

The 16th Annual National Systems Engineering Forum

**Sponsored by the National Defense Industrial
Association Systems Engineering Division**

October 30, 2013

**“An Integrating Framework for Supporting Systems
Engineering”**

**Held at The Hyatt Regency Crystal City, Arlington, VA
October 28 - 31, 2013.**

Agenda: Wednesday, October 30, 2013

**An Integrating Framework for Supporting Systems
Engineering**

- **Introduction – Need for an Integrating Framework**
- **Missions and Means Framework (MMF)**
- **Illustration of Framework Application**
- **MMF Products**
- **A Brief Word about Executability**
- **Conclusion/Summary**

Introduction

- Premise - We need a common structural framework supported by a commonly understood language to describe:
 - Missions and the operations envisioned to accomplish them
 - The role that systems are to play in accomplishing the mission
 - How system components support overall system and each other
 - Effect of component(s) loss or degradation on system ability to perform role

- Military professionals use doctrine and constructs like the Military Decision Making Process (MDMP) to describe missions and operations

Introduction Cont.

- MDMP logic and supporting processes, when properly applied to inform missions and operations to systems engineering provides:
 - Identification and sharing of necessary and sufficient metrics
 - Identification and description of linkages and dependencies
 - Explanation and traceability of breaks or interruptions to operational impact

- Missions and Means Framework (MMF) is result of collaborative effort by Army scientists and operational SMEs to provide abstractive structure for MDMP

- MMF provides roadmap to achieve interoperability and systems integration, SOS engineering and effective M&S through comprehensive and explicit description of missions and linkage to requisite means

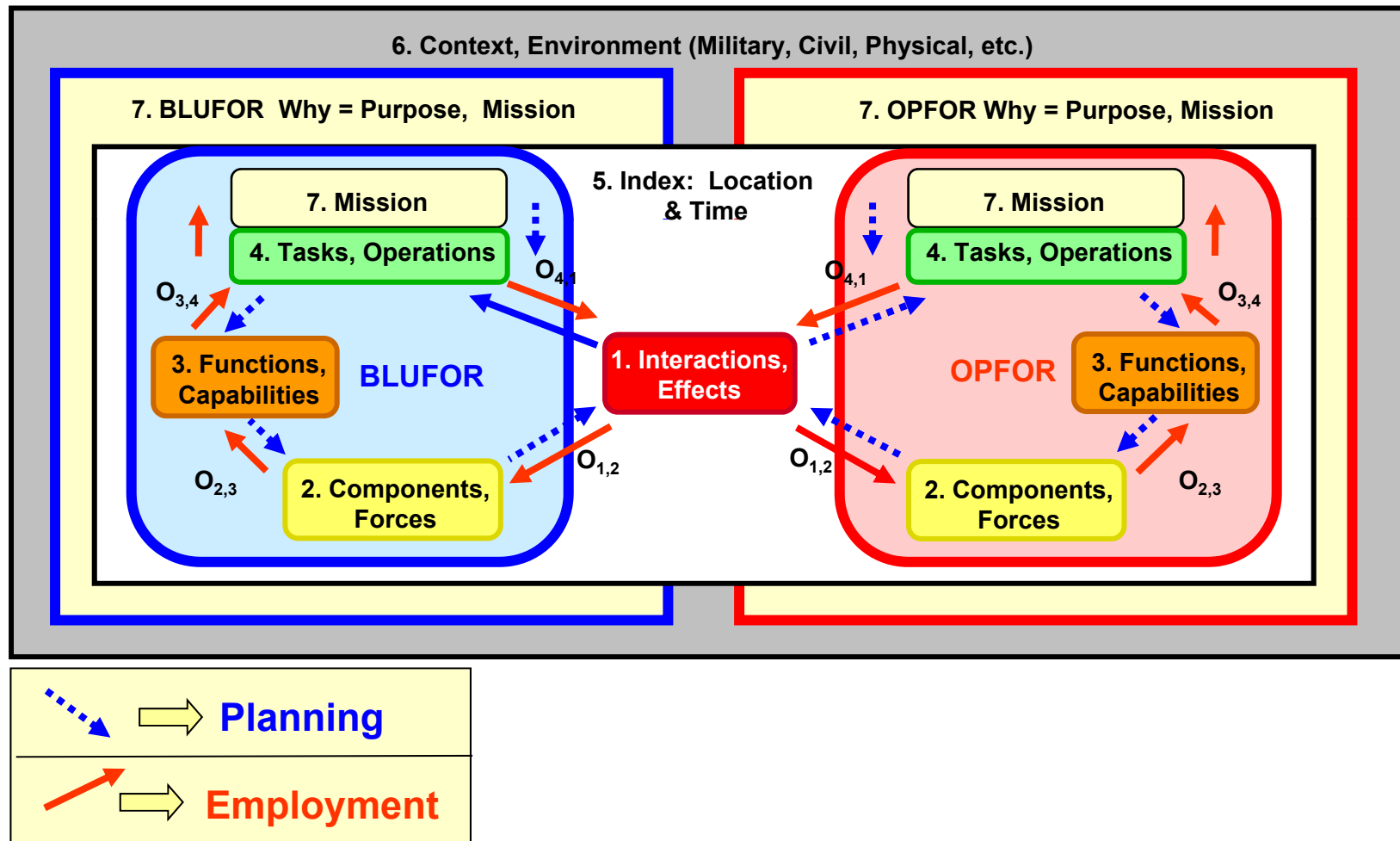
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Missions and Means Framework Model

