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

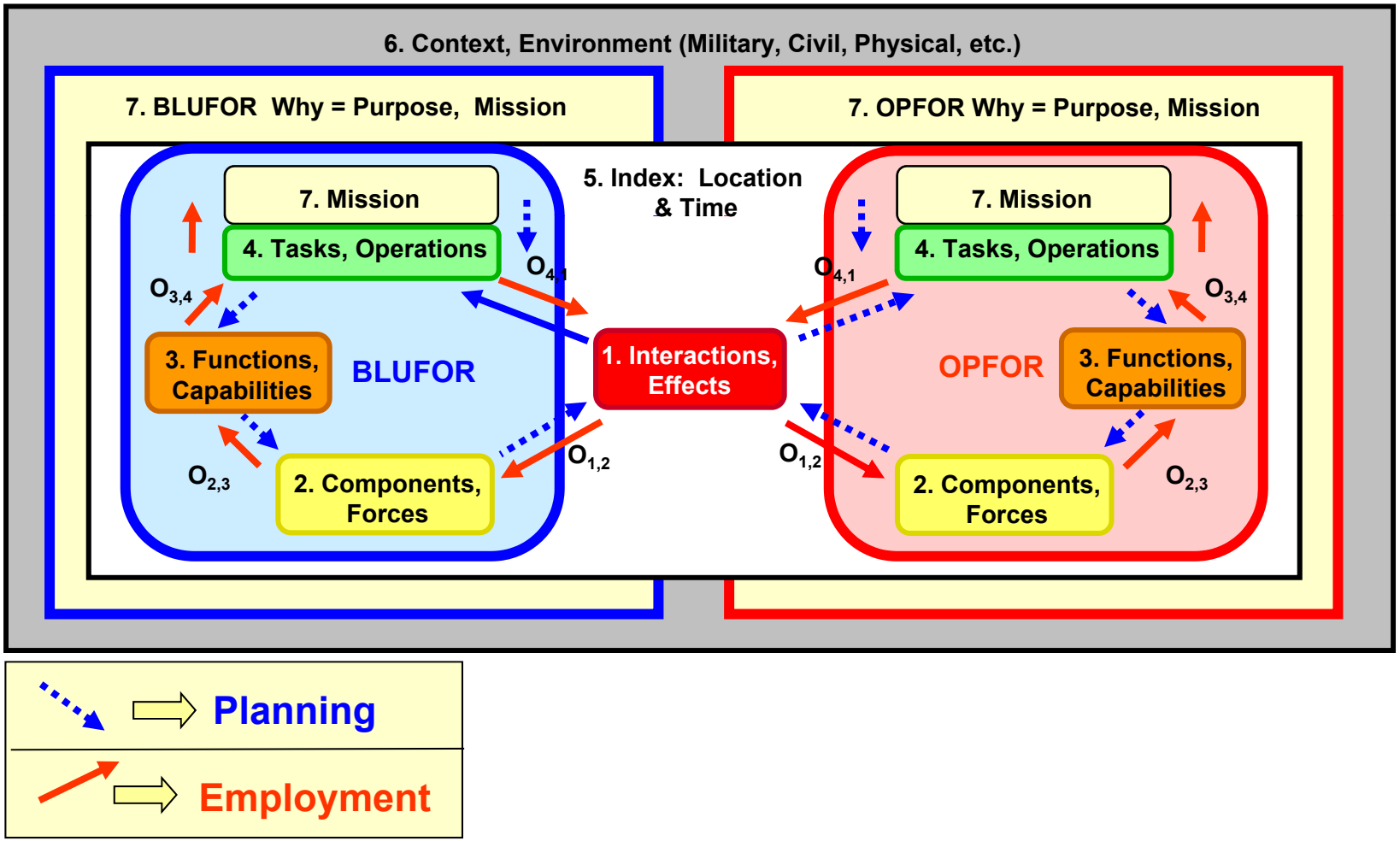
Agenda: Wednesday, October 30, 2013

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

Missions and Means Framework Model

11 Fundamental Elements: 7 levels, 4 operators

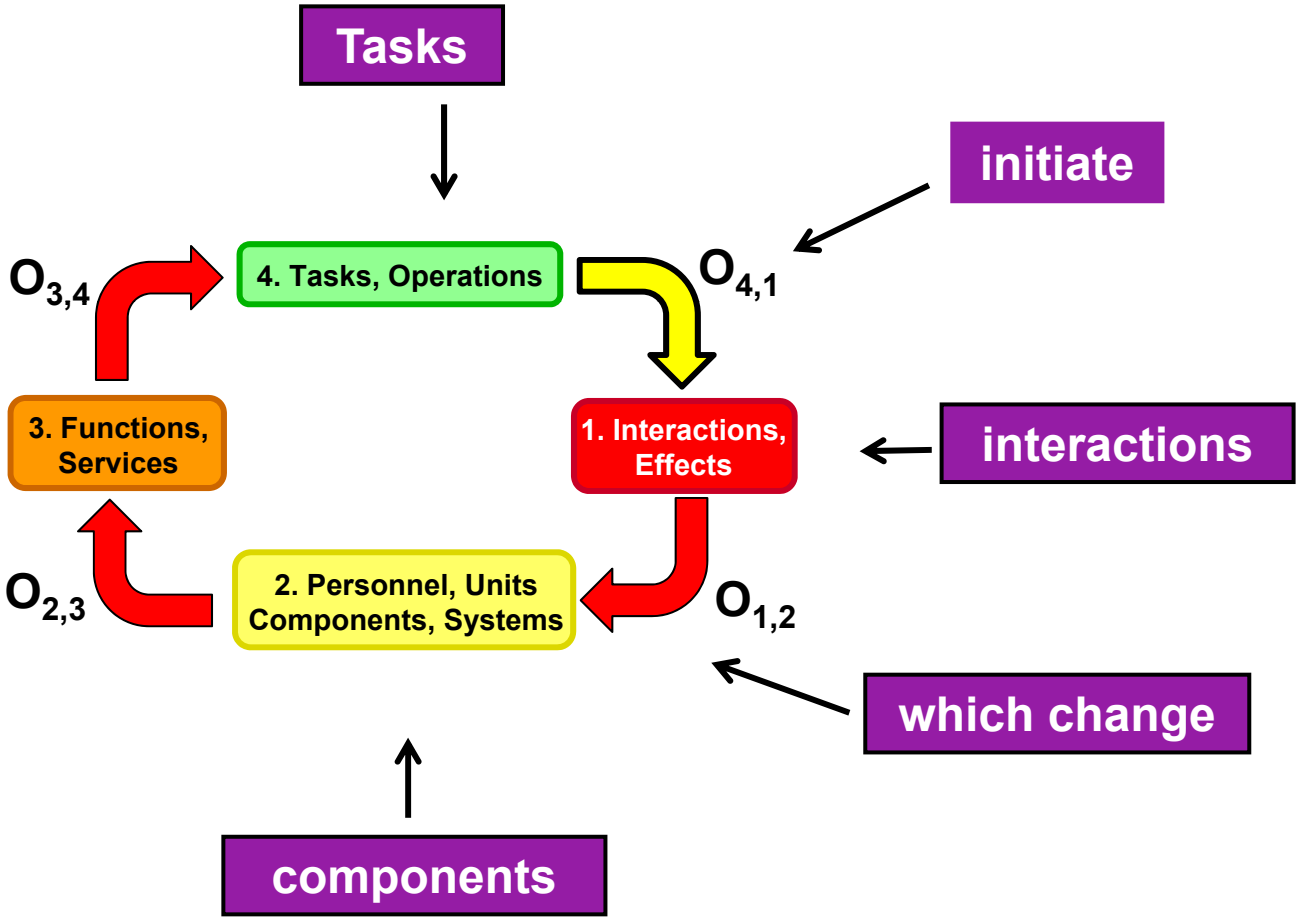


Agenda: Wednesday, October 30, 2013

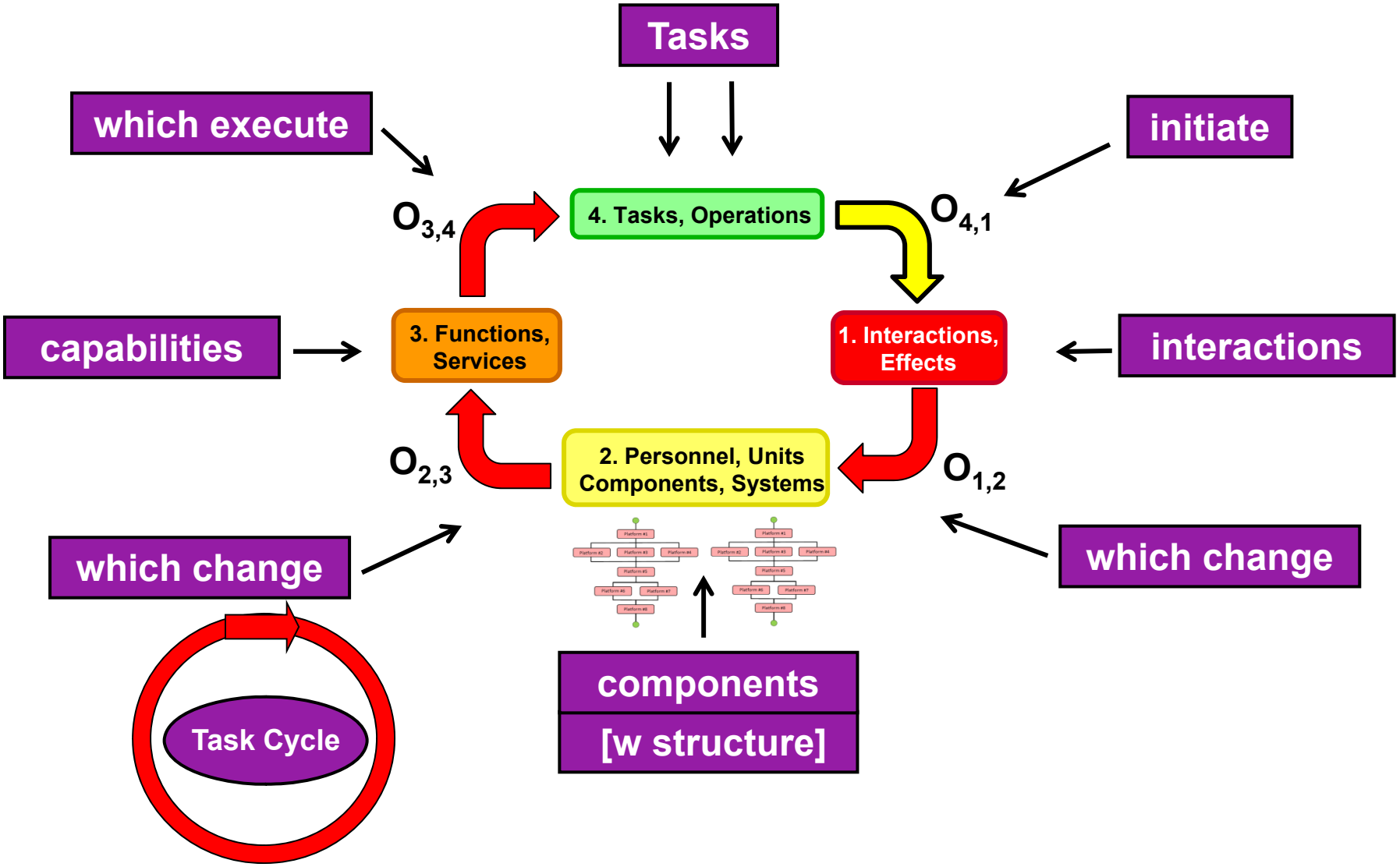
