28th Annual NDIA Test & Evaluation Conference
Hilton Head, SC
12-15 March, 2012

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Application of the Missions and Means Framework to Combat System Requirements, Development, and Refinement

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Conference Focus

The 28th Annual National T&E Conference is focusing on proper role of T&E in our Defense System Requirements Process.

This paper will address

- What constitutes a set of valid (supportable), measureable (testable), realistic and achievable requirements?
- How can the T&E Community best engage the Defense Community at large?

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Implications?

- The reference/superior knowledge sets:
  - Which sets are necessary and sufficient?
  - How are these sets formally structured?
- The subordinate knowledge sets:
  - Identify the requisite supporting disciplines (e.g., DT, OT, M&S, Human Dimension, Logistics, Reliability, Effectiveness . . .
  - How are these sets formally structured particularly so that their elements can be related one to another (i.e., horizontal linkage)?
- How are the superior and subordinate knowledge sets formally (i.e., vertically) linked?

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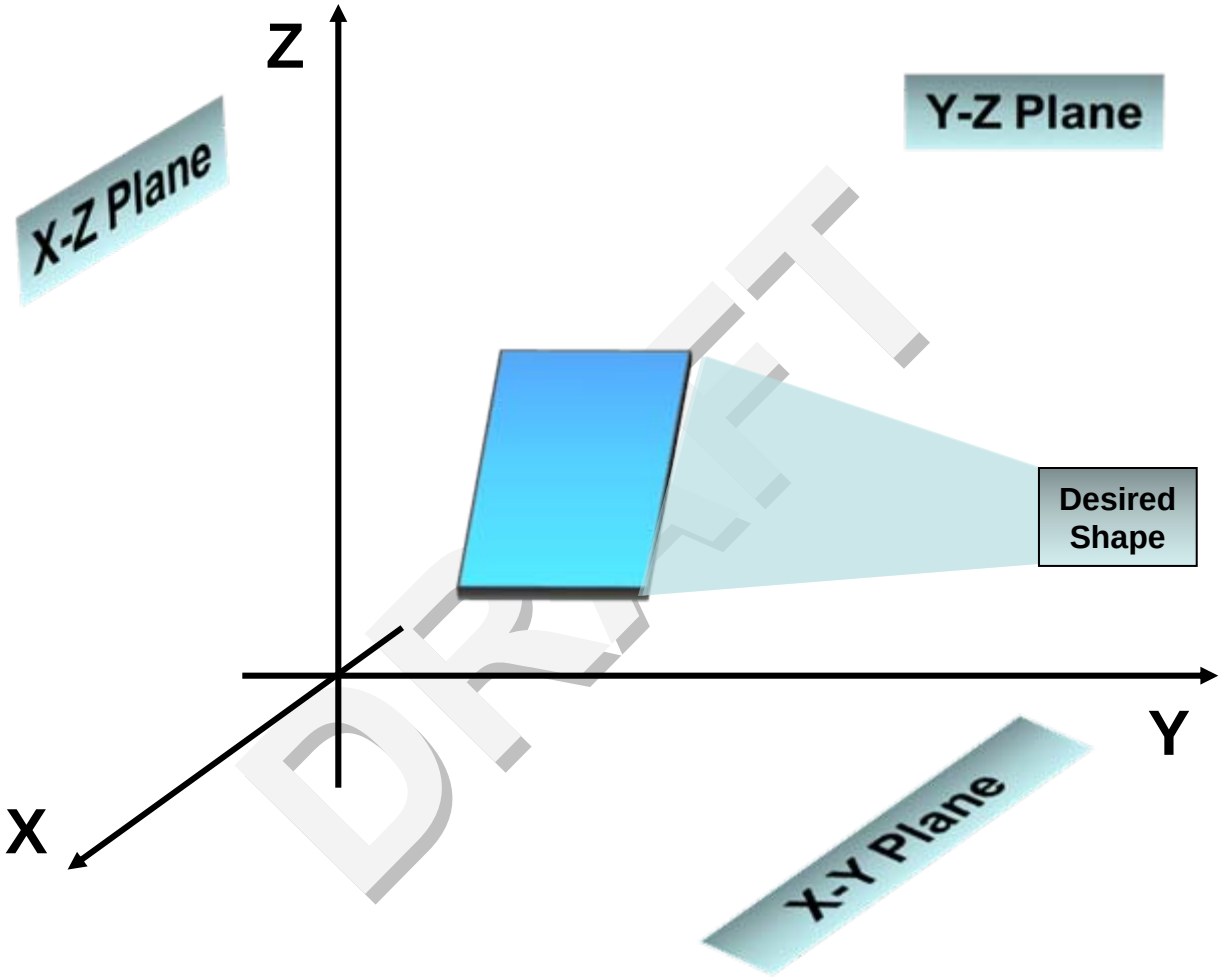
- To meet these implied requirements, the many elements which comprise this problem set must be cast into a single framework!

3-D Space/3-D Object



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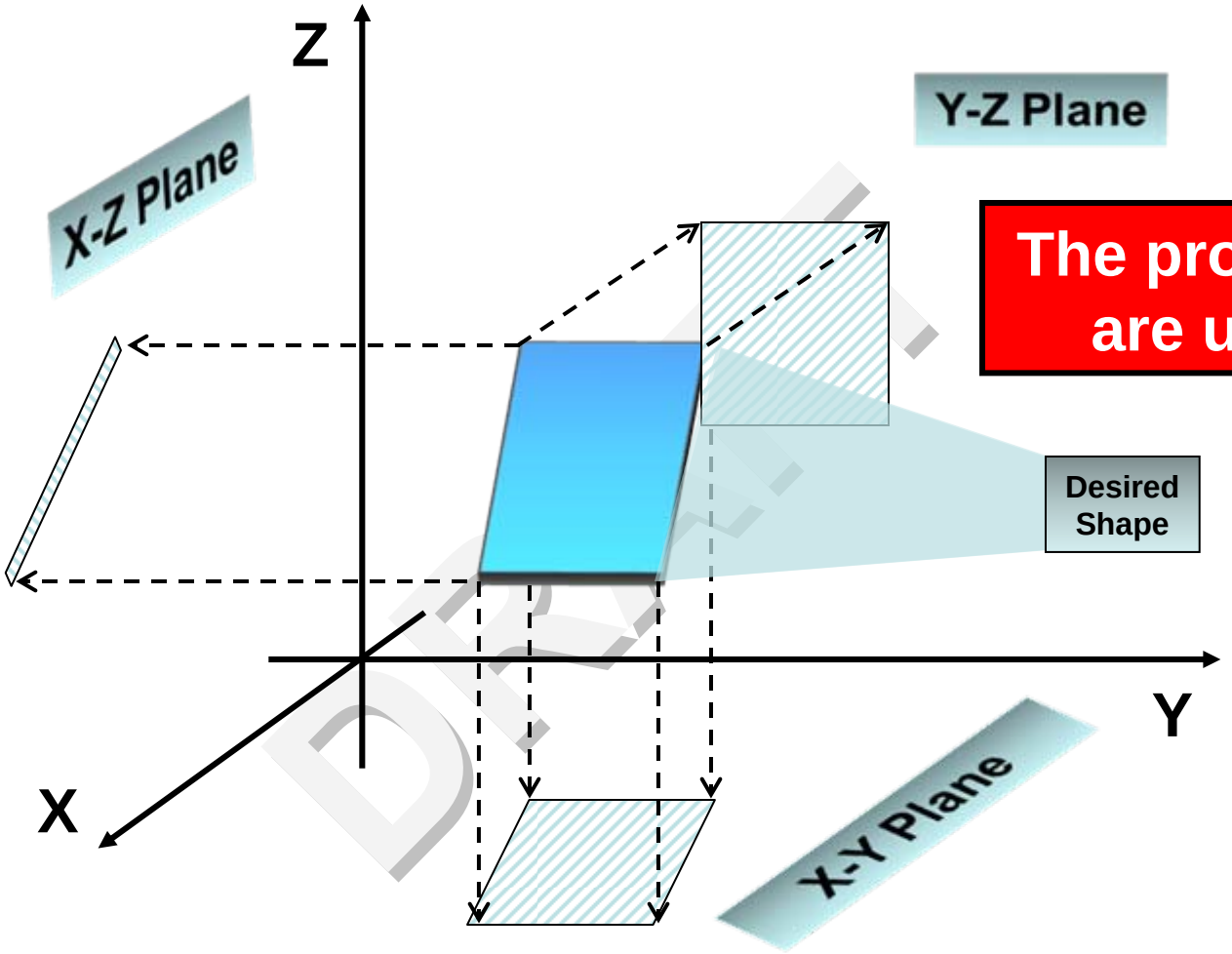
Three Mappings from 3-D to 2-D Spaces