11 Fundamental Elements: 7 levels, 4 operators

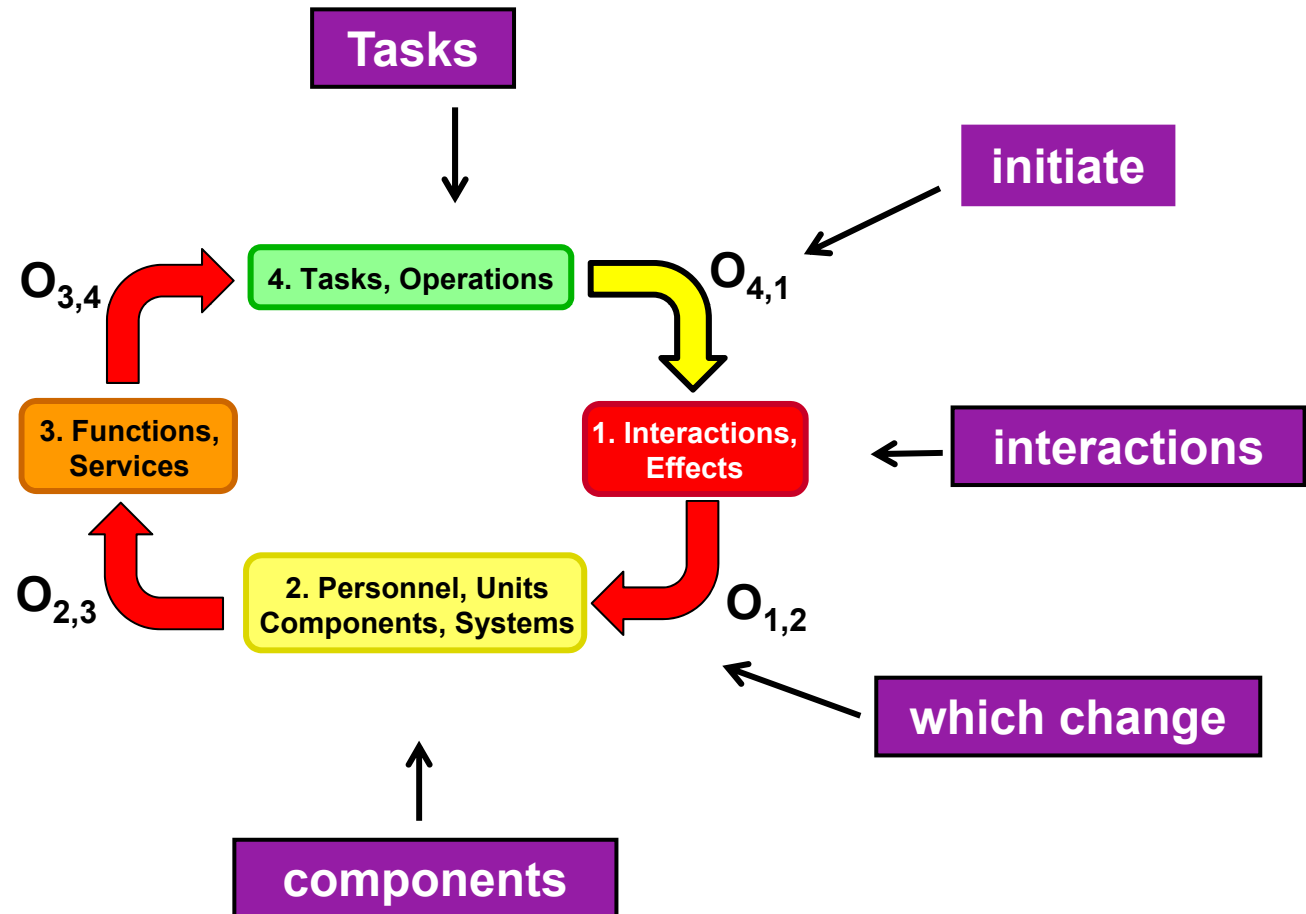


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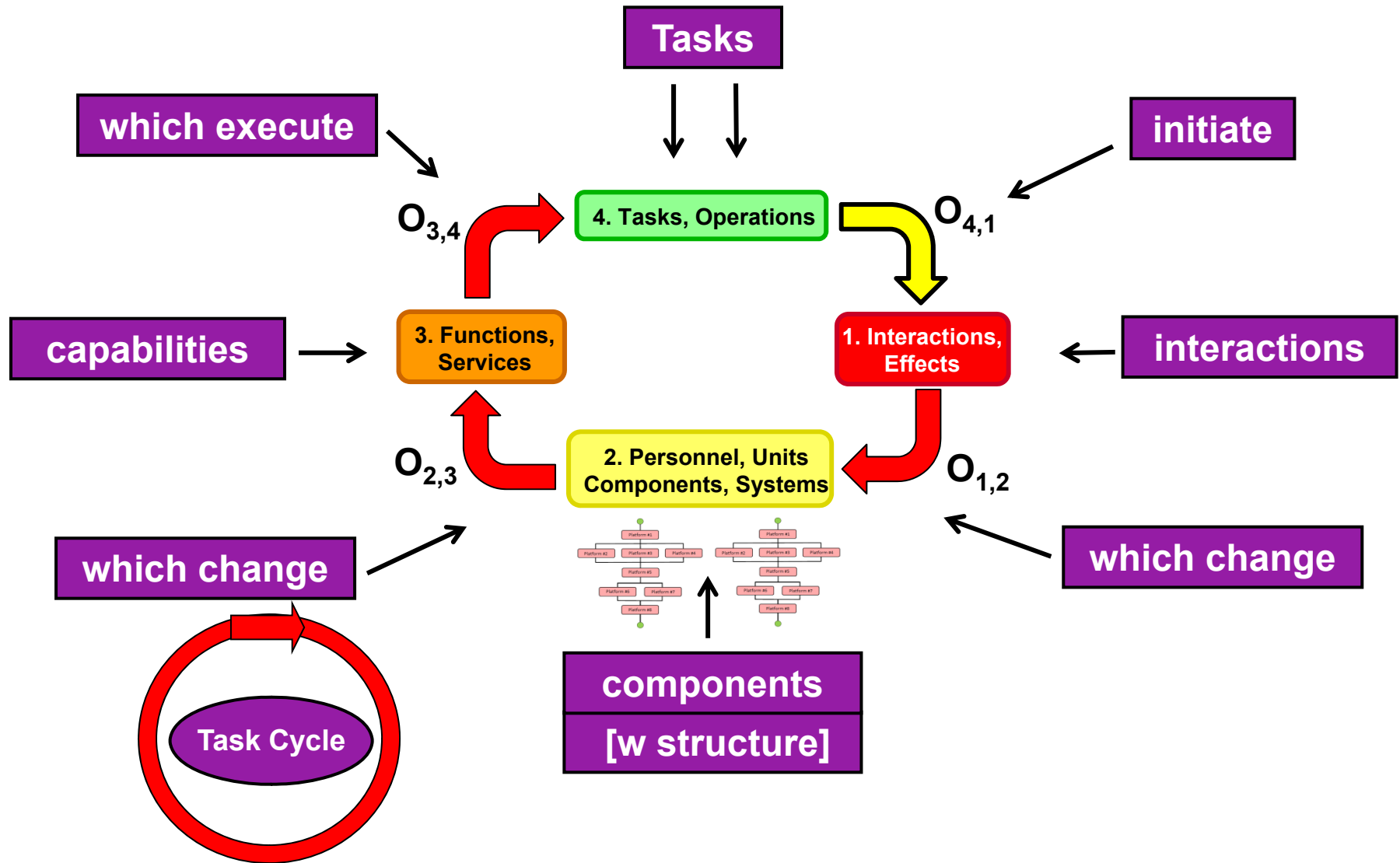
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So how are Tasks executed? [1/2]



So how are Tasks executed? [2/2]



Intra-system Component Linkage

2. Personnel, Units
Components, Systems

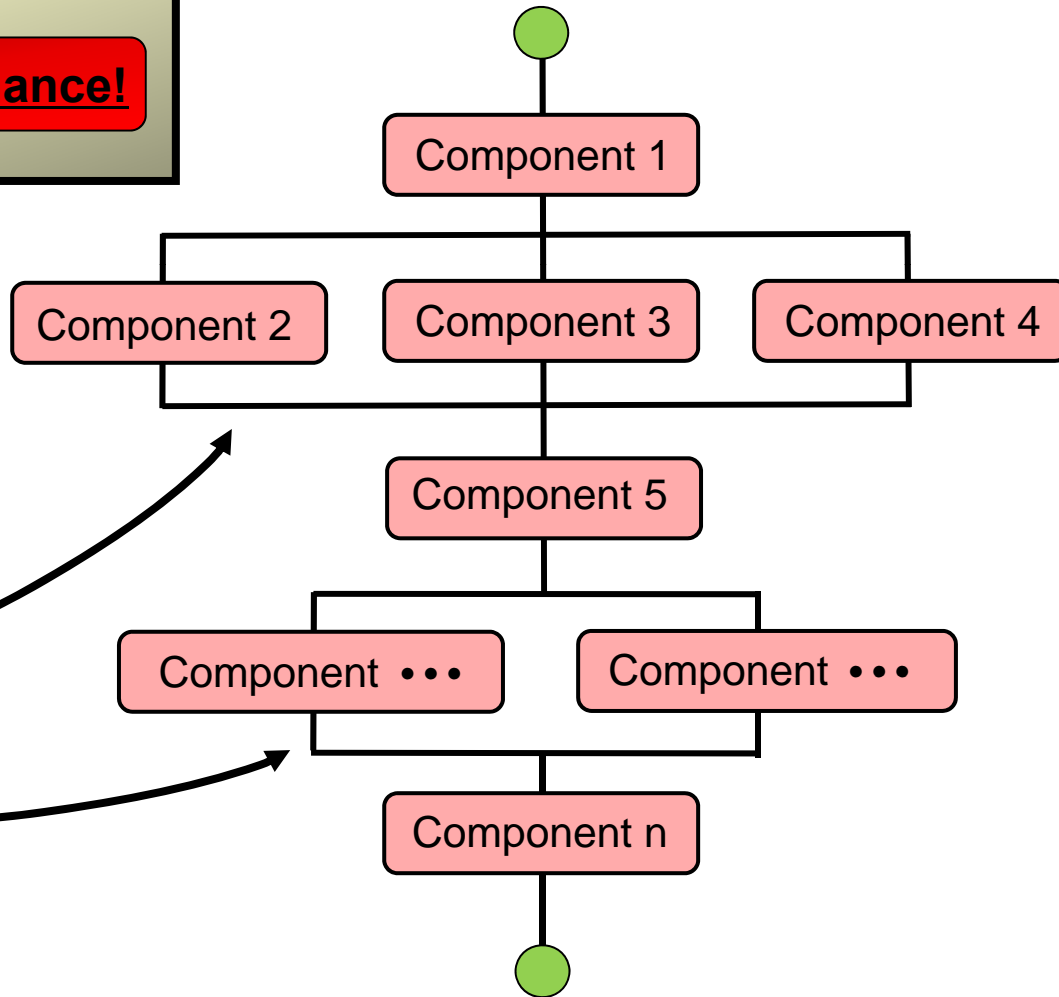
System assessment based on

Individual Task Performance!

Linkages can be:

- Mechanical
- Electrical
- Hydraulic
- Radiative
- Conductive

•
•
•



Intra-system Component Linkage

2. Personnel, Units
Components, Systems

System assessment based on

Individual Task Performance!

Component 1

Did the system perform as required? If not, why not?
Traditional Engineering Concern