An Integrating Framework for Supporting Systems Engineering

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

So how are Tasks executed? [1/2]



So how are Tasks executed? [2/2]

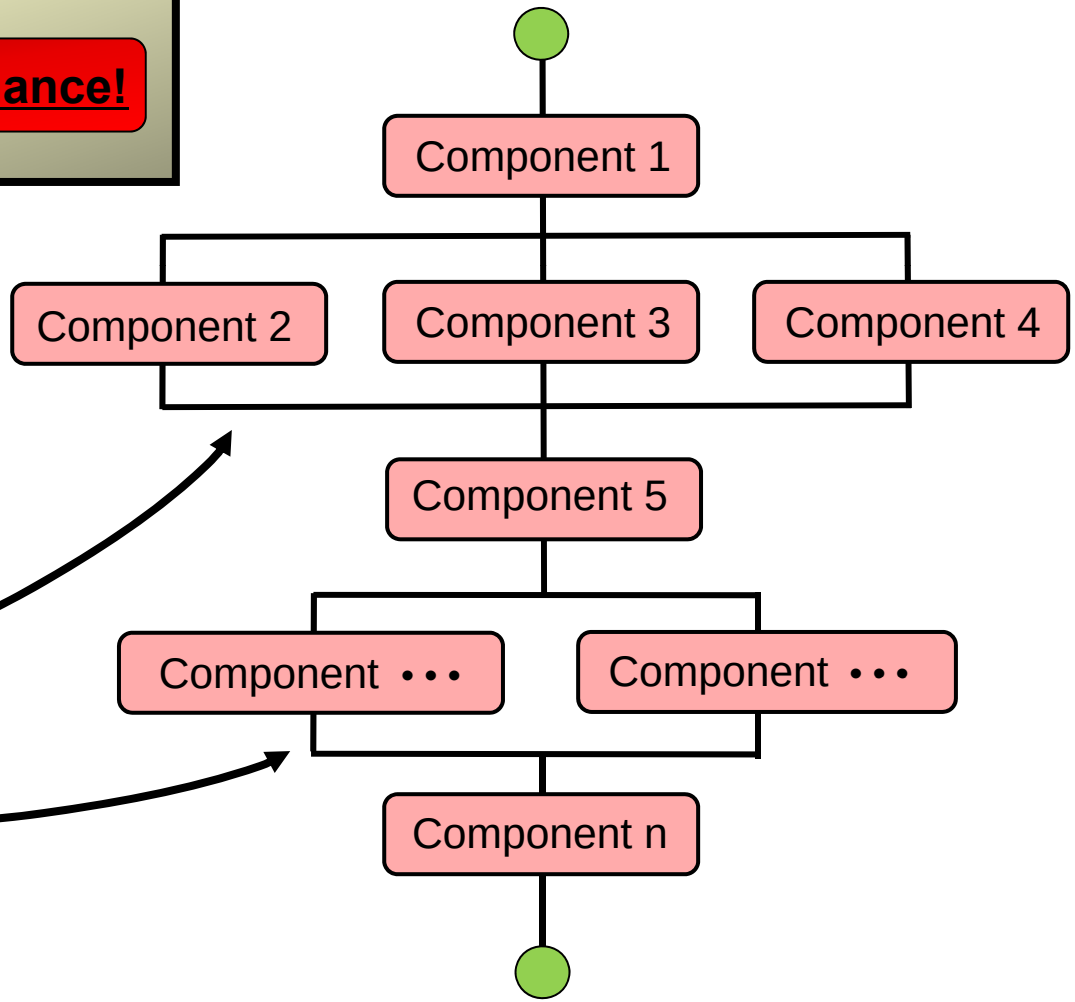


Intra-system Component Linkage

2. Personnel, Units Components, Systems

System assessment based on

Individual Task Performance!

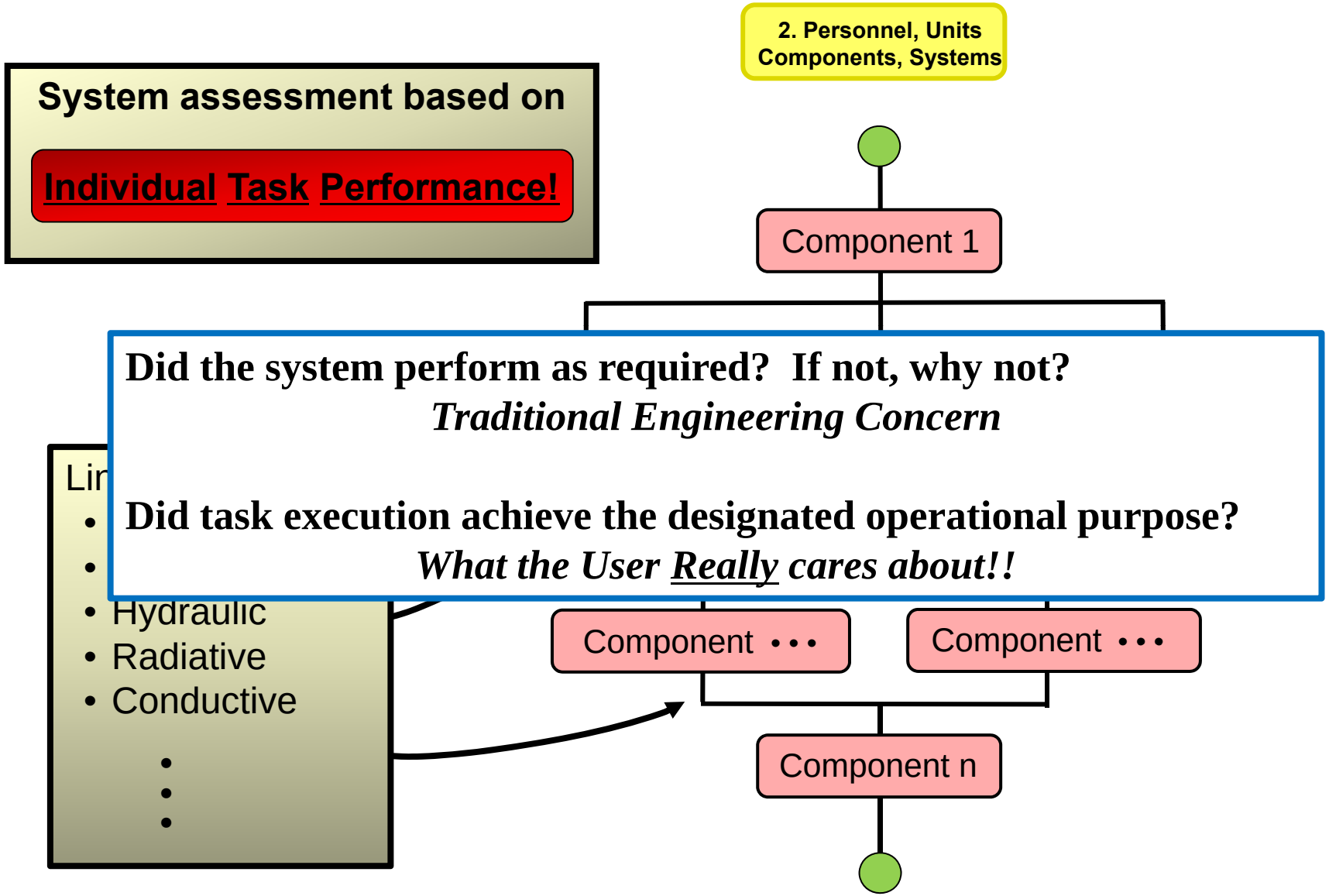


Linkages can be:

- Mechanical
- Electrical
- Hydraulic
- Radiative
- Conductive

•
•
•

Intra-system Component Linkage



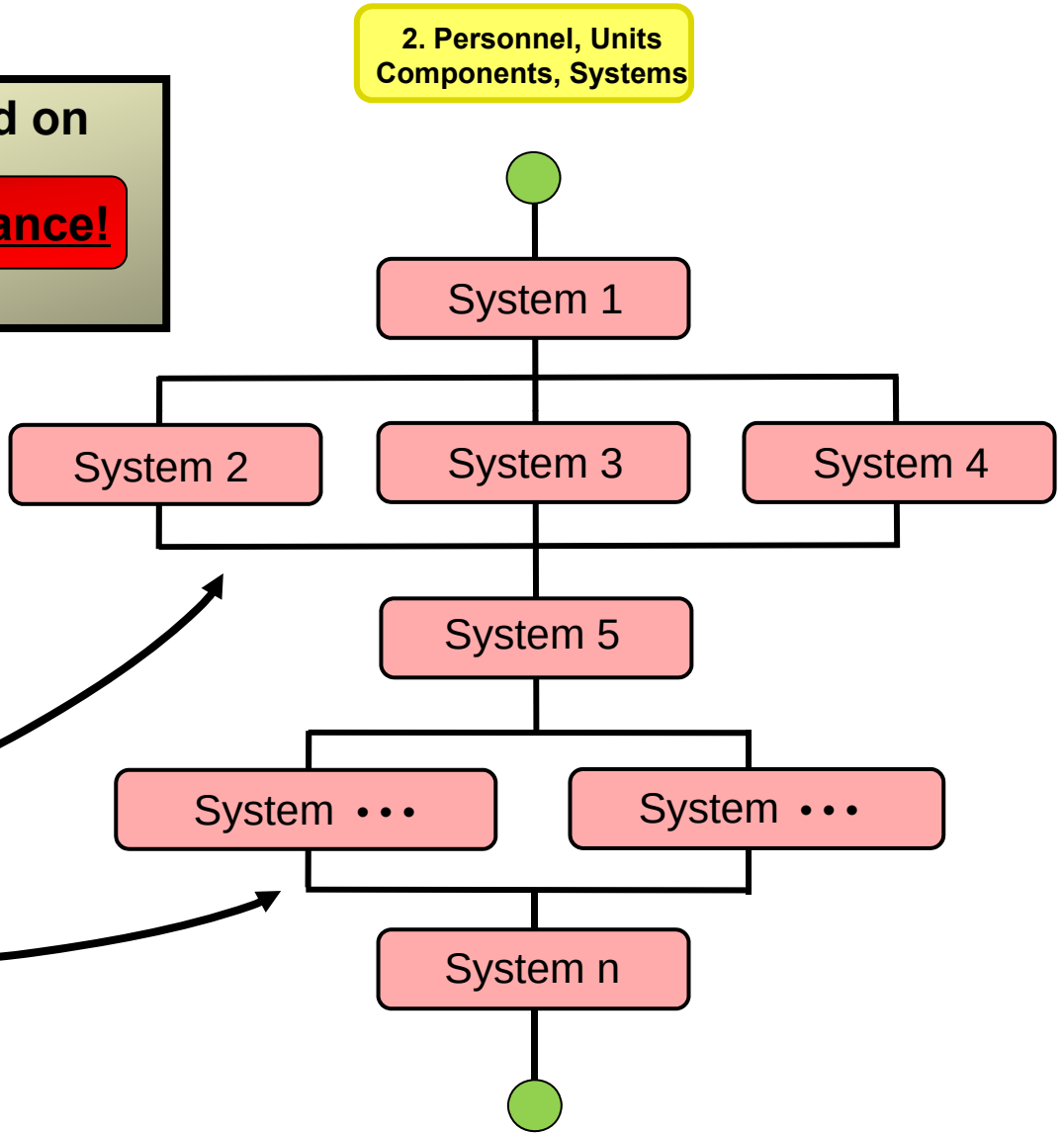
Intersystem Linkage: Key SoS Construct

SoS assessment based on

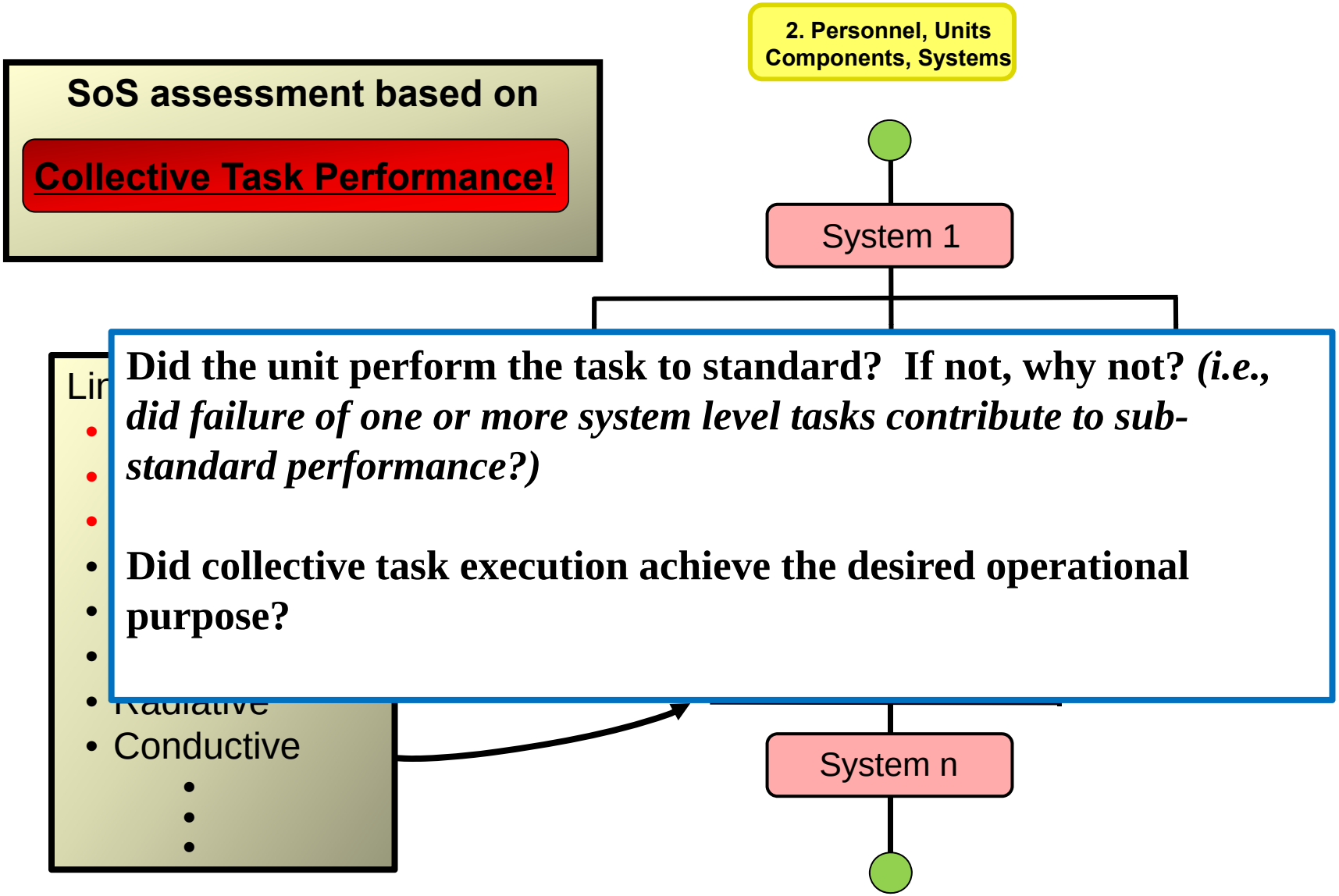
Collective Task Performance!