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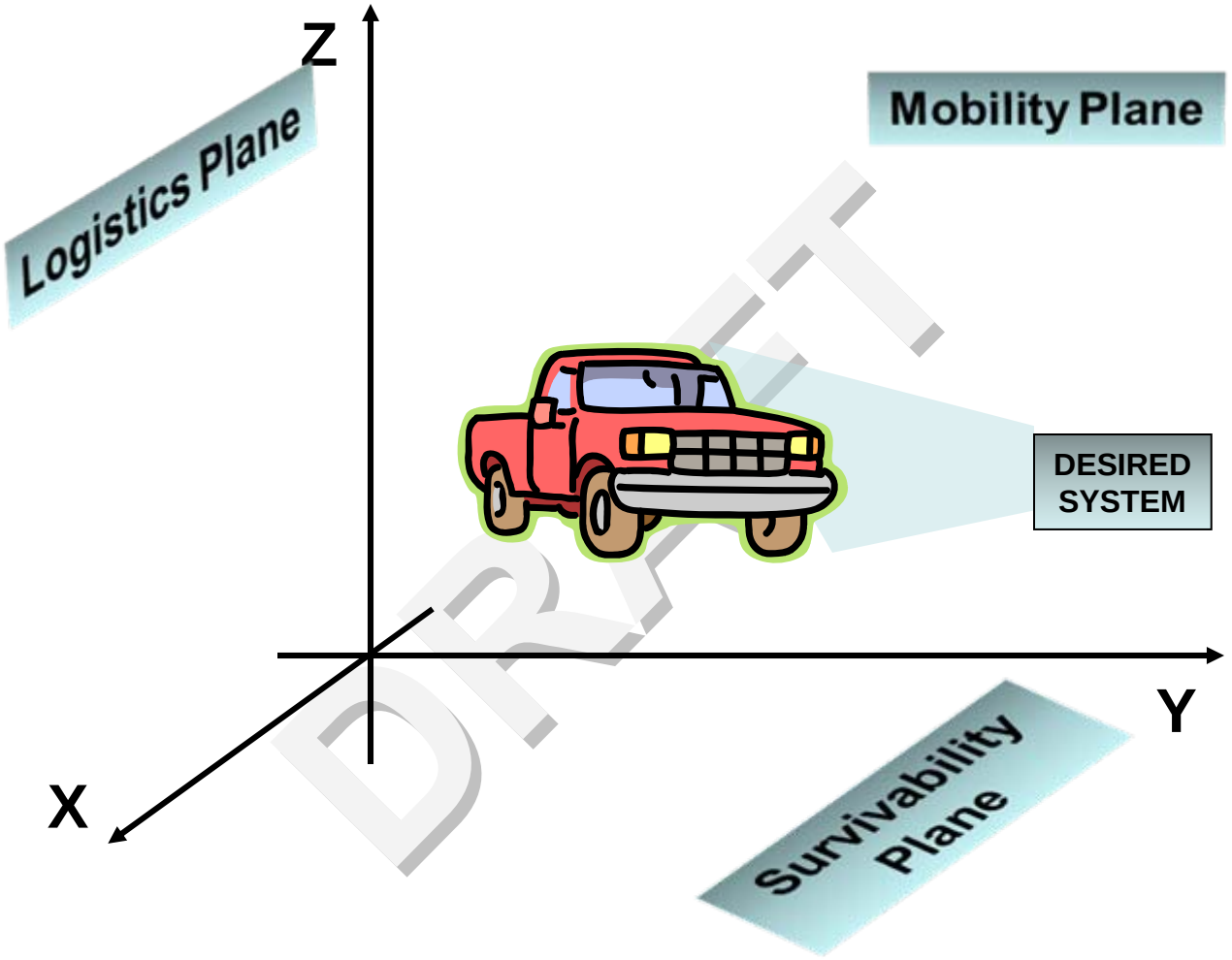
Military Operations in 3-D Space



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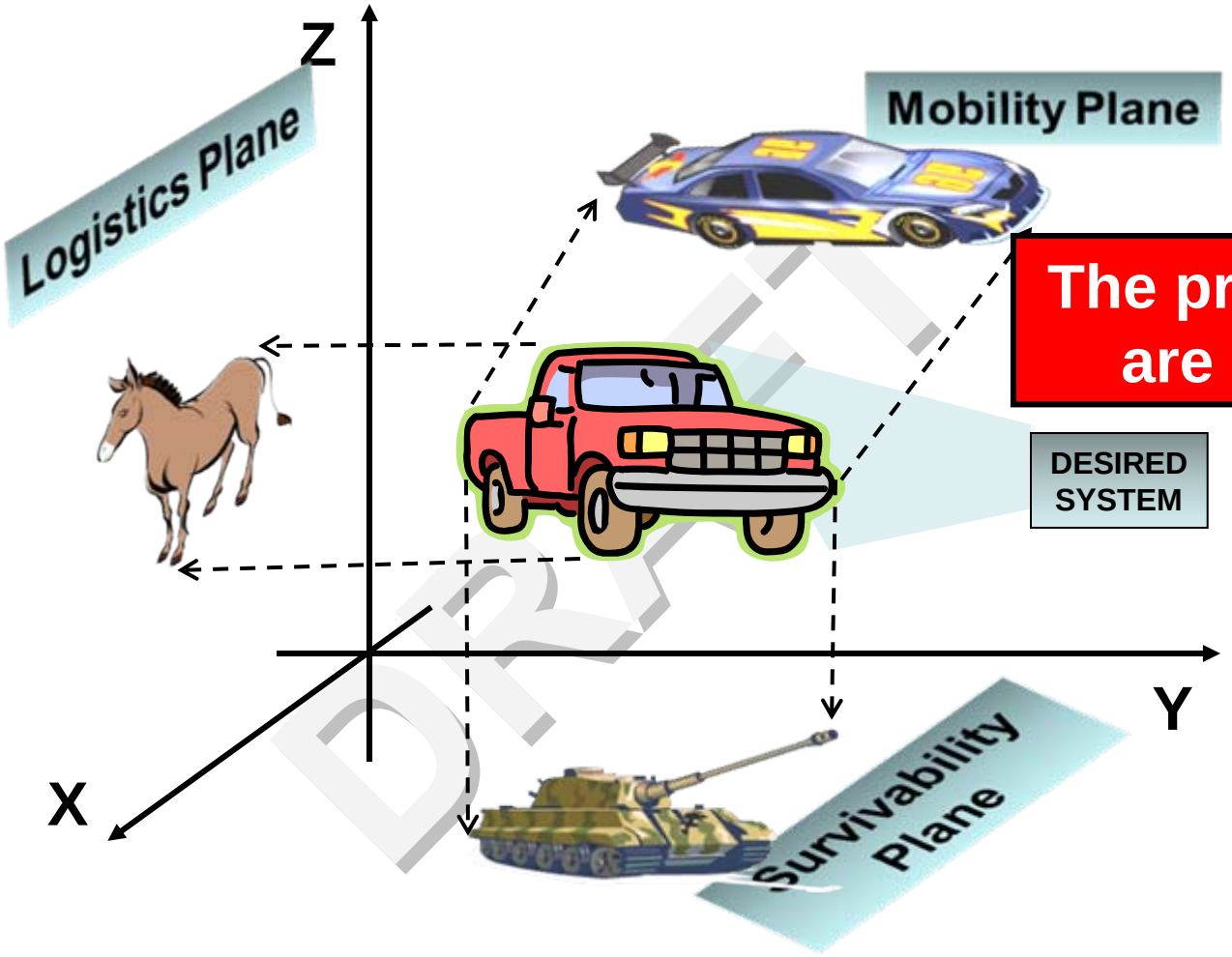
Military Operations in 3-D Space w Projections