Link

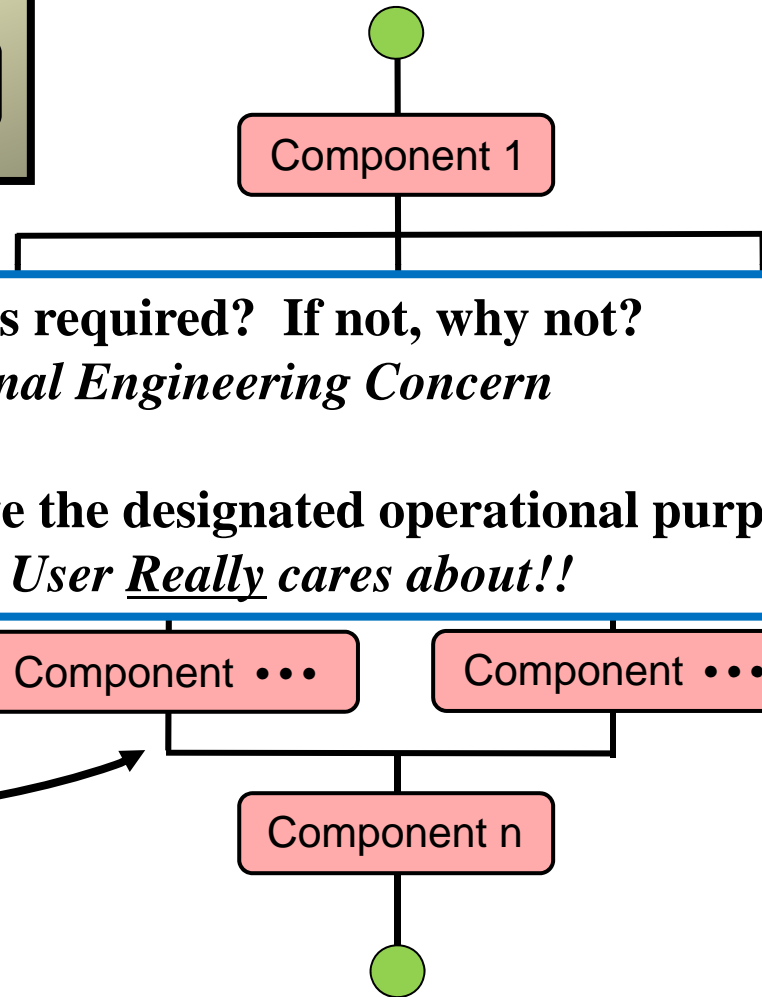
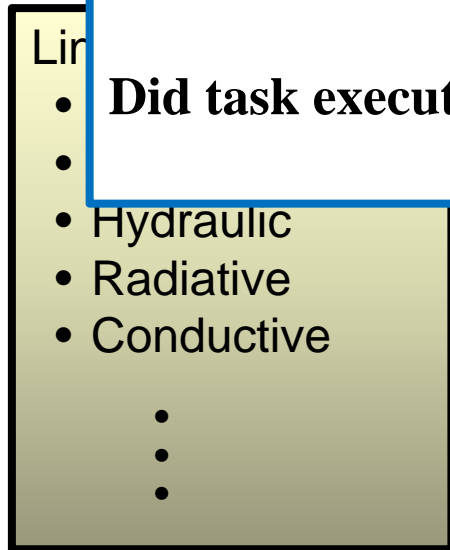
- Did task execution achieve the designated operational purpose?
- *What the User Really cares about!!*

- Hydraulic
- Radiative
- Conductive
-
-
-

Component ...

Component ...

Component n



Intersystem Linkage: Key SoS Construct

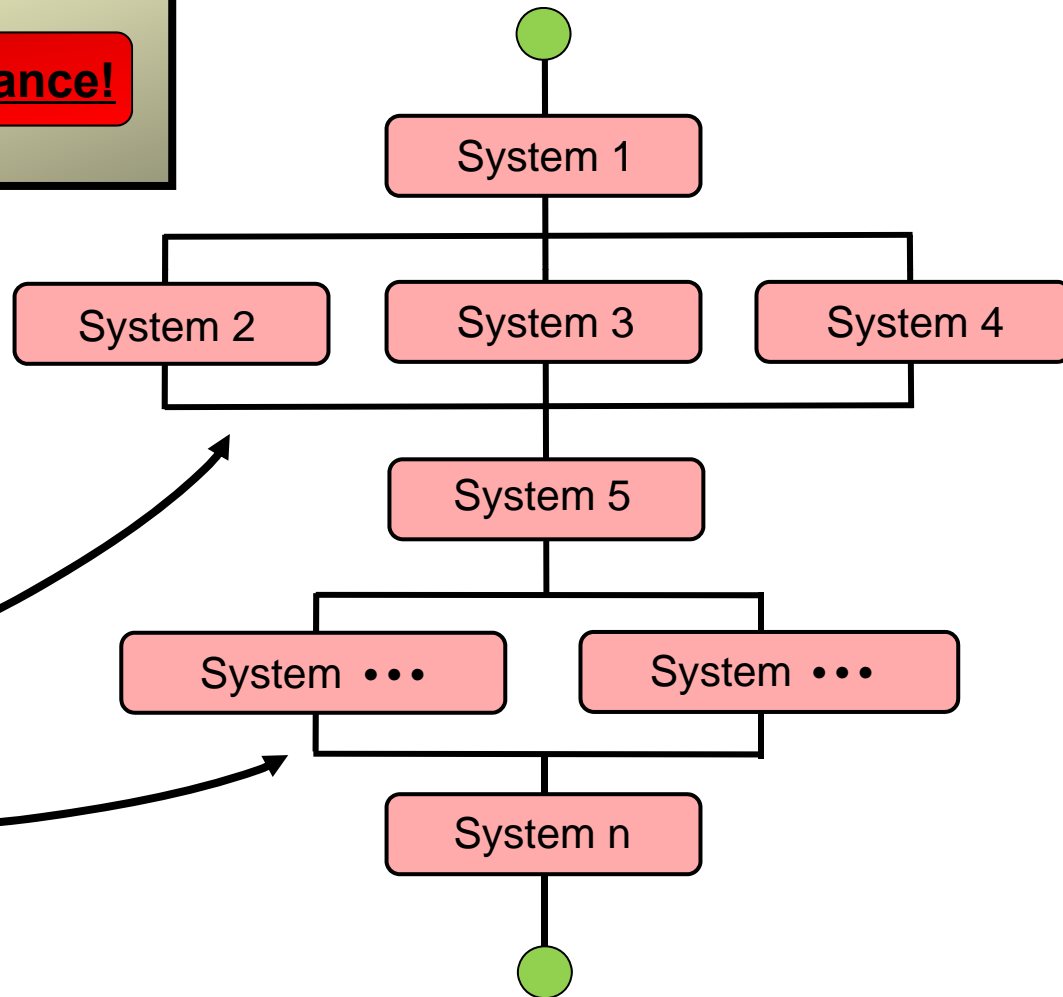
2. Personnel, Units
Components, Systems

SoS assessment based on

Collective Task Performance!

Linkages can be:

- Time Based
- Event Based
- Effects Based
- Mechanical
- Electrical
- Hydraulic
- Radiative
- Conductive
-
-
-



Intersystem Linkage: Key SoS Construct

2. Personnel, Units
Components, Systems

SoS assessment based on

Collective Task Performance!

System 1

Lir

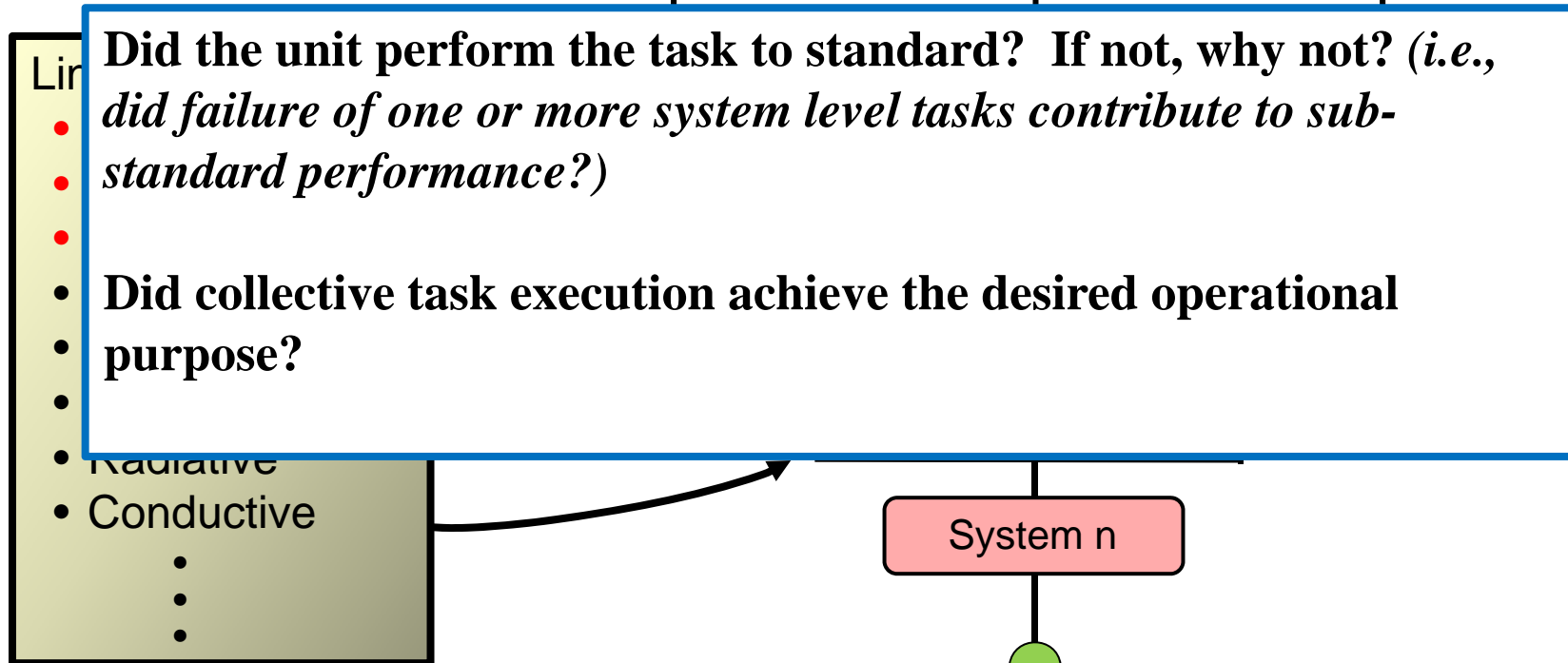
- Did the unit perform the task to standard? If not, why not? (*i.e., did failure of one or more system level tasks contribute to sub-standard performance?*)

- Did collective task execution achieve the desired operational purpose?