Linkages can be:

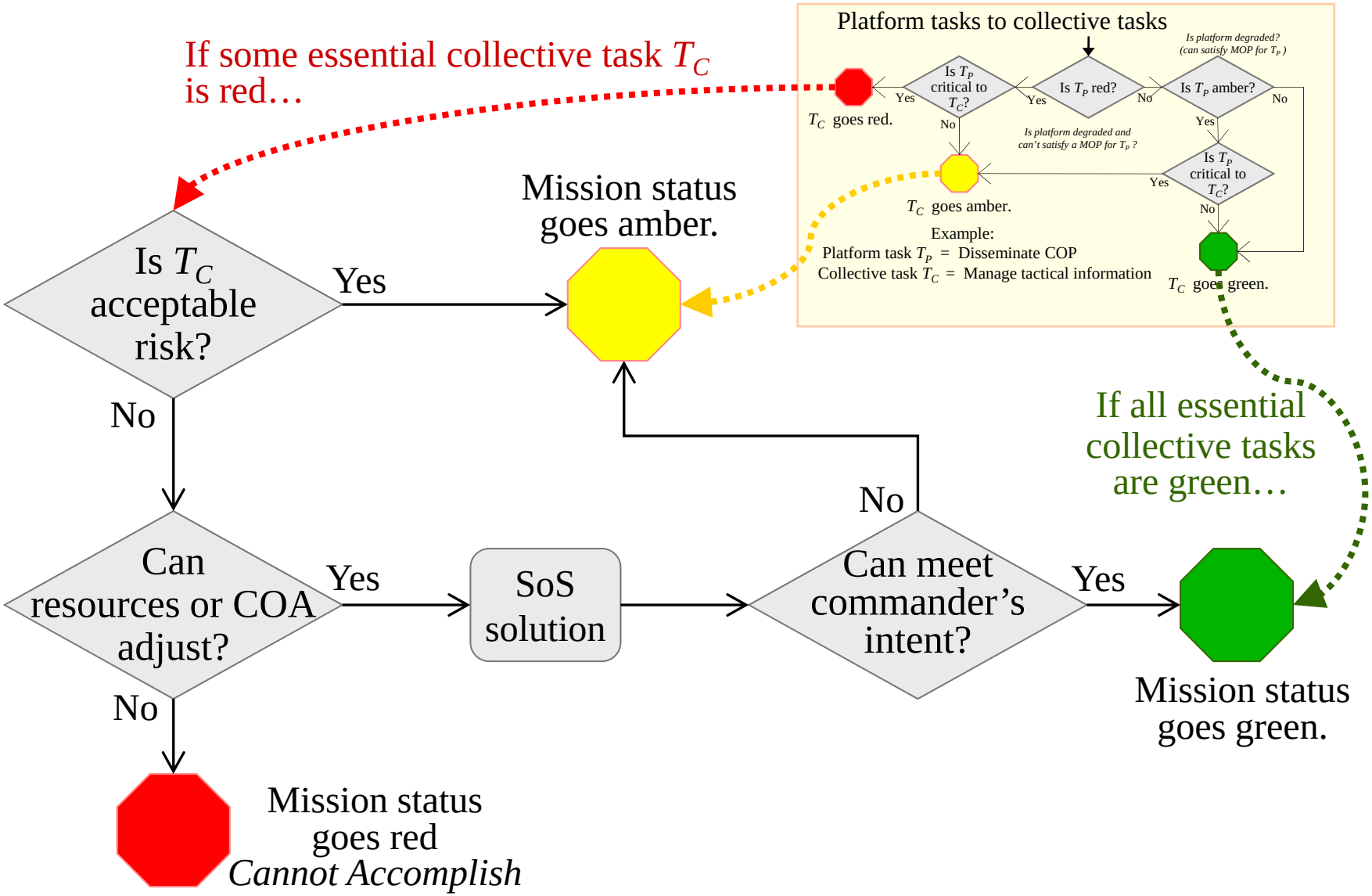
- Time Based
- Event Based
- Effects Based
- Mechanical
- Electrical
- Hydraulic
- Radiative
- Conductive



Intersystem Linkage: Key SoS Construct

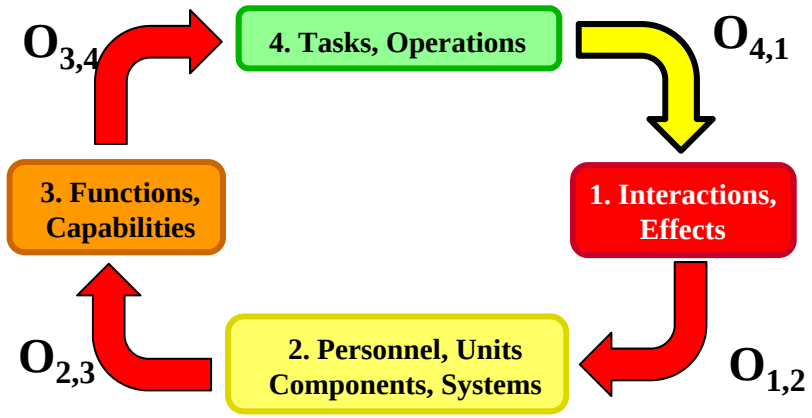


Determining Mission Impact



Supporting Contexts‡ [1/4]

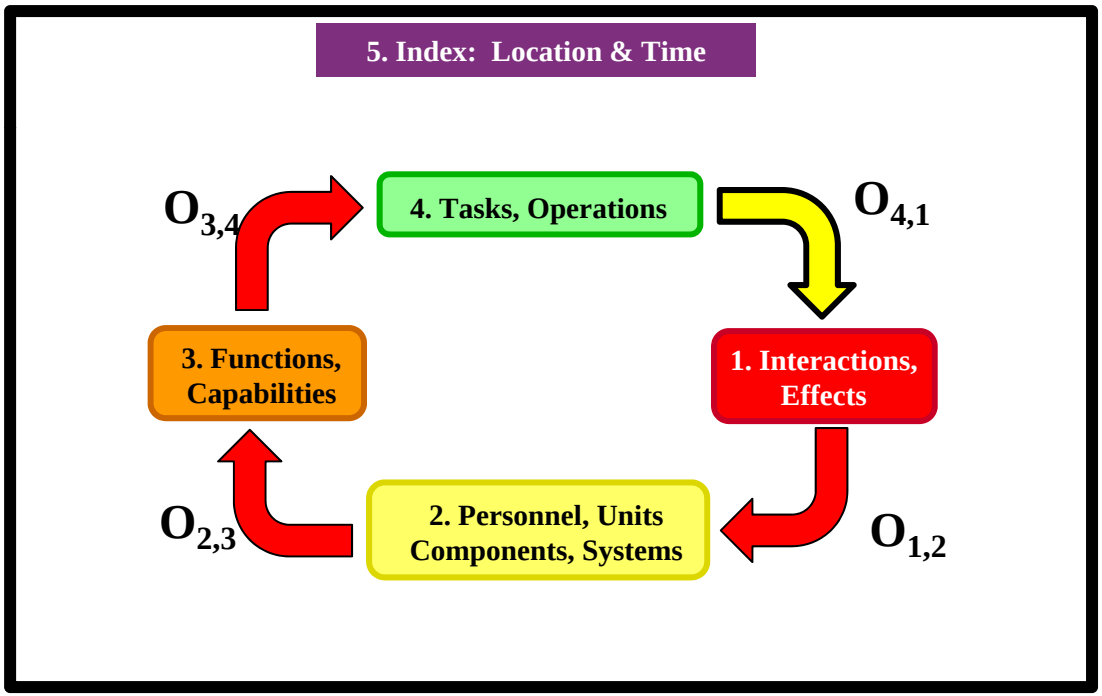
These Principal Elements are necessary, but not sufficient, to define a full representation of the MDMP.



‡The OPFOR is not shown!

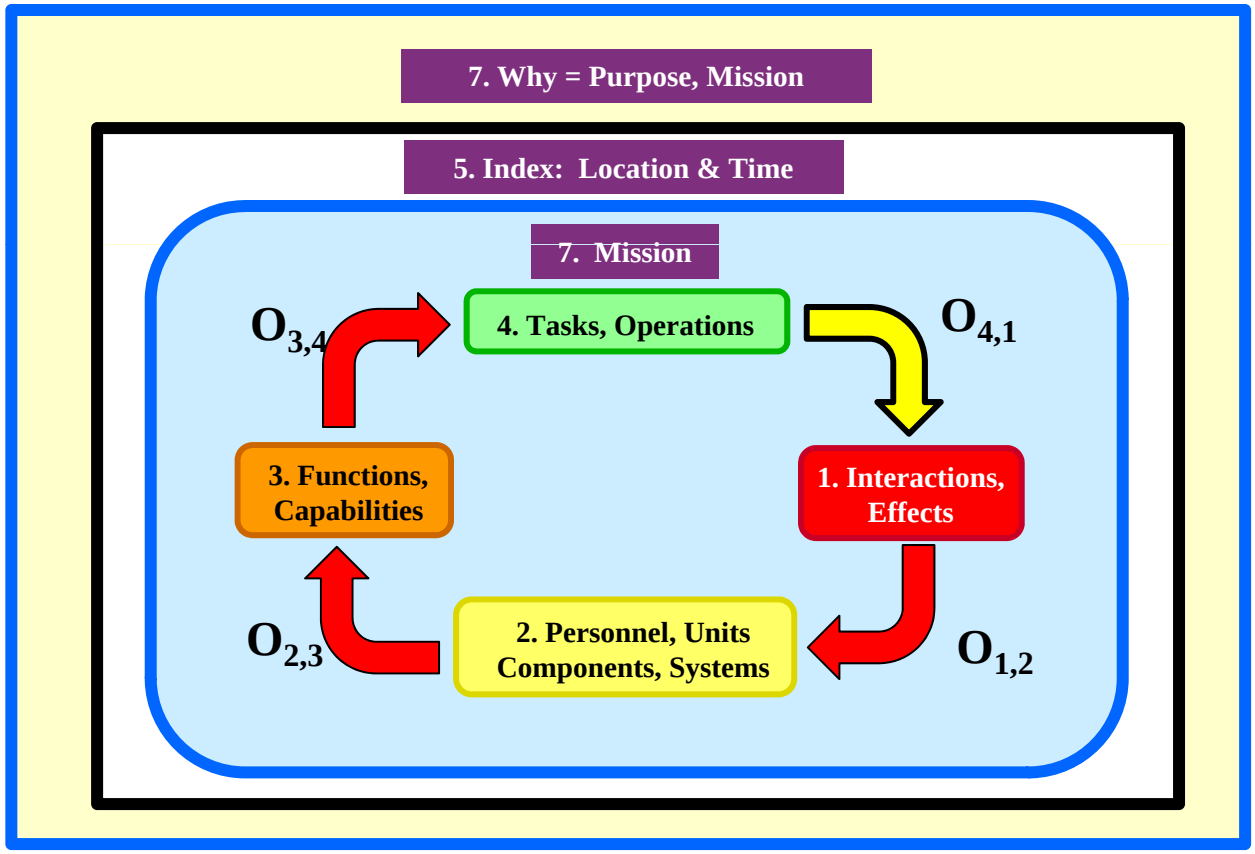
Supporting Contexts [2/4]