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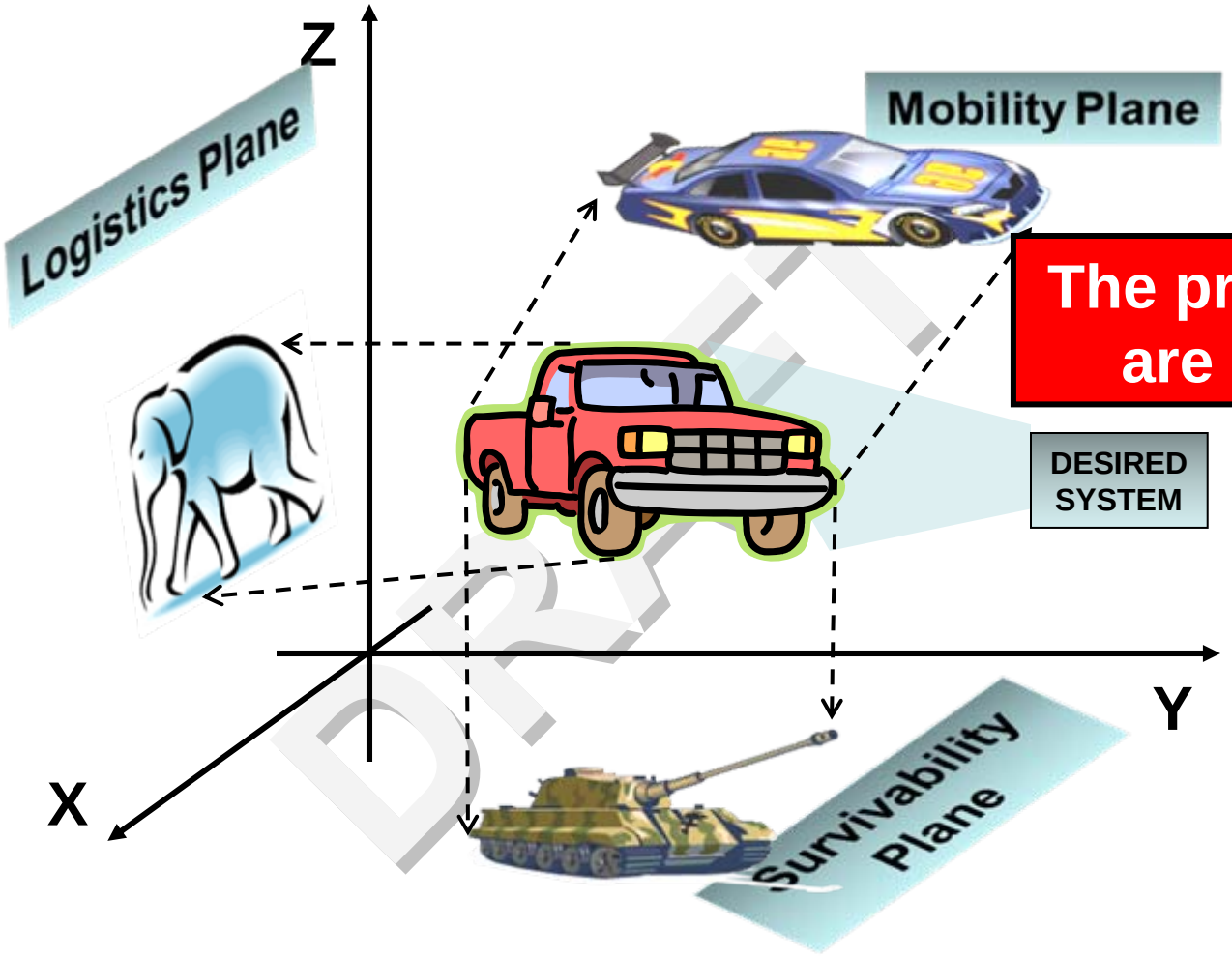
Military Operations 3-D Space w Projections‡



‡ An alternate GOP view!

The Military Decision-Making Process [MDMP]

- We suggest that the MDMP should serve as the single integrating framework for all military analyses.

- Also that the reference (top-most) knowledge set(s) is constituted by the highest specific mission(s) developed under this construct.

- All subordinate knowledge sets be derived recursively from higher levels via expressed and implied tasks.

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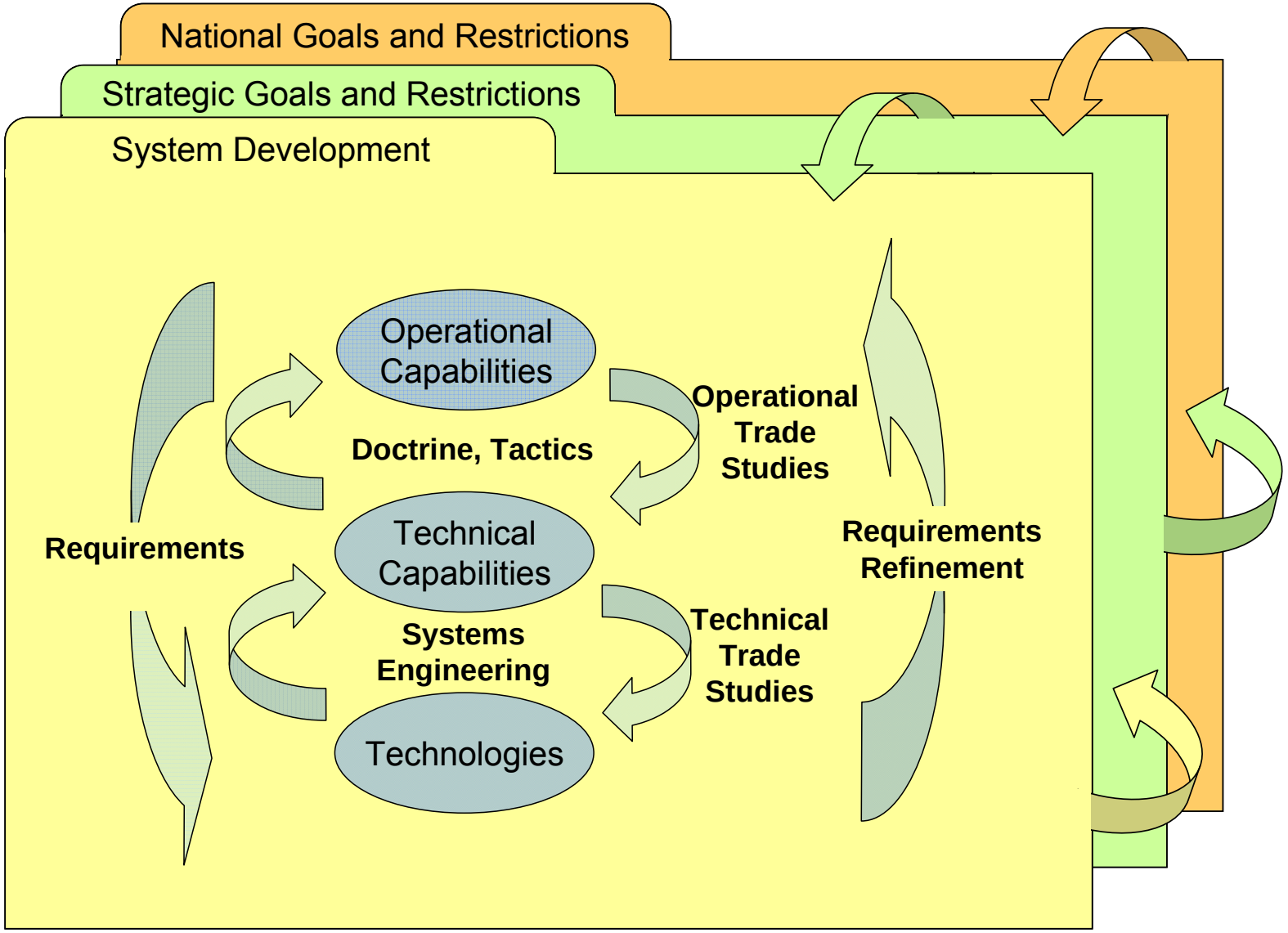
A Requirements Development Model



Formalizing the MDMP

- Over the past 14 years, considerable efforts have been expended to:
  - establish top-down linkages (per level of war),
  - establish horizontal linkages (e.g., System-of-Systems),
  - represent an OPFOR in addition to an OWNFOR so that multiple sides can be played against each other
  - reduce/eliminate ambiguity in representation by developing a formal structure for MDMP (including executable tasks and executing people/material) in order to
  - establish an executable framework (so that this can be automated)

- We call this the Missions and Means Framework (MMF)

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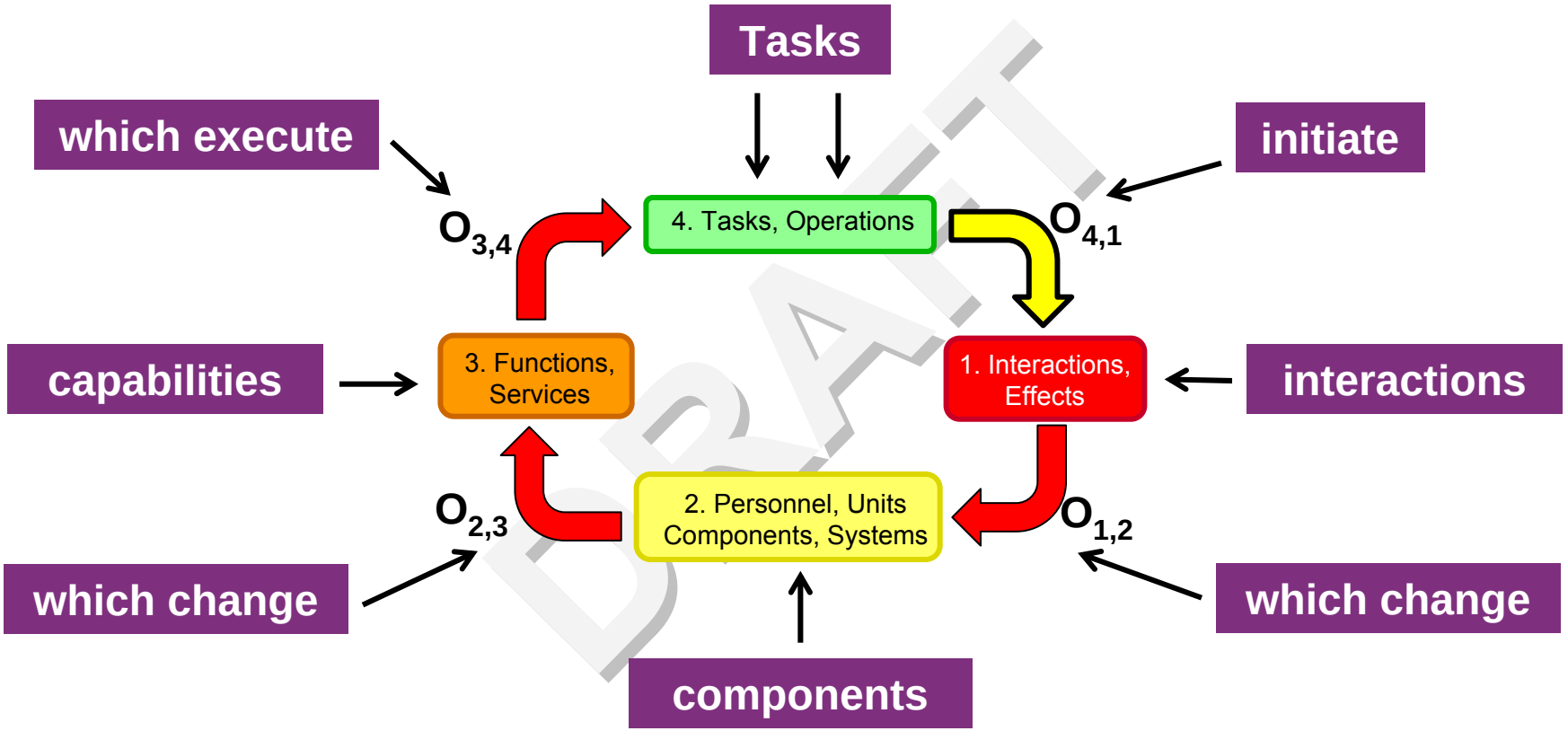
MMF Principal Elements/Linkage