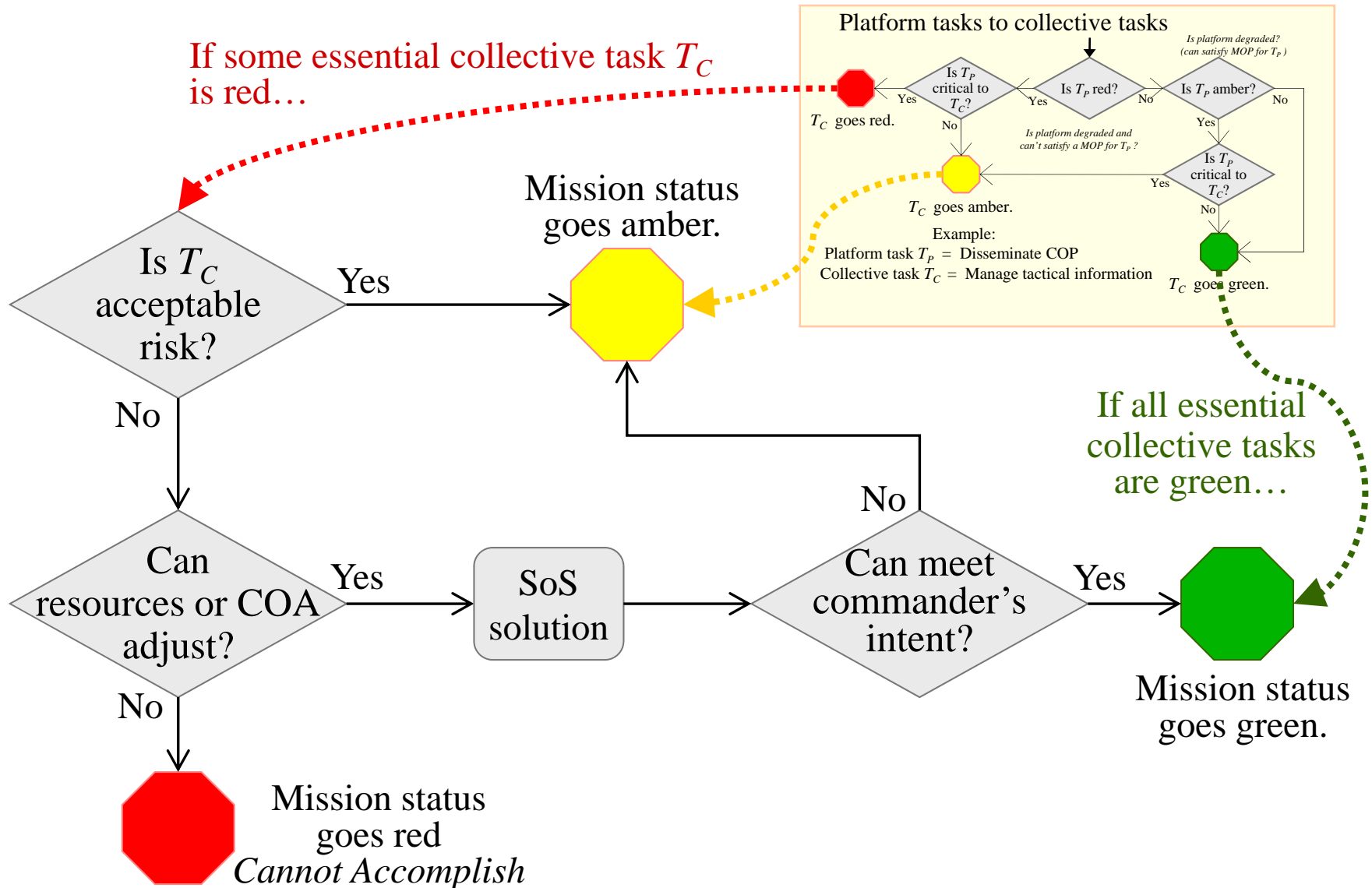
- Radiative
- Conductive

•
•
•

System n

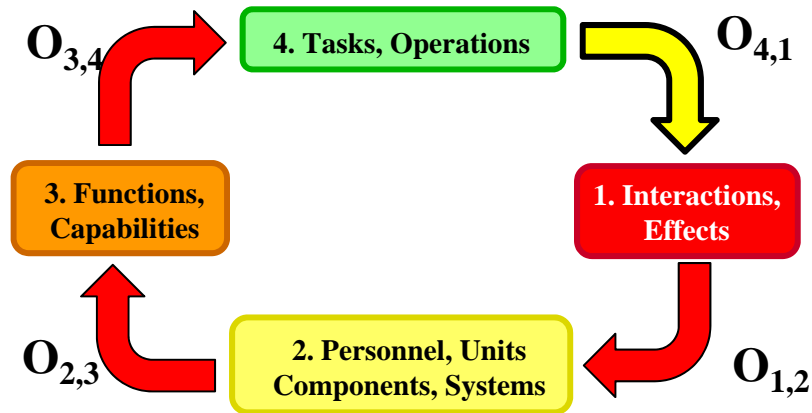


Determining Mission Impact



Supporting Contexts‡ [1/4]

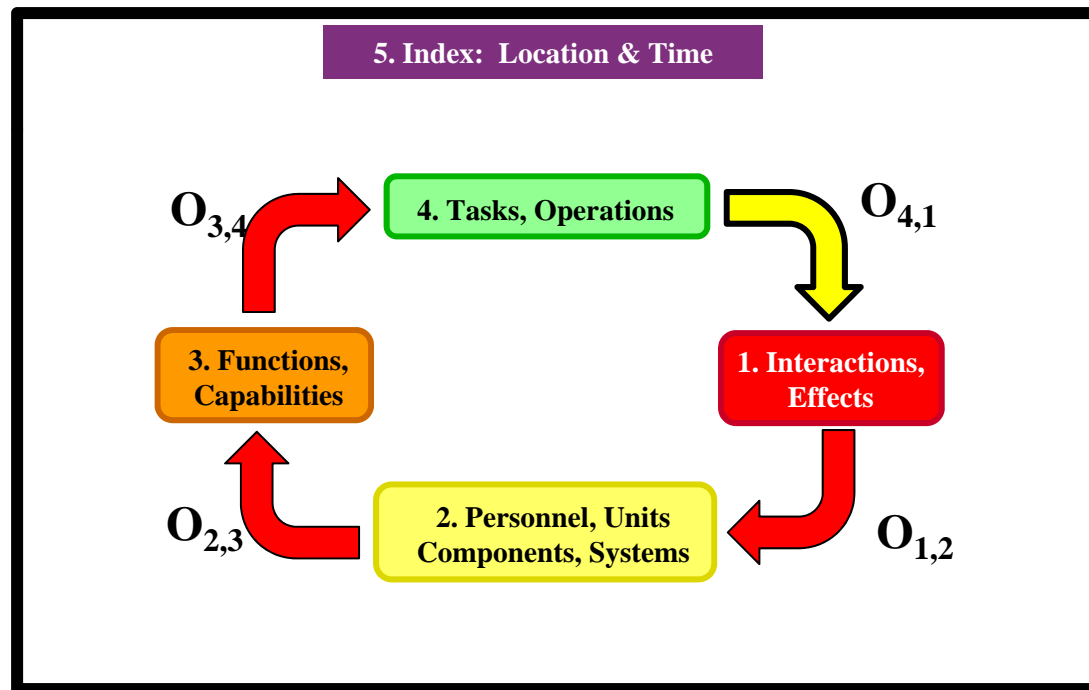
These Principal Elements are necessary, but not sufficient, to define a full representation of the MDMP.



‡ The OPFOR is not shown!

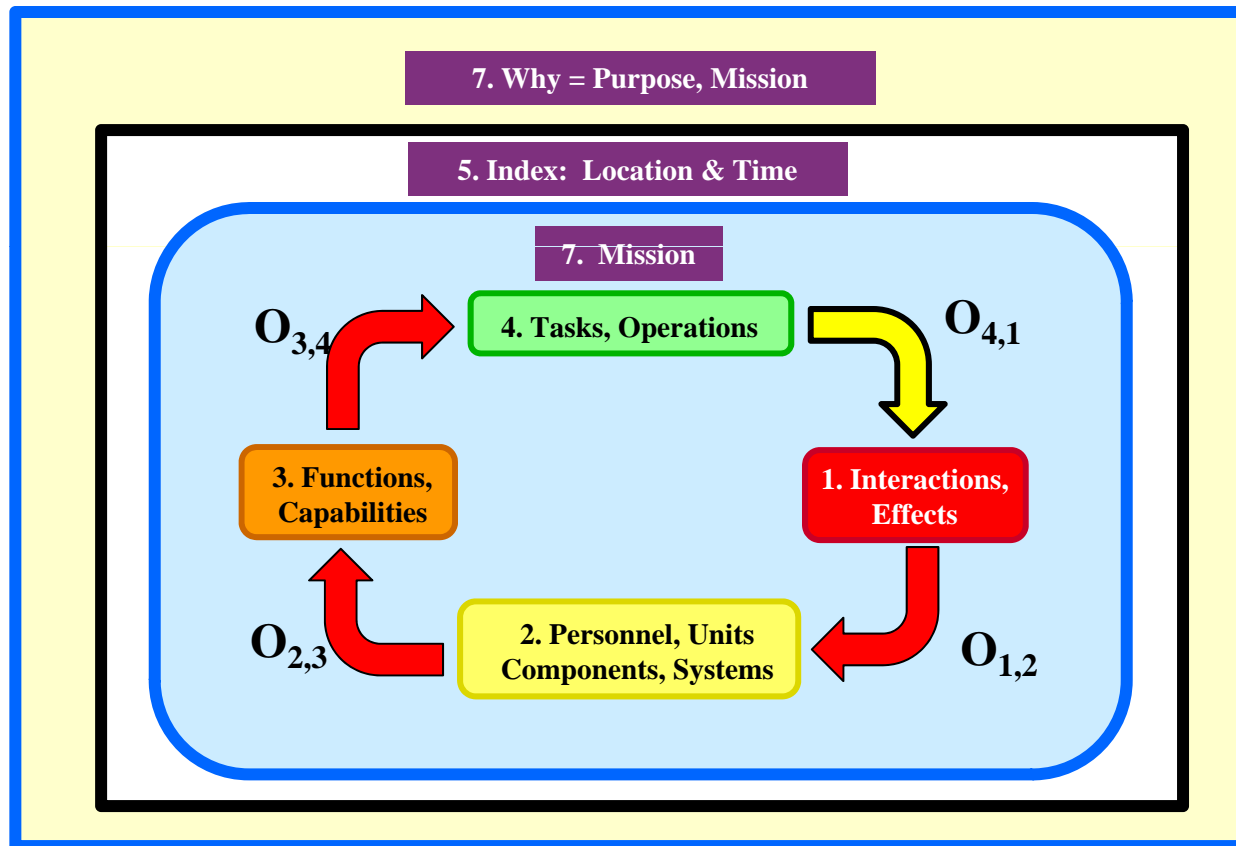
Supporting Contexts [2/4]