Level 5: Index- Location & Time



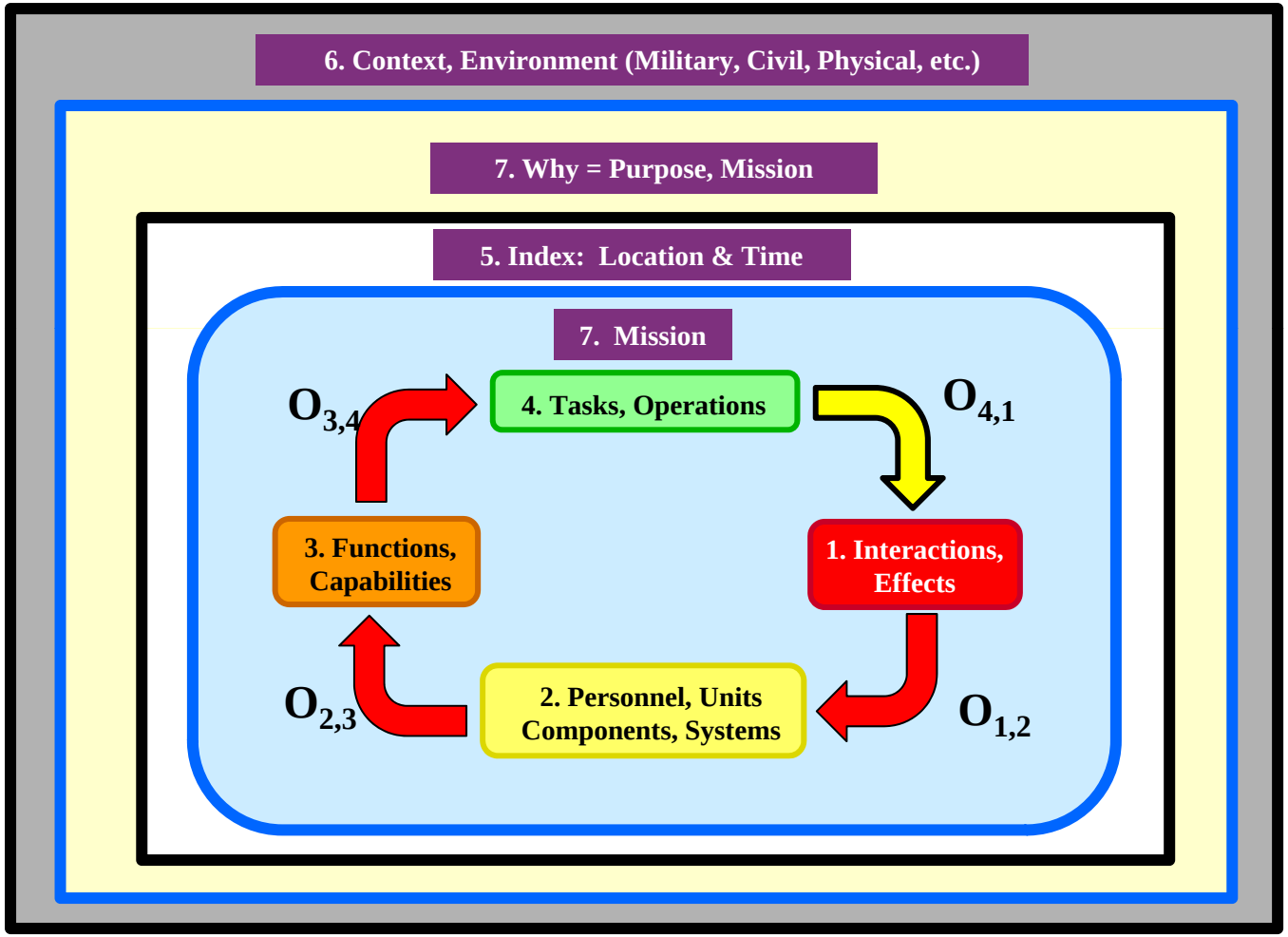
Supporting Contexts [3/4]

Level 7: OWNFOR Purpose, Mission



Supporting Contexts [4/4]‡

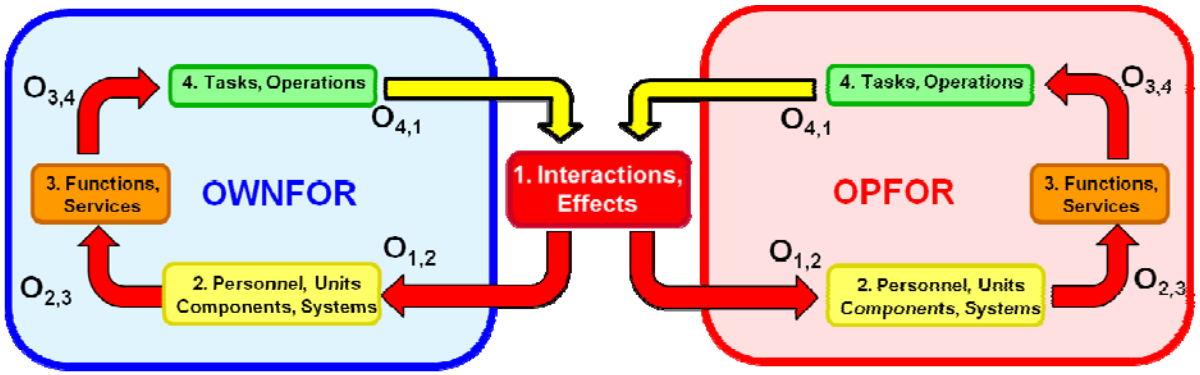
Level 6: Environment- Military, Civil, Physical, . . .

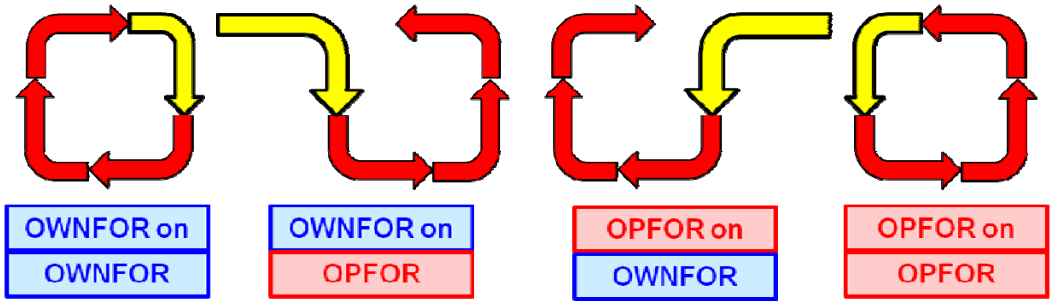


‡The OPFOR is not shown!

