative Count Threat Systems Engaged
1. Threat System detection time (t_d)
6. Threat System fires time (t_f)

Key Terms

1. **Threat Systems (TS_d) detected in JOA** : Those threat systems **(TS_d)** that are detected in the JOA and a request for fires is executed. (**System Type**: identifying type; **Detection time**: Time at which TS was first detected (t_d.), Request for Fires time: Time at which request for fires on TS was executed (t_r.)

6. **Threat Systems (TS_k) targeted in JOA** : Those threat systems **(TS_k)** that are targeted and attacked in the JOA during the trial period. (**System Type**: identifying type; **Fires time**: Time at which TMP was fired on (t_f.)

Example

Calculation   ### *Success Criteria*

$$BET = \frac{\dfrac{\sum \left(\text{ThreatSystemFiresTime } t_f \ - \ \text{ThreatSystemDetectionTime } t_d \right)}{\text{CumulativeCountThreatSystemsEngaged}}}{\text{BlueDesiredEngagementTime}} \qquad \forall \ TS_k \quad \text{and Engaged}$$

$\Rightarrow$ BET ≥ 1.0

Path Forward

- Need Analysis Framework
- Need regular tests in JCAs
- Need CONUS virtual range stood up

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