Level 5: Index- Location & Time



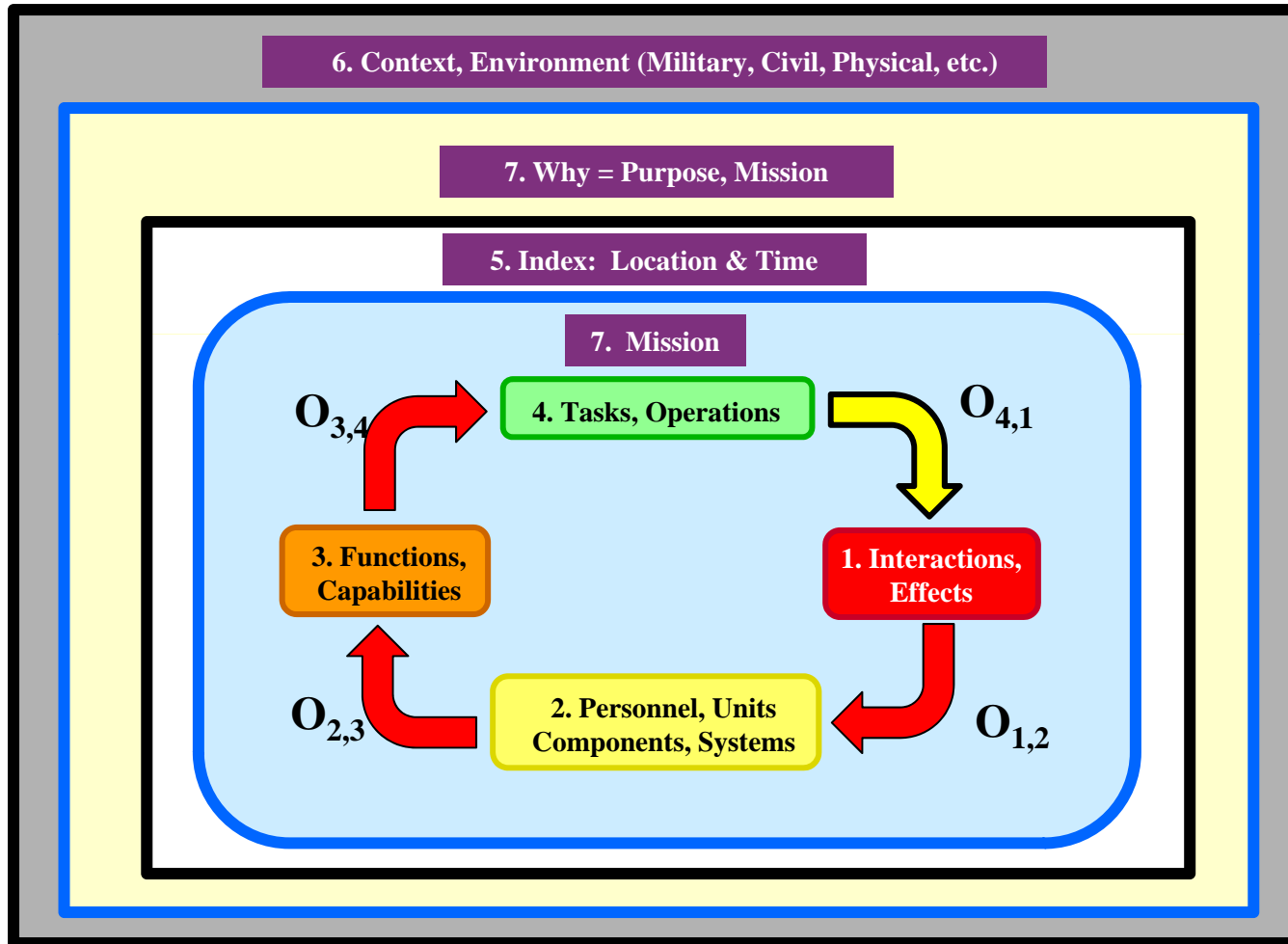
Supporting Contexts [3/4]

Level 7: OWNFOR Purpose, Mission



Supporting Contexts [4/4] ‡

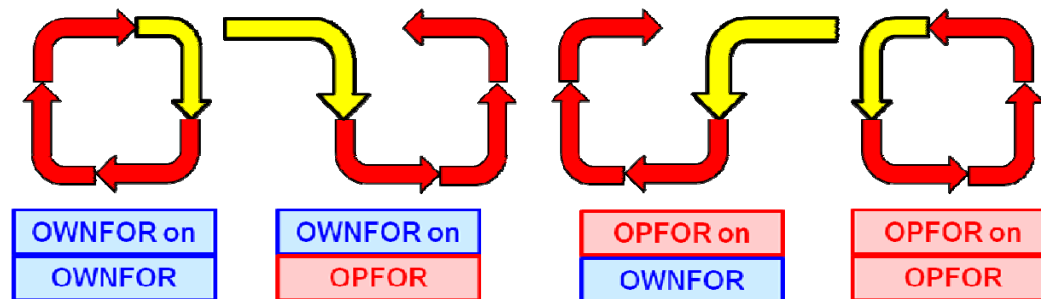
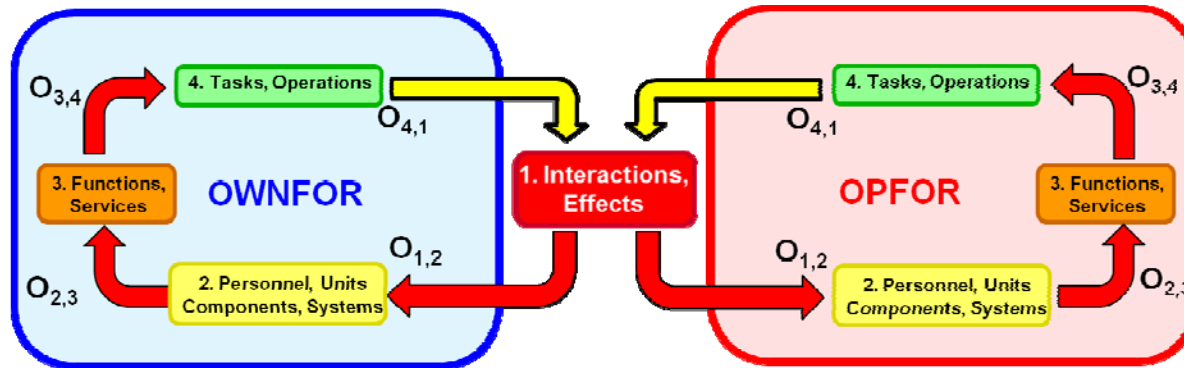
Level 6: Environment- Military, Civil, Physical, . . .