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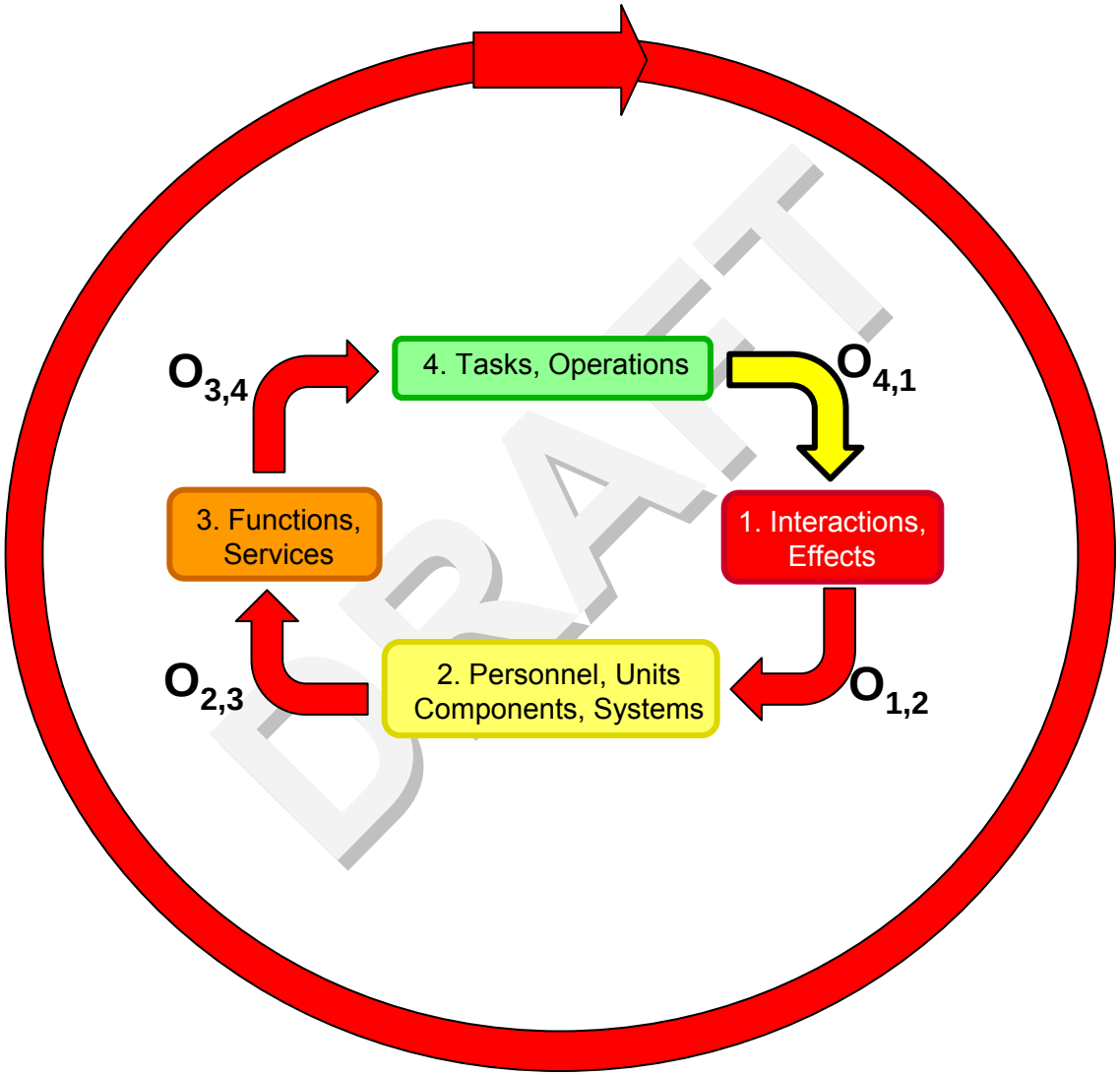
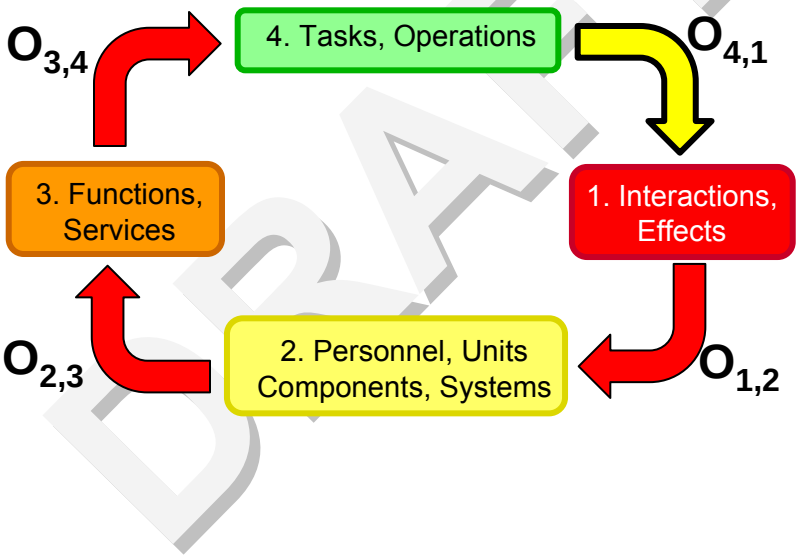
Task Commutation Process



Supporting Contexts [1/4]