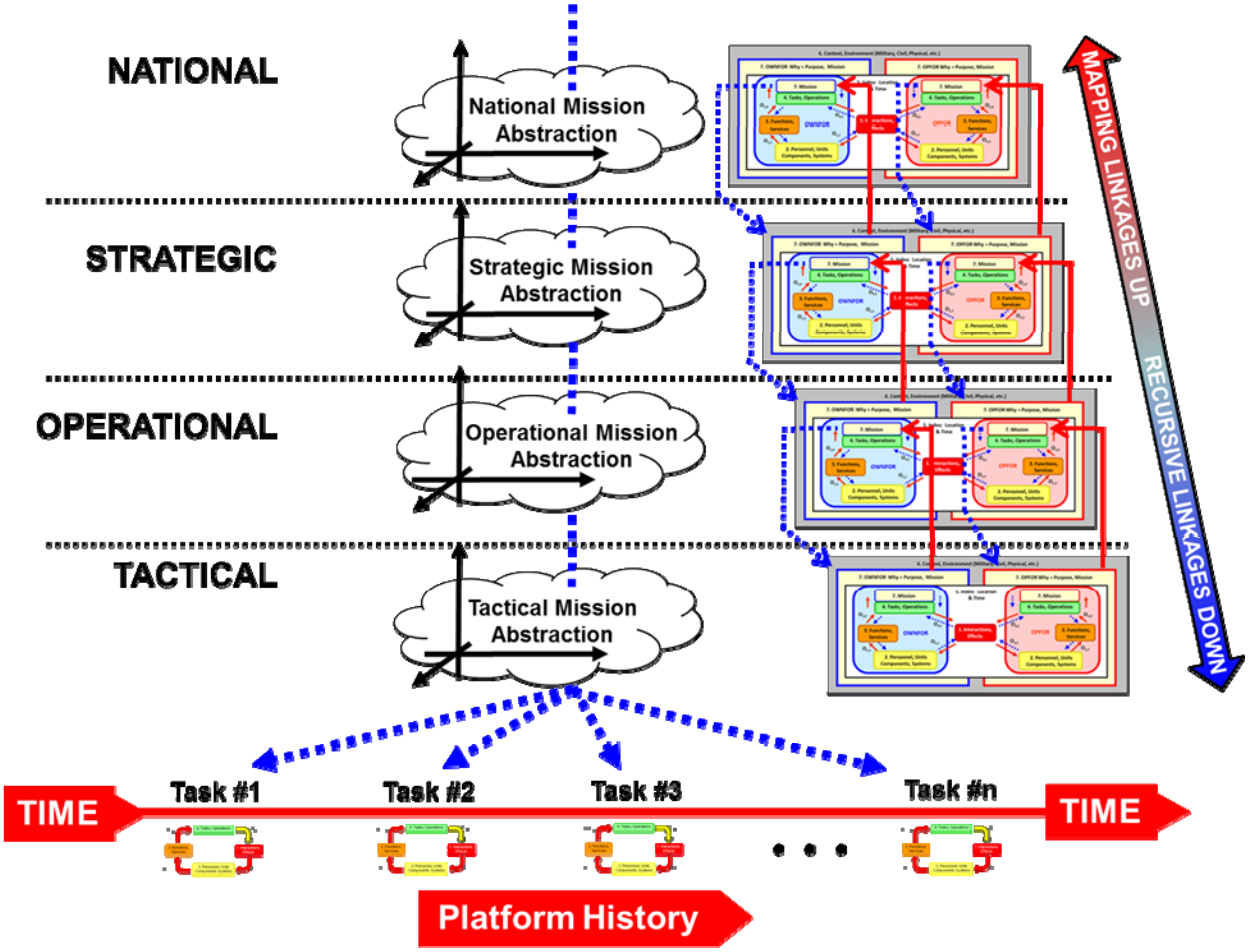
Context is critical for <u>all</u> mapping levels!

Navigating the MMF





MMF by Level of Conflict

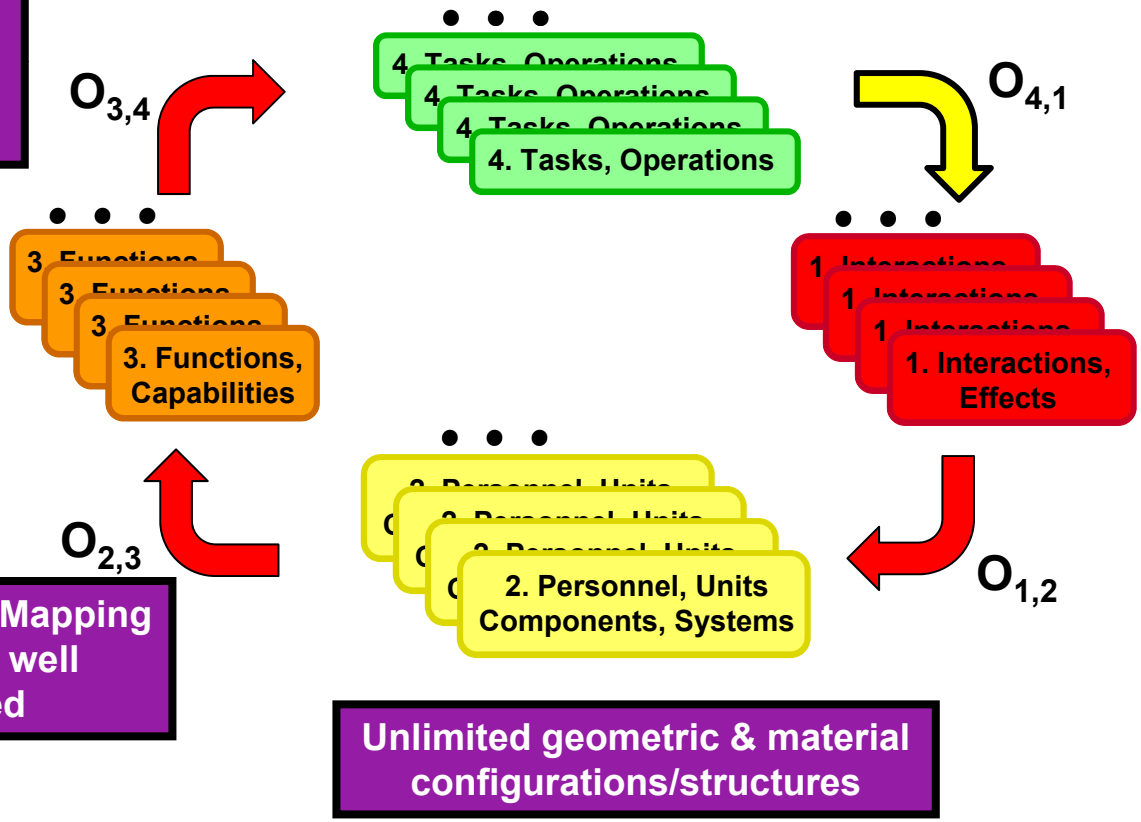


A "Lego" Collection of Mission/Performance Elements

Ability to Mix & Match Levels & Operators

- ≈ 2200 Universal Joint Tasks
  - ≈ 350 Condition Descriptors
  - ≈ 4 Standards per Task
- ≈ 680 Army Universal Tasks
  - ≈ 350 Condition Descriptors
  - ≈ 4 Standards per Task

Capabilities described in task-compatible metrics



- Ballistic Effects
- Jamming
- Damage Repair
- Chemical
- Resupply
- Repair
- Laser Damage
- Sleep
- Directed Energy
- Nuclear
- Physics of Failure
- Logistics Burdens
- Reliability
- Fair Wear & Tear
- Fatigue
- Heat Stress
- . . .
- . . .