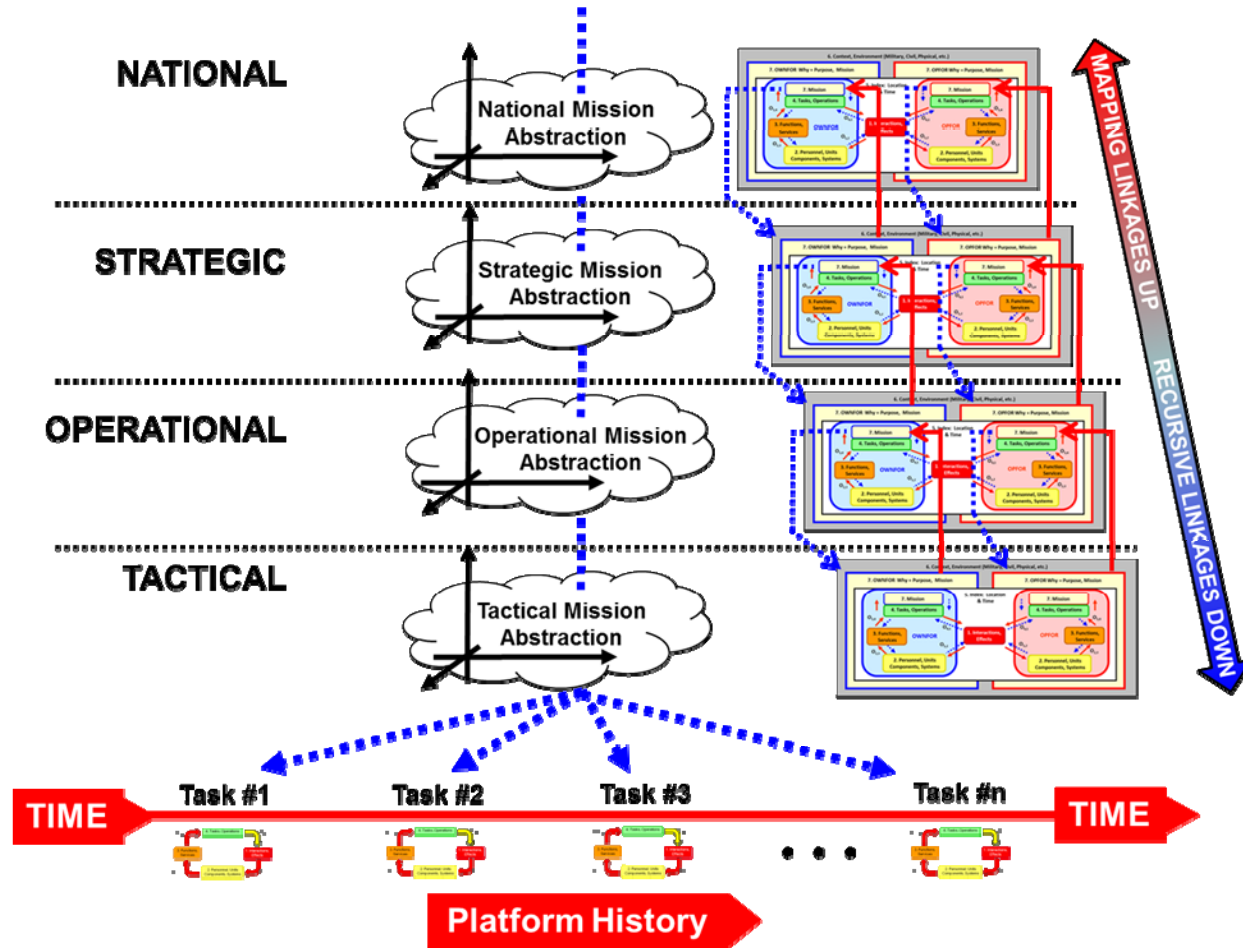
‡ The OPFOR is not shown!

Context is critical for all mapping levels!

Navigating the MMF

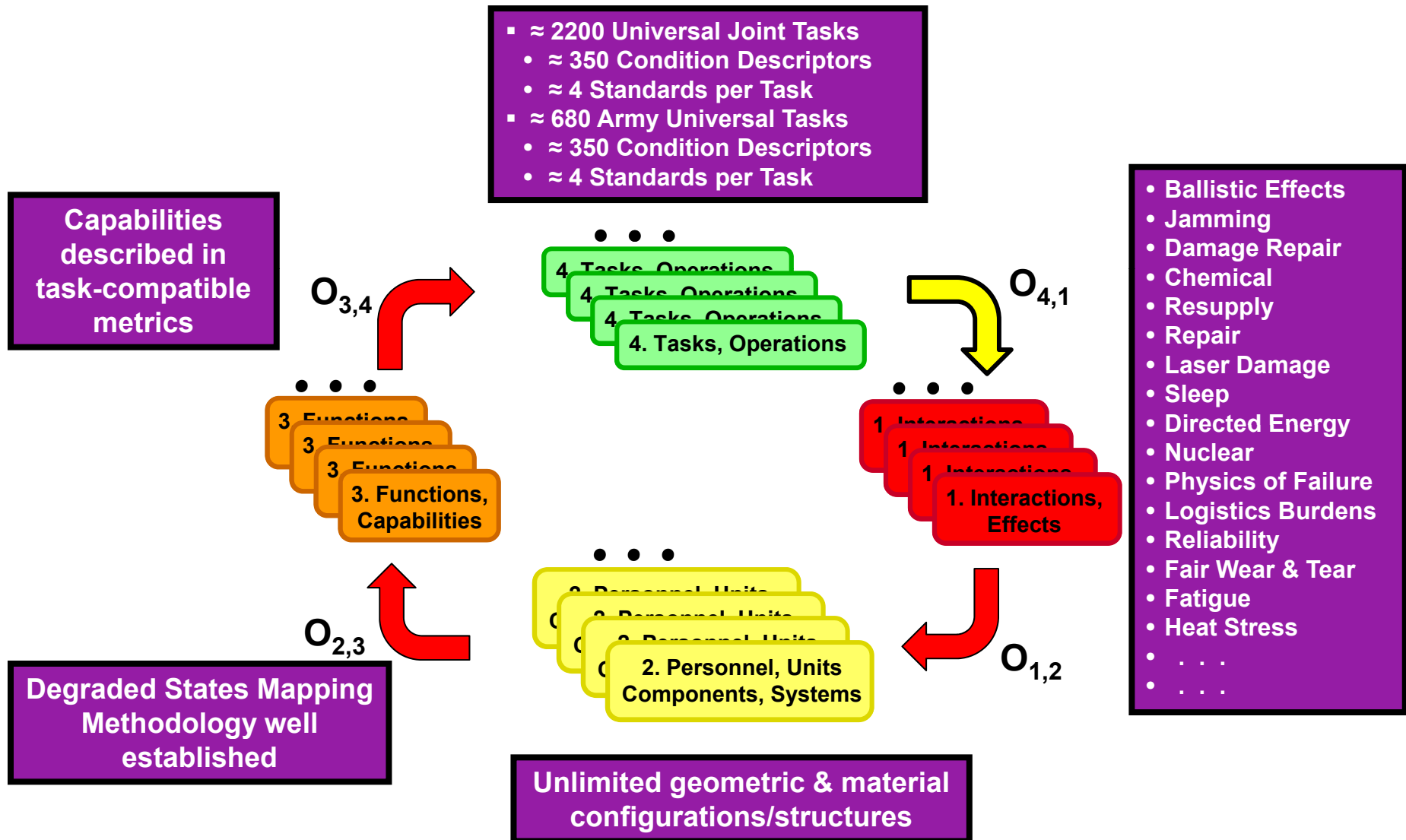


MMF by Level of Conflict



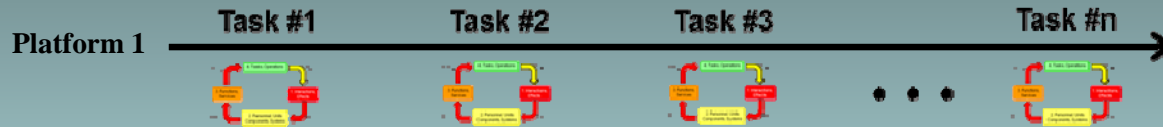
A “Lego” Collection of Mission/Performance Elements

Ability to Mix & Match Levels & Operators



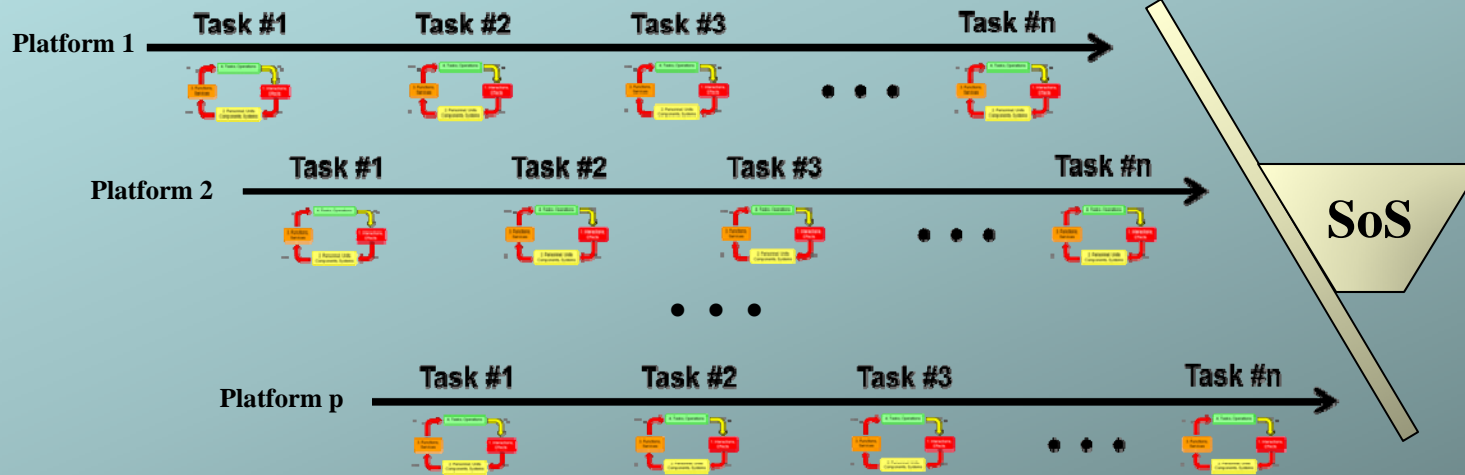
Analysis, Evaluation & OT Issues

Sequences of task cycles define and focus Operational Testing



Note: A sequence of **1. Interactions, Effects** accumulated by the same **2. Person, Unit Component, System** IS NOT the same as a sequence of **1. Interactions, Effects**, each on a pristine **2. Person, Unit Component, System**, followed by post processing!