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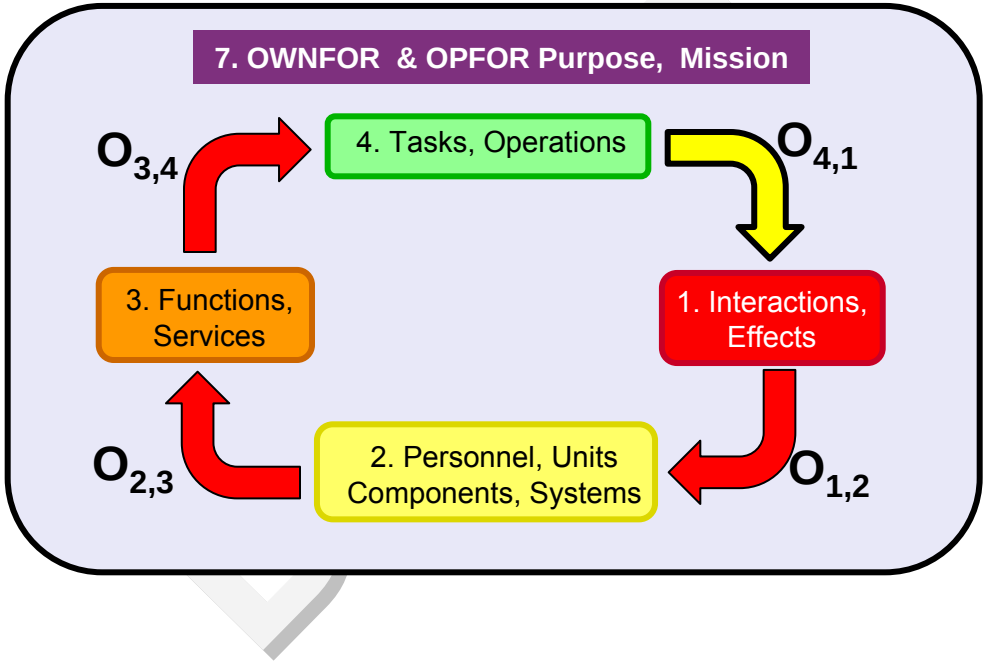
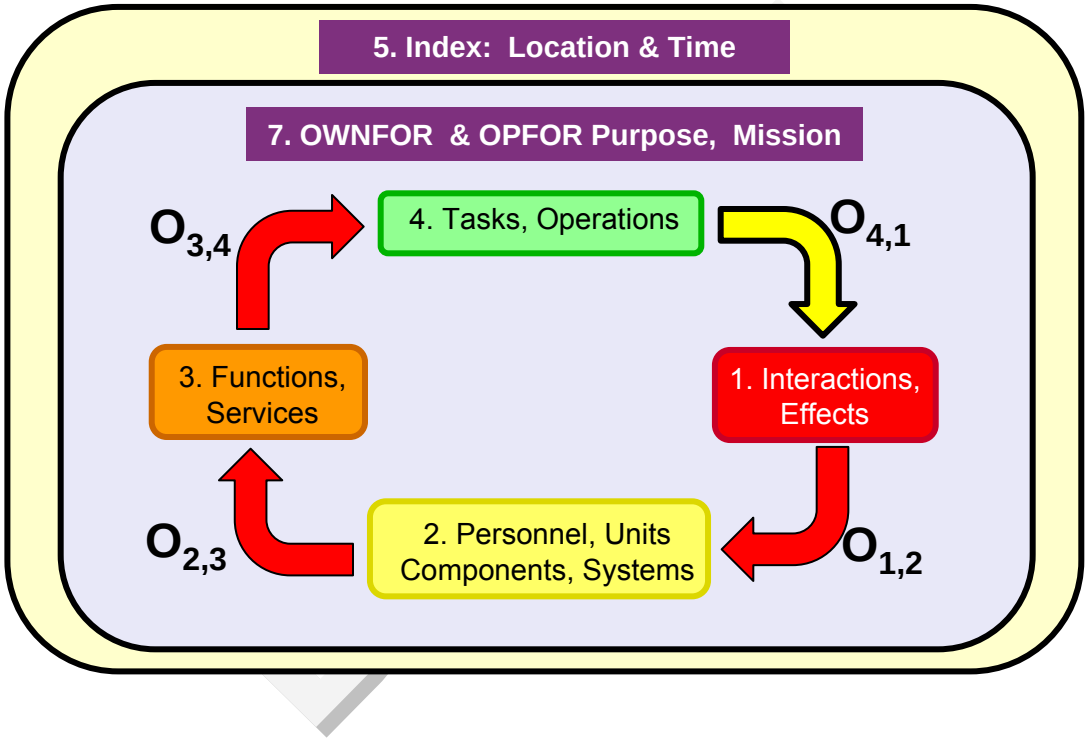
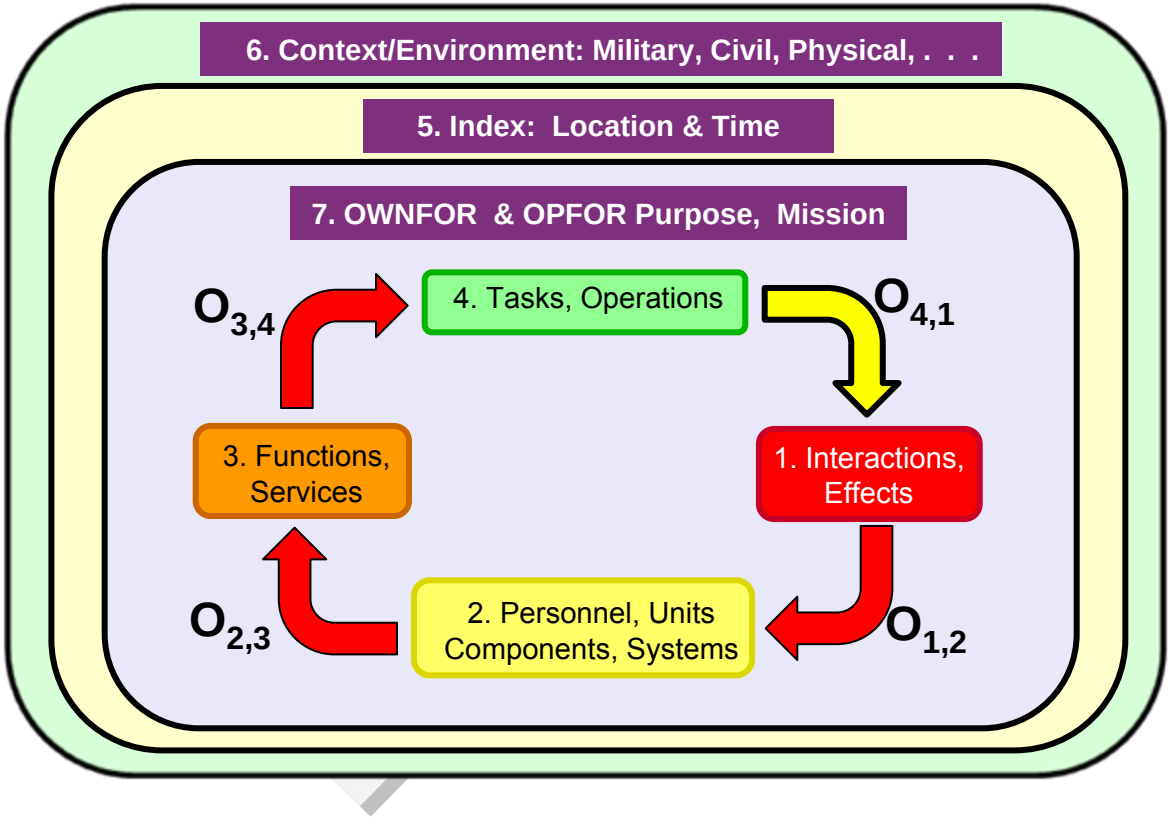
Supporting Contexts [2/4]



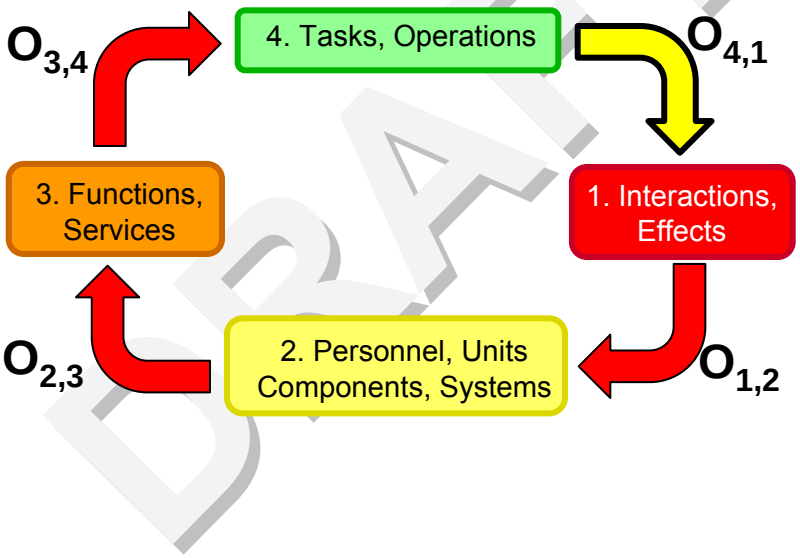
Supporting Contexts [3/4]



Supporting Contexts [4/4]



Lumped Task Commutation [1/2]