Degraded States Mapping Methodology well established

Unlimited geometric & material configurations/structures

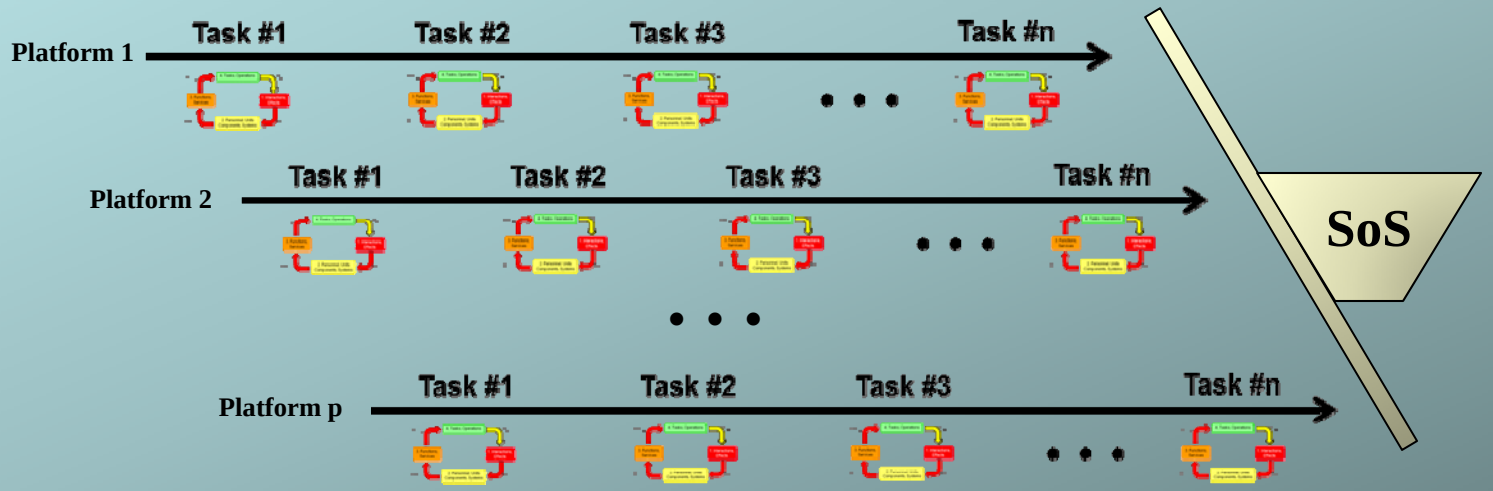
Analysis, Evaluation & OT Issues

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

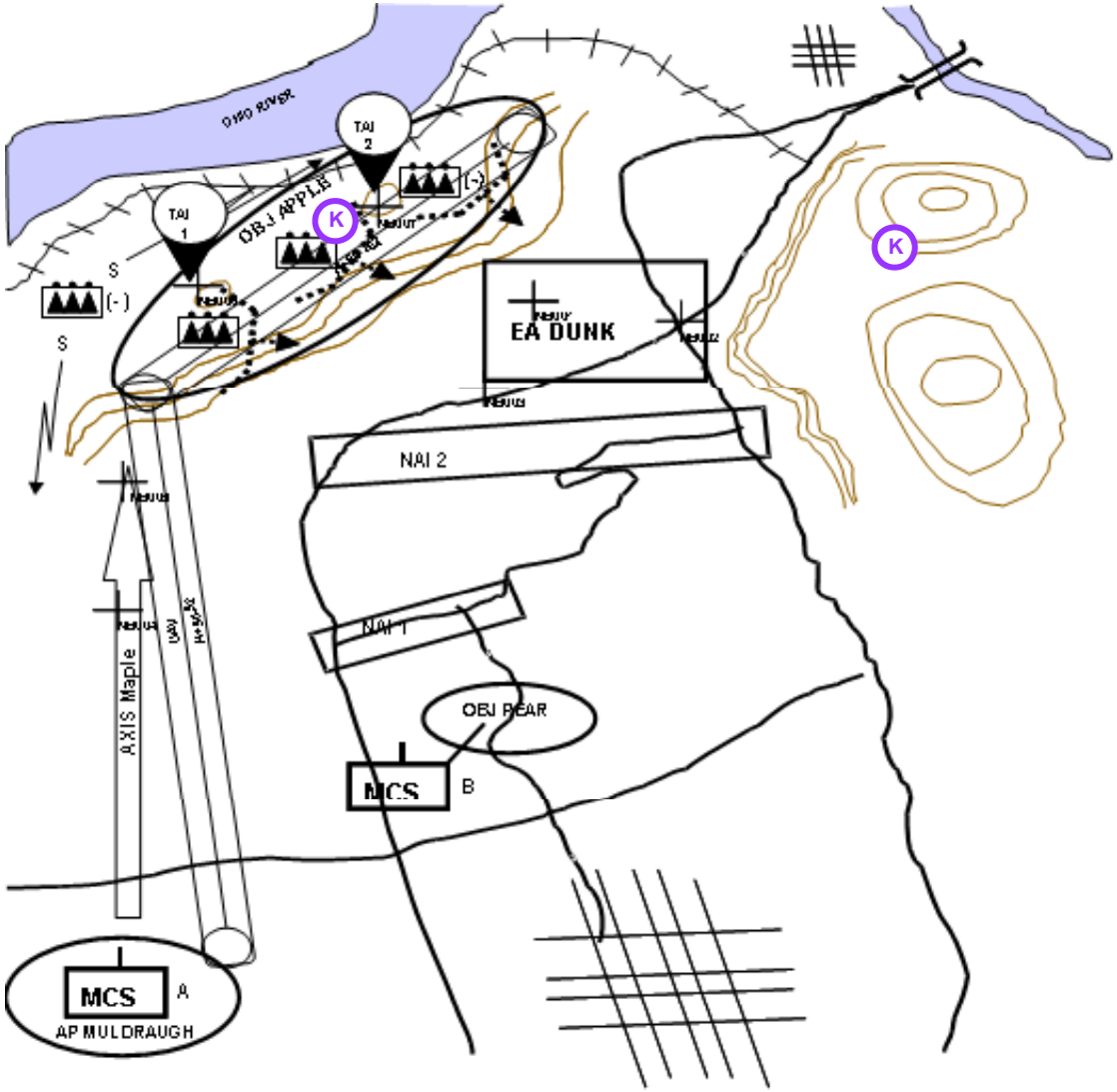


Agenda: Wednesday, October 30, 2013

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

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.