Parallel chains of task cycles connected by common purpose define and focus Systems-of-Systems OT via Collective Tasks

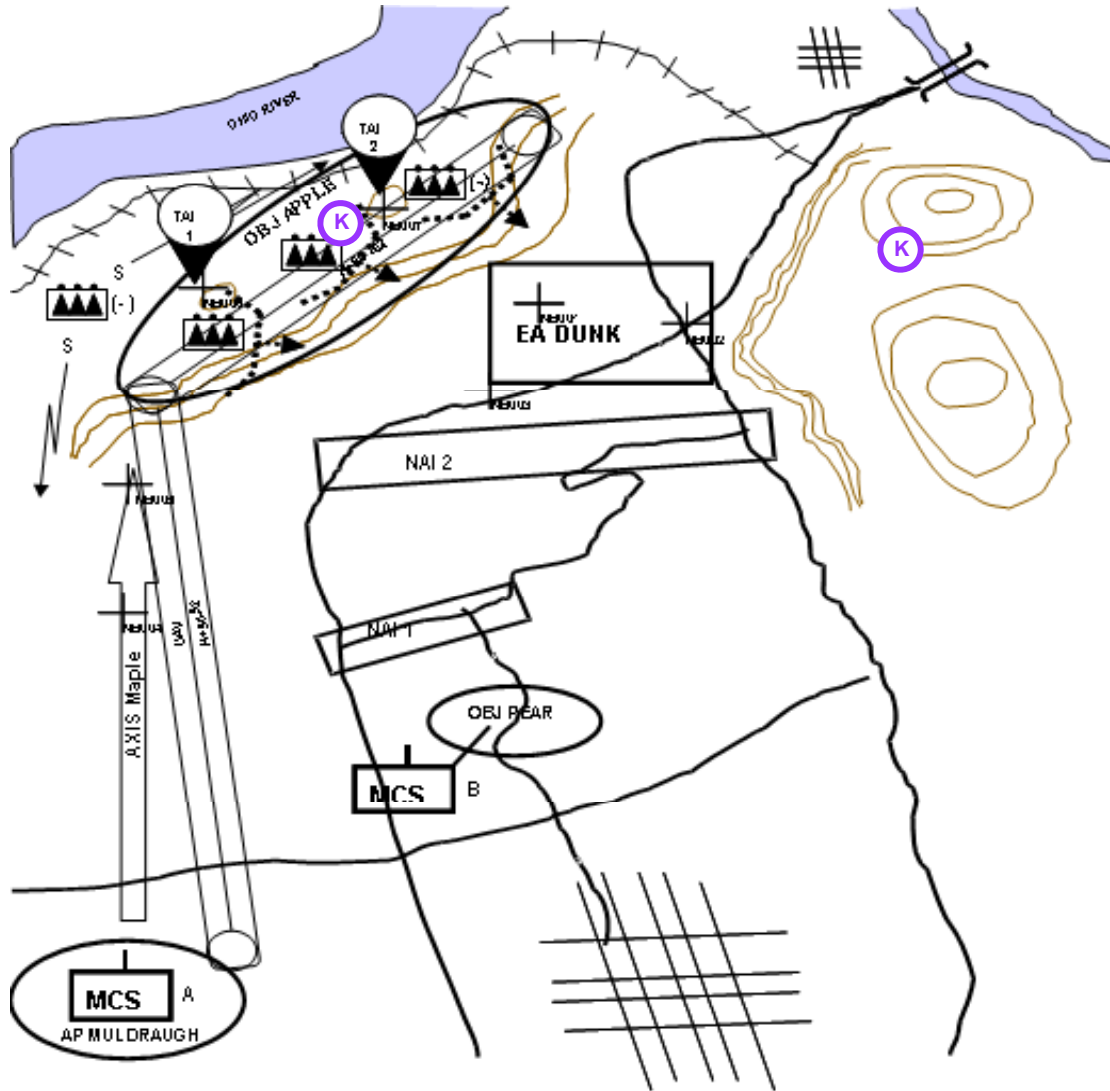


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Operational Vignette







MISSION:

Attack north on AXIS Maple and seize OBJ APPLE NLT 0600 hrs. Establish attack by fire positions on OBJ APPLE and engage enemy forces already in or entering EA DUNK IOT block enemy forces from moving north to support rebel leadership vic Westpoint or support enemy forces defending in and around Louisville.

ENDSTATE:

Enemy forces vicinity of Knox remain south of EA DUNK until friendly operations vicinity of Westpoint are completed.

-  TAJ - Targeted Area of Interest
-  K - Key Terrain
-  - MCS Engagement Area
-  NAI - Named Area of Interest

Mission Task Report

The screenshot displays the JTIMS v2.0c interface. The left pane shows a hierarchical tree of mission tasks, including LSI A2.7 EXECUTE TACTICAL OPERATIONS, LSI A2.1 EXERCISE BATTLE COMMAND, LSI A2.3 MANAGE TACTICAL INFORMATION, LSI A2.4 ASSESS TACTICAL SITUATION AND OPERATIONS, LSI A5.1.3 EMPLOY FIRES TO INFLUENCE THE WILL / DESTROY OR SUPPRESS ENEMY FORCES, and ART 1.0 The Intelligence Battlefield Operating System. The right pane shows the details for the selected mission, including its name, code, commandant, and a detailed description of the attack plan.

Mission: SLAD Demo MCS CO CAB2 - Conduct an Attack

Security Classification: (U)

Name: SLAD Demo MCS CO CAB2 - Conduct an Attack

Code: US Army-2004-0084

Combatant Command: DYNAMICS RESEARCH CORPORATION **Modify...**

Last Modified: 2004-09-20 12:42:31.0

Created: 2004-04-22 10:32:54.0

*** Subordinate Command:** **Modify...**

*** OPLAN:** **Modify...**

Published: U

Level:
 Primary Mission (M)
 Operation (O)
 Phase (P)
 Specified Task (S)
 Implied Task (I)

*** Description:** **Zoom...**
Attack north on Axis Maple to occupy OBJ Apple. Establish attack by fire positions on OBJ Apple. On order, engage enemy forces already in or entering EA Dunk IOT prevent them from moving north to support rebel leadership party vicinity of West Point or to support enemy main body defending in and around Louisville. End State is MCS A occupying ABF positions on OBJ Apple with at least 80% combat power prior to enemy movement north from Knox.

• Screen shot of results of Mission to Task decomposition using JTIMS automated KA tool.

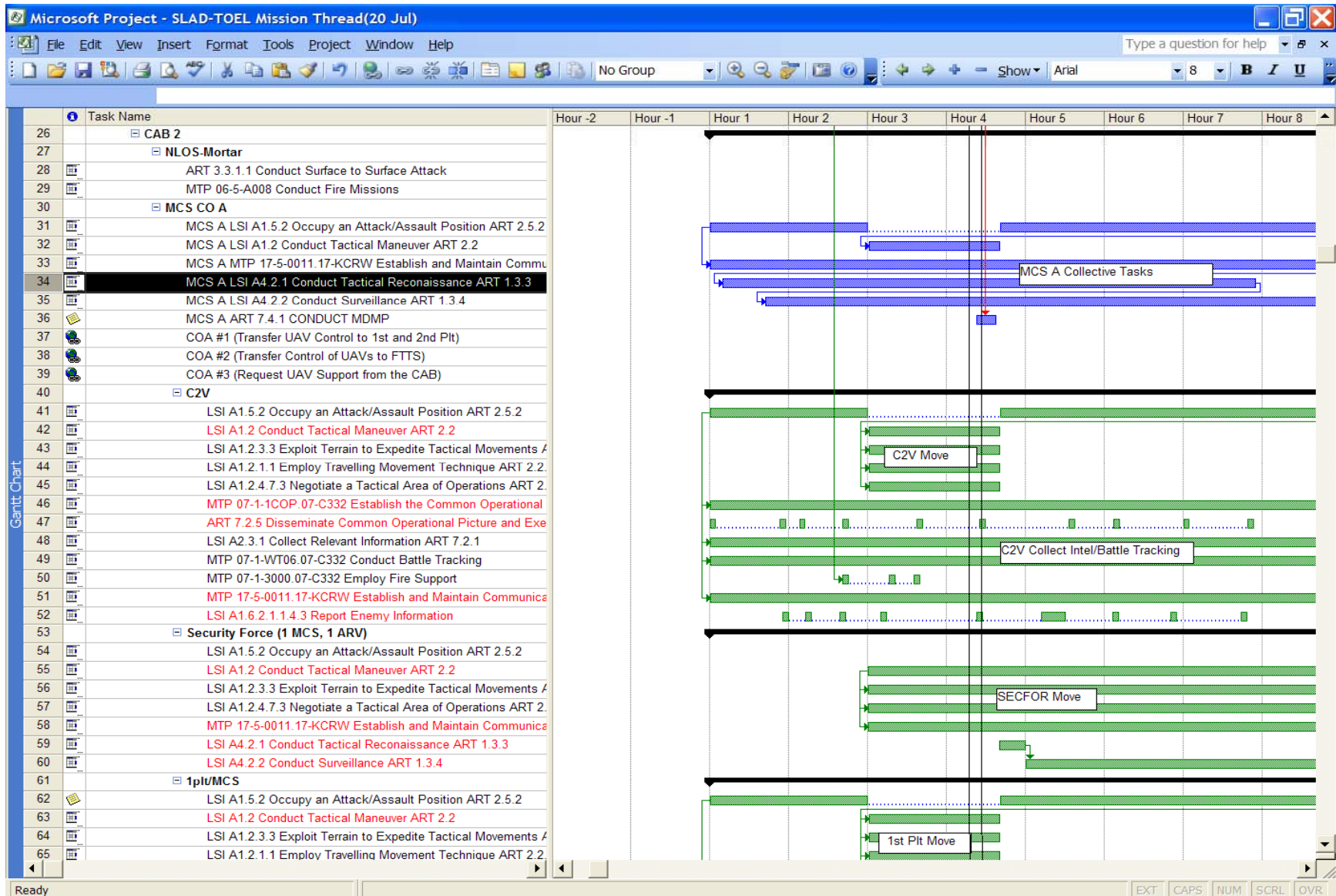
• Used to document break down of MCS A mission into component tasks.