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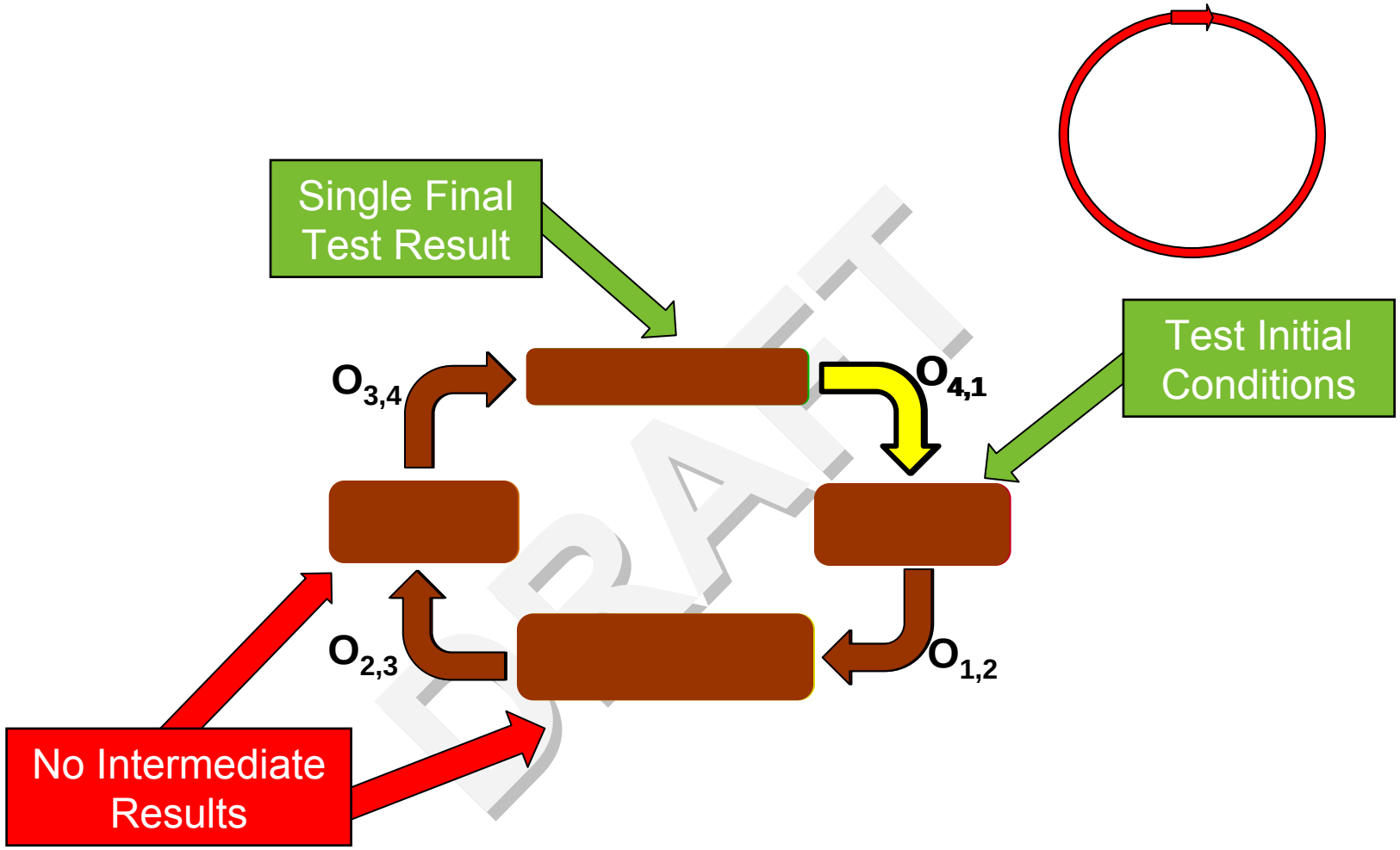
Lumped Task Commutation [2/2]

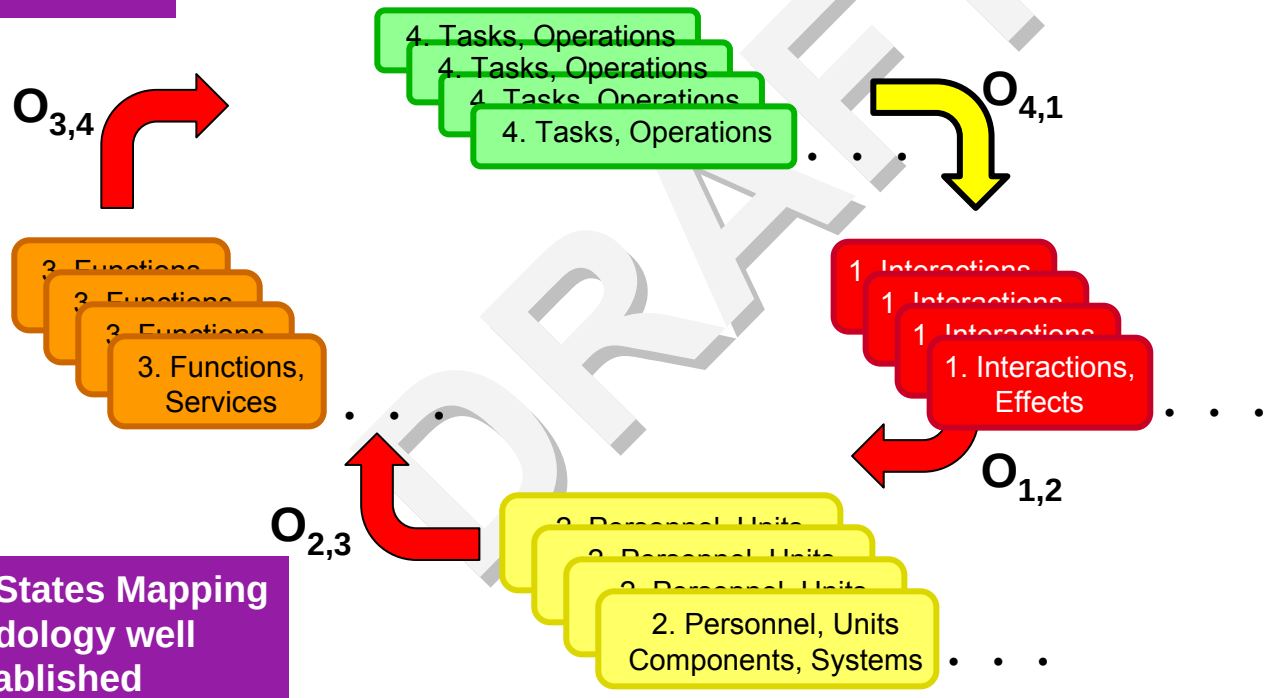


A "Lego" Collection of Mission/Performance Elements

Ability to Mix & Match Levels & Operators

Capabilities described in task-compatible metrics

- 600 Joint Tasks
- xx Army Universal Tasks
- xxxx



Degraded States Mapping Methodology well established

Unlimited geometric/ material configurations

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

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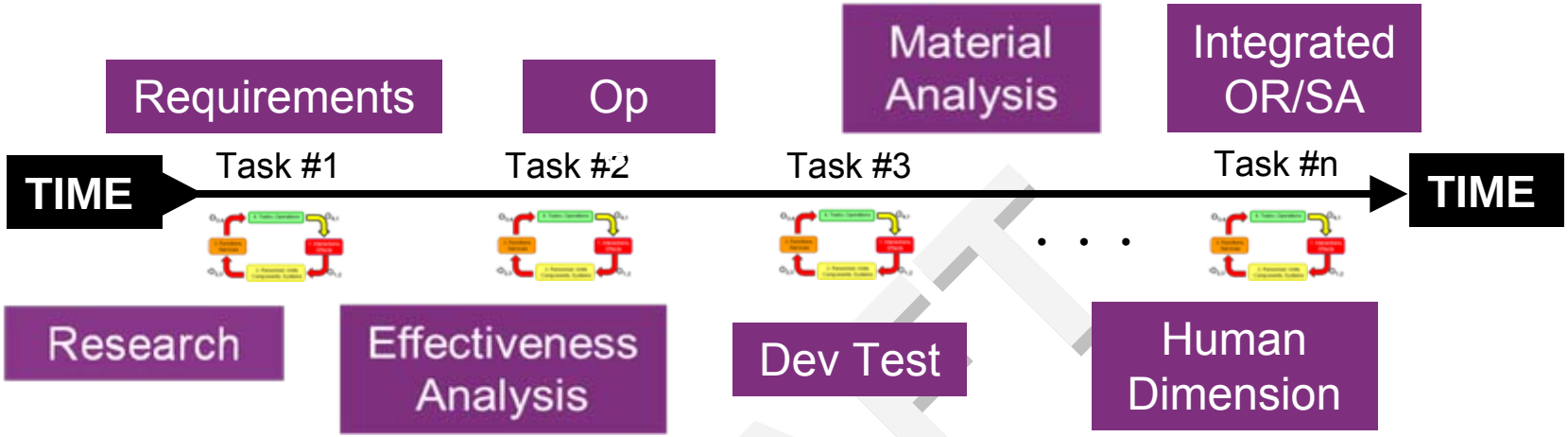
TOELs a Sequence of Task Commutations



- Each event involves a task execution, i.e., one commutation
- With each execution, an interaction occurs, a material change state results, a new capability results, and the next task is/is not executed.
- The levels and operators can be combined endlessly to emulate interactions, frequency of interactions, geometry configuration, capability changes, and event-wise mission utility.
- Various disciplines can focus on the operator/level subsets of interest to them. Shared/exclusive issues are informed.