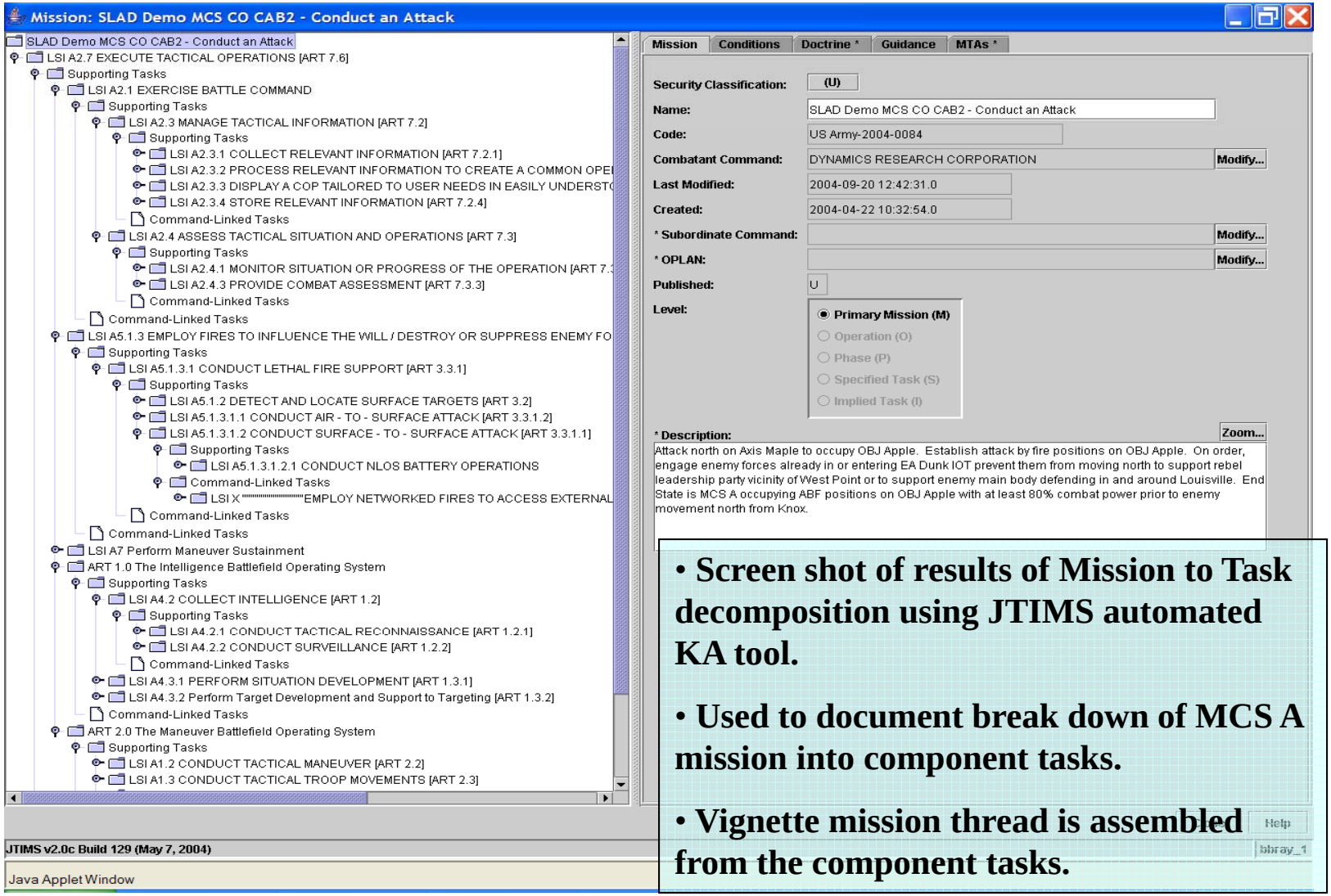
TAI - Targeted Area of Interest

K - Key Terrain

MCS - MCS Engagement Area

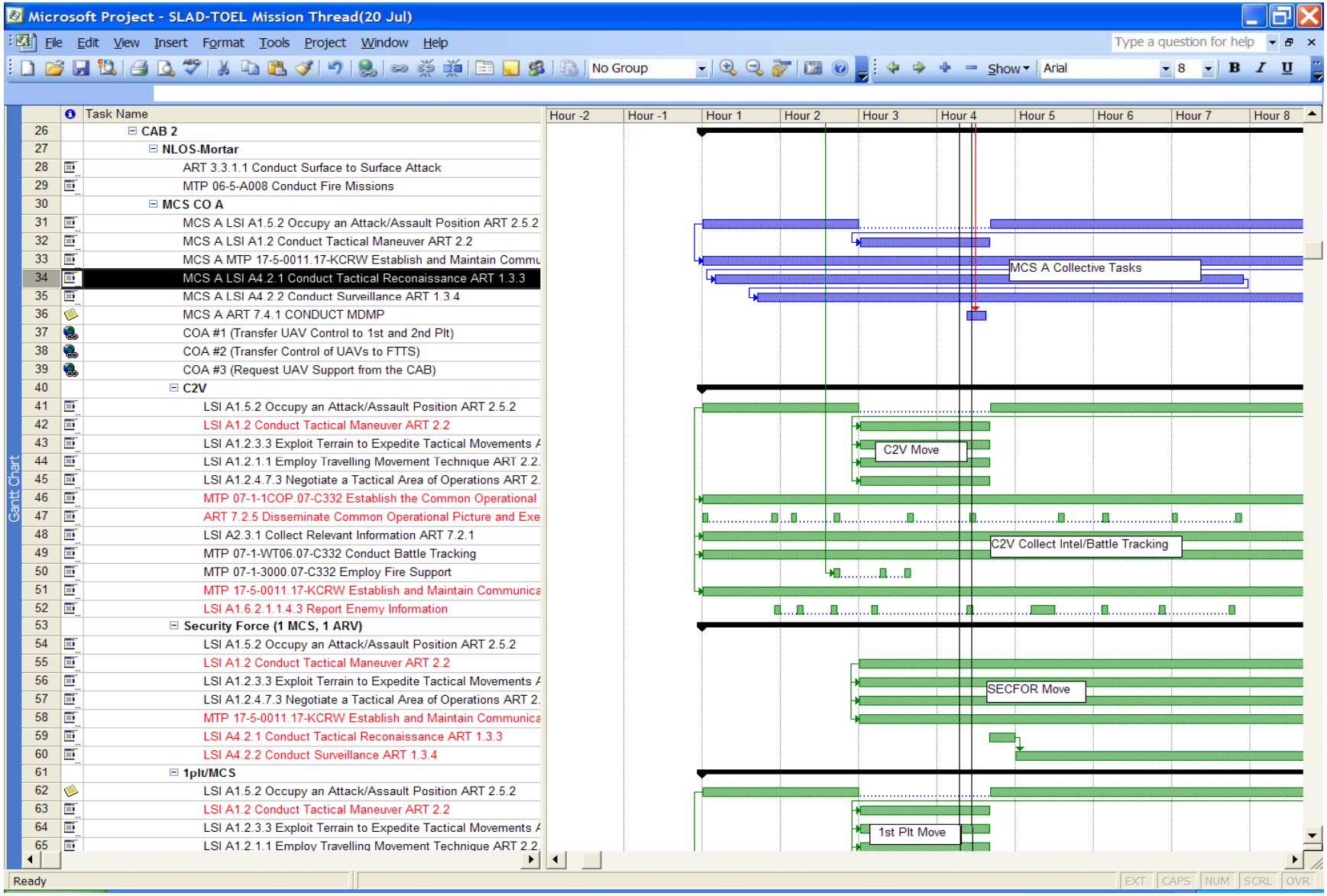
NAI - Named Area of Interest

Mission Task Report

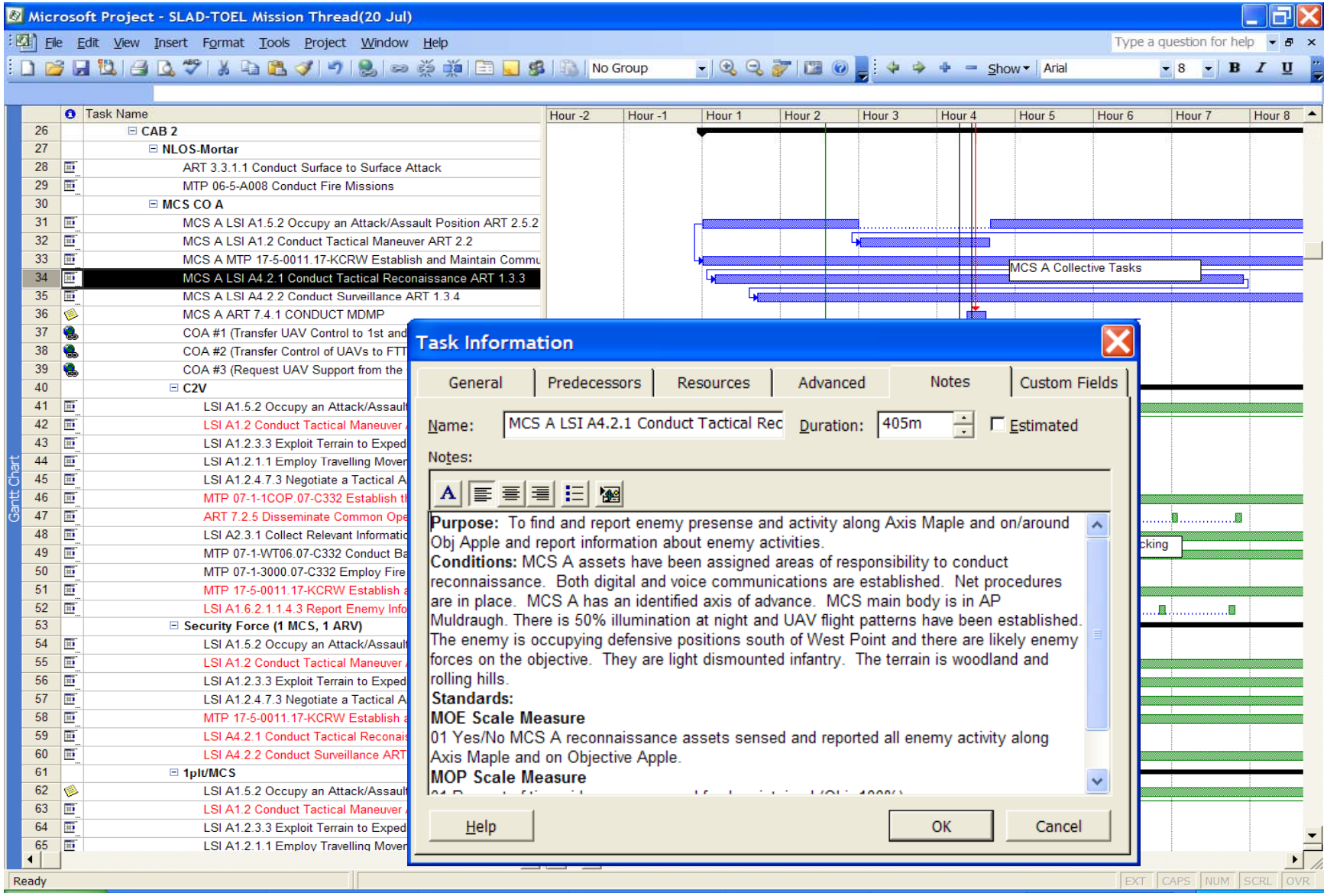


- **Screen shot of results of Mission to Task decomposition using JTIMS automated KA tool.**
- **Used to document break down of MCS A mission into component tasks.**
- **Vignette mission thread is assembled from the component tasks.**

Mission Thread (MS Project)



Mission Thread (with Task Information)



TOEL (Matrix form with MMF Elements)

1	Lines from the TOEL												
2			TASKS	PLATFORM			Comms						
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					

TIMELINES | P-Lines | Sheet3

Draw AutoShapes

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**

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

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**

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.

The 16th Annual National Systems Engineering Forum

Sponsored by the National Defense Industrial Association Systems Engineering Division

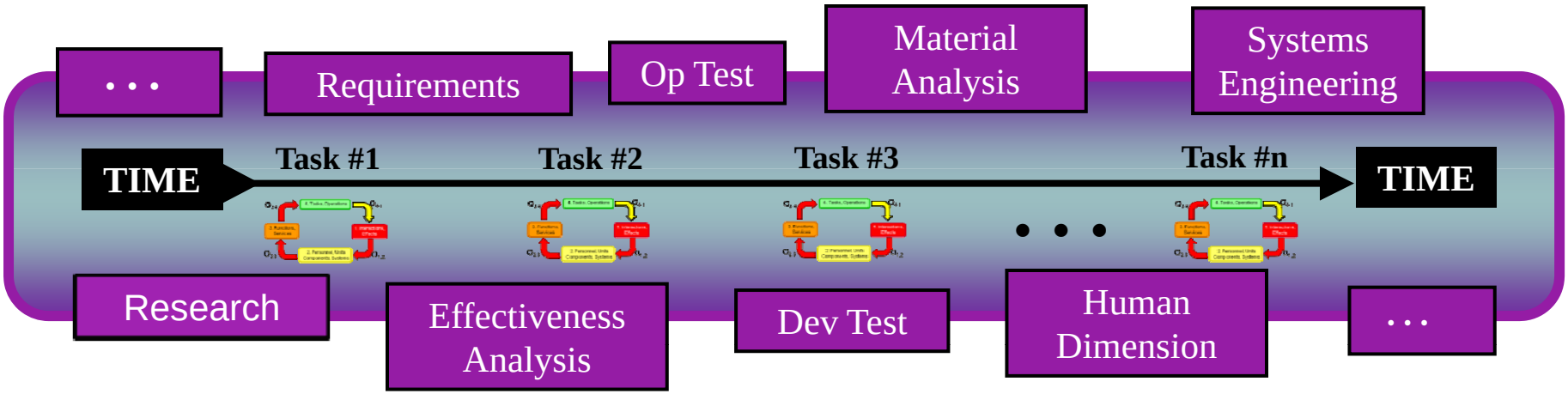
October 30, 2013

"An Integrating Framework for Supporting Systems Engineering"

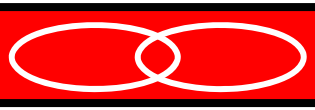
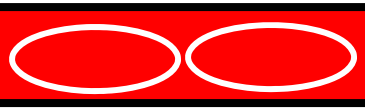
Britt Bray
DRC
(785) 550-5573
bbray@drc.com

Back Up Charts

Sequence of Task Cycles Forms a TOEL

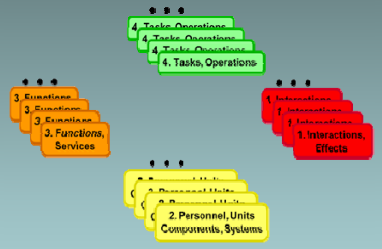


- Missions are composed of task sequences
- Following task initiation, an event cycle occurs
- As a result, material, capability, and utility changes may follow
- When the "lego" elements are developed at this level of resolution, they can be combined endlessly with great extensibility
- All communities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

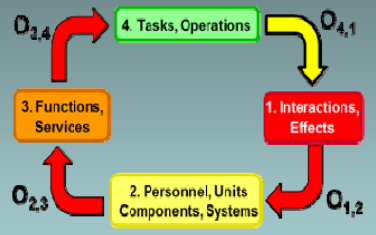
Are the Venn data sets  **or**  **or**  **?**

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.