• Vignette mission thread is assembled from the component tasks.

JTIMS v2.0c Build 129 (May 7, 2004)

Java Applet Window

Mission Thread (MS Project)



Mission Thread (with Task Information)

The screenshot displays the Microsoft Project interface for a mission thread. The main window shows a Gantt chart with tasks scheduled across eight hours. A task named "MCS A LSI A4.2.1 Conduct Tactical Reconnaissance ART 1.3.3" is highlighted in the task list and its details are shown in the "Task Information" dialog box.

Task Information Dialog Box:

- General Tab:**
 - Name: MCS A LSI A4.2.1 Conduct Tactical Rec
 - Duration: 405m
 - Estimated:
- Notes Tab:**
 - Purpose:** To find and report enemy presense and activity along Axis Maple and on/around Obj Apple and report information about enemy activities.
 - Conditions:** MCS A assets have been assigned areas of responsibility to conduct reconnaissance. Both digital and voice communications are established. Net procedures are in place. MCS A has an identified axis of advance. MCS main body is in AP Muldraugh. There is 50% illumination at night and UAV flight patterns have been established. The enemy is occupying defensive positions south of West Point and there are likely enemy forces on the objective. They are light dismounted infantry. The terrain is woodland and rolling hills.
 - Standards:**
 - MOE Scale Measure**
01 Yes/No MCS A reconnaissance assets sensed and reported all enemy activity along Axis Maple and on Objective Apple.
 - MOP Scale Measure**

TOEL (Matrix form with MMF Elements)

1	Lines from the TOEL				Comms							
2			TASKS	PLATFORM								
51	0200-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	ARV 2			x0		x2	x3	x4	
52	0412-0417	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	ARV 2			x0		x2	x3	x4	
53	0200-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	ARV 3			x0		x2	x3	x4	
54	0757-0802	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	ARV 3			x0		x2	x3	x4	
55	0200-1000	ART 7.2	*MTP 07-1-1COP.07-C332 Establish the Common Operational Picture	C2V			x0	x1	x2	x3	x4	x5
56	0200-0205, 0253-0258, 0308-0313, 0341-0346, 0437-0442, 0525-0530, 0633-0638, 0707-0712, 0800-0805, 0849-0854	ART 7.2	*ART 7.2.5 Disseminate Common Operational Picture and Execution Information	C2V			x0	x1	x2	x3	x4	x5
57	0200-1000	ART 7.2	LSI A2.3.1 Collect Relevant Information ART 7.2.1	C2V			x0	x1	x2	x3	x4	x5
58	0200-1000	ART 7.2	MTP 07-1-WT06.07-C332 Conduct Battle Tracking	C2V			x0	x1	x2	x3	x4	x5
59	0200-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	C2V			x0	x1	x2	x3	x4	x5
60	0255-0300, 0313-0318, 0339-0344, 0410-0415, 0523-0528, 0612-0617, 0706-0711, 0750-0755, 0844-0849	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	C2V			x0	x1	x2	x3	x4	x5
61	0210-0542	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	UAV 1			x0	x1				
62	0250-0255, 0305-0310, 030-0335	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	UAV 1			x0	x1				
63	0340-0835	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	UAV 2			x0	x1				
64	0431-0436, 0715-0720	ART 7.2	*LSI A1.6.2.1.1.4.3 Report Enemy Information	UAV 2			x0	x1				
65	0543-1000	ART 7.2	*MTP 17-5-0011.17-KCRW Establish and Maintain Communications	UAV 3			x0	x1				

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Example of Executable Model Initialization Data Requirements

- Tactical scenario (*to provide operational context*)
- Military organizations and equipment (*included in scenario and important to study*)
- Important data elements and relationships
 - Task to capability relationship (*Min required level of capability to satisfy task purpose*)
 - System to capability relationship (*Type and level of capability delivered by system*)
 - Sequence of events (*TOEL, execution matrix, etc.*)
 - Effect of degradation (*e.g., component loss*) on system capability
 - Effect of degraded capability on task accomplishment
 - Mission thread of tasks and task relationships

Example of Executable Model Outputs:

- Map component-level state changes to platform level capabilities
- Map platform level capabilities to ability to perform tasks
- Map ability to perform tasks to mission success
- Determine system level tasks that can't be performed to standard with available systems given operational context
- Determine system of system level (i.e. collective/unit level) tasks that can't be performed to standard based on results of system level task execution
- Determine and articulate risk to mission accomplishment

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Conclusion/Summary

- Success in design and integration of systems and systems of systems depends heavily on how and why system is to be employed:
 - What role does the system play in accomplishing the mission?
 - How do system components support overall system and each other in that role?
 - How does loss or degradation of one or more components affect the systems ability to perform that role?
- The MMF provides the necessary structure and common language to ask and answer these questions throughout system life cycle.
- MMF products document results of MDMP application in detail needed to support system integration and analysis in the context of operational effectiveness.

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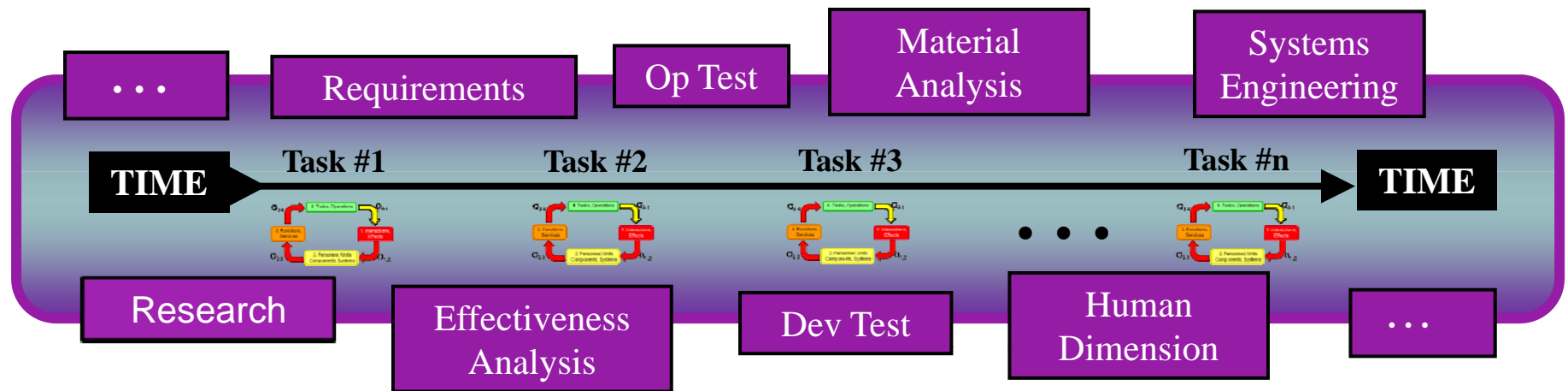
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Back Up Charts

Sequence of Task Cycles Forms a TOEL



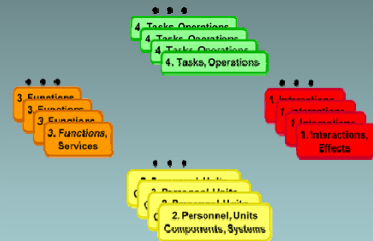
- Missions are composed of task sequences
- Following task initiation, an event cycle occurs
 - As a result, material, capability, and utility changes may follow
- When the “lego” elements are developed at this level of resolution, they can be combined endlessly with great extensibility
- All communities of interest can focus on the specific elements with clarity, define sharing or exclusivity with others, resolve precedence, dependencies,

...

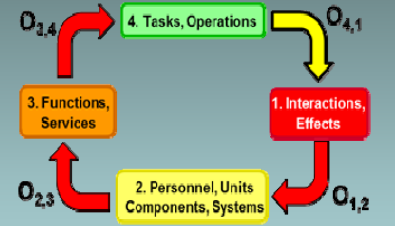
Are the Venn data sets  or  or  ?

Analysis, Evaluation & DT Issues

Individual lego elements combine into task cycles, define model elements, and focus Developmental Testing



Model Assessment
Test Planning



A single DT cycle

For a particular system under study, identify which Levels and Operators are insufficiently understood.