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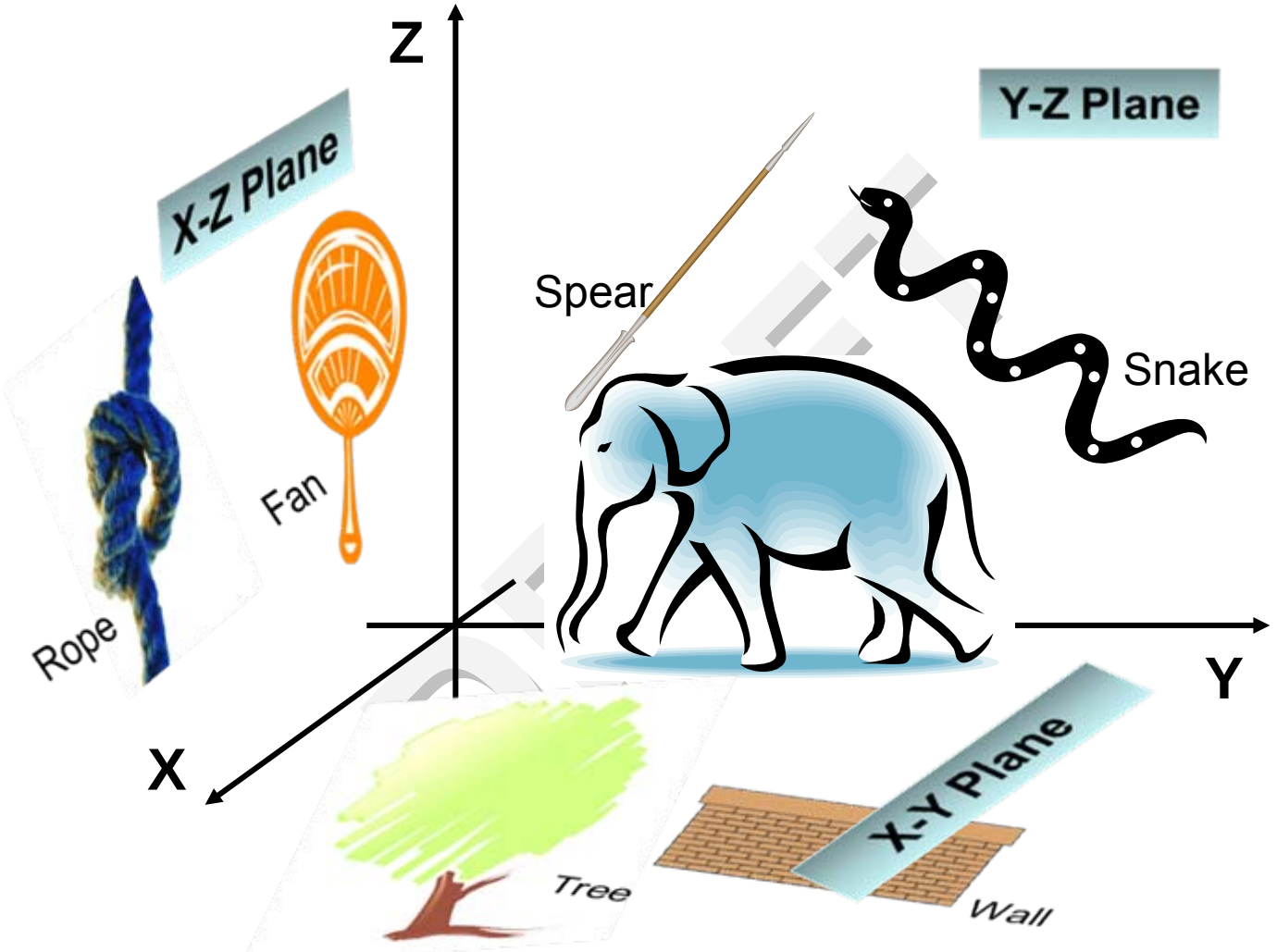
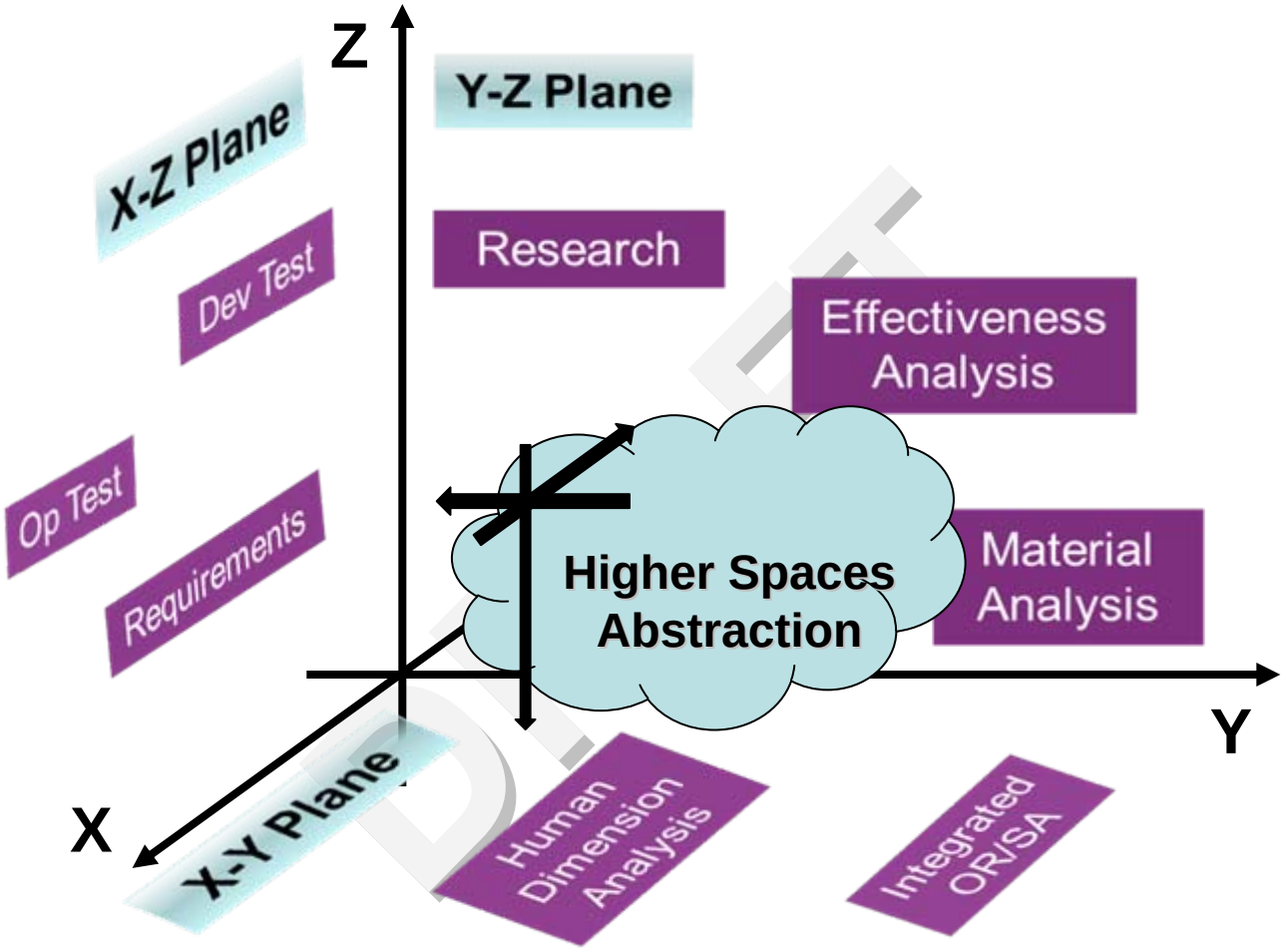
The Blind Men and the Elephant



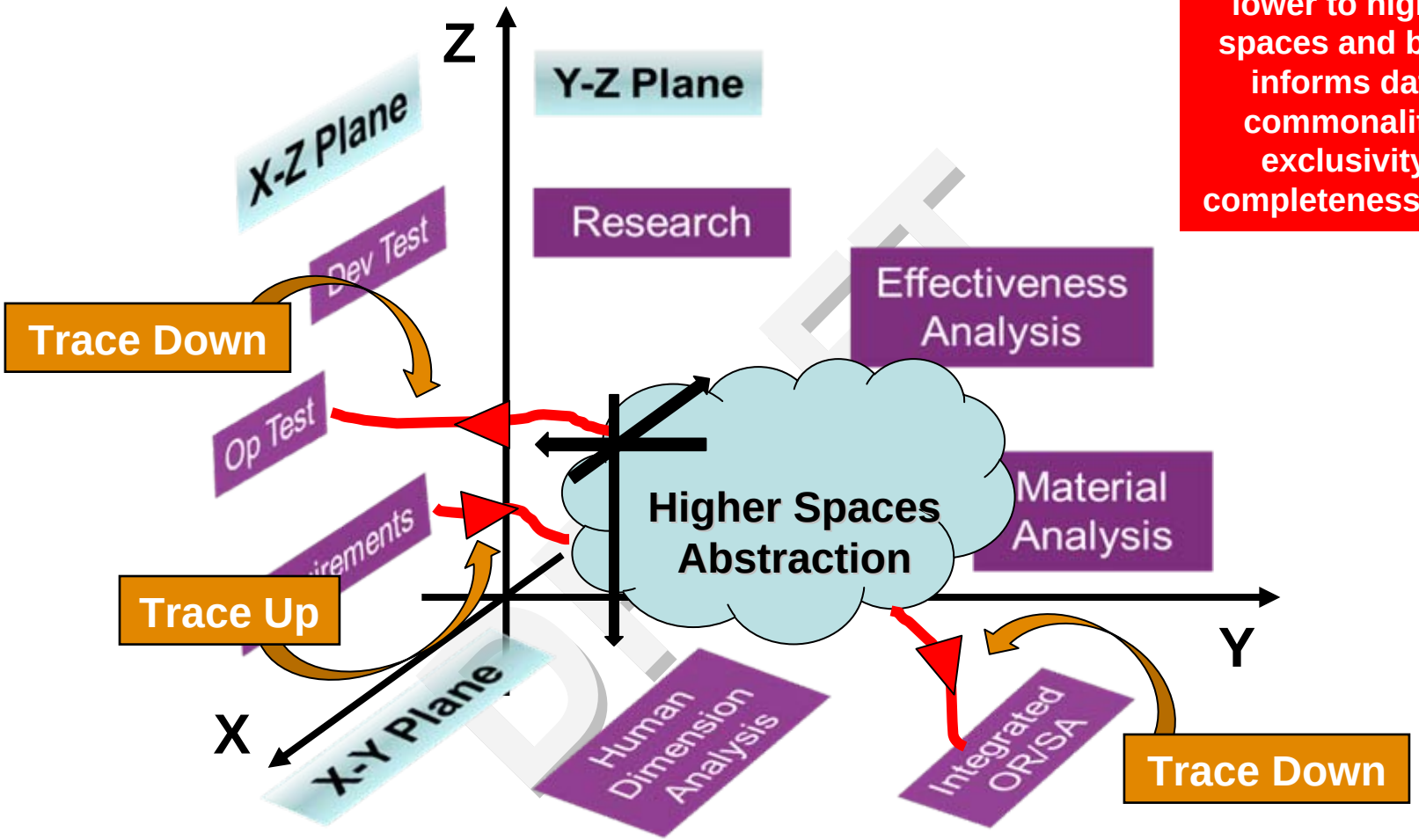
Single Reference Object: Multiple Perceived Projections

The MDMP Structure Frames the Primary, Derivative Spaces



Single Reference Space: Multiple Sub-Spaces, Projections

The MDMP Structure



Backup

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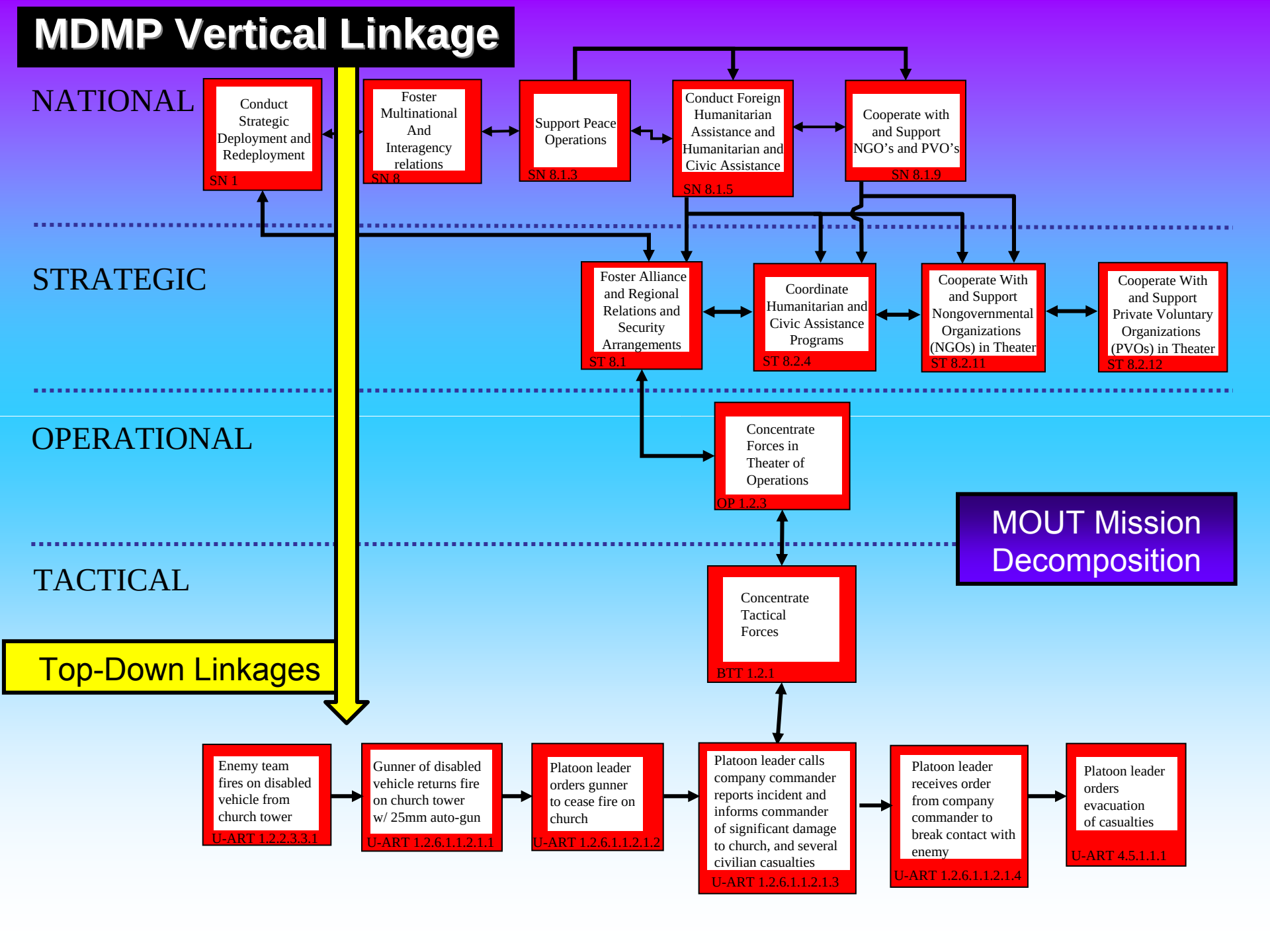
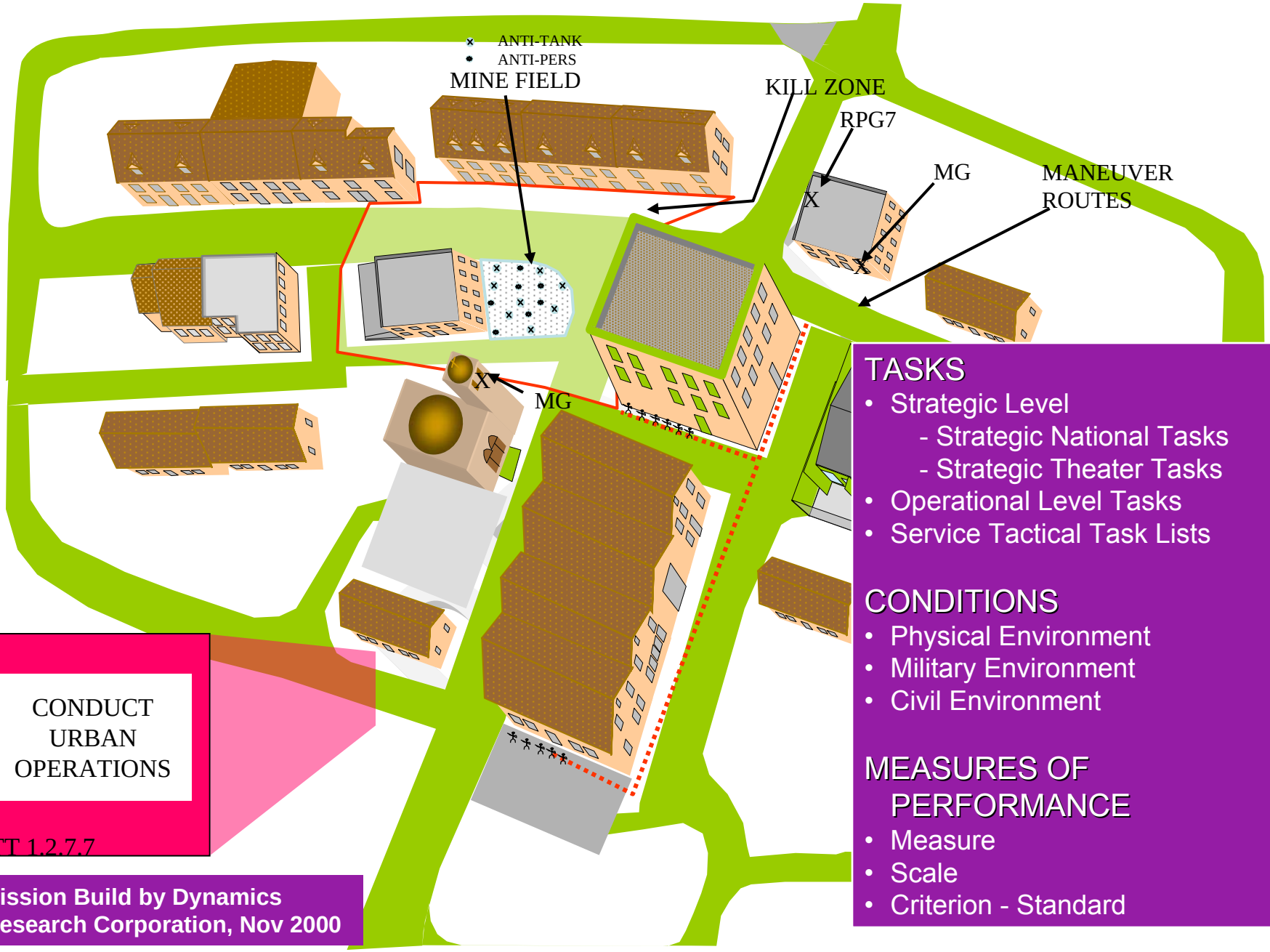
MDMP Vertical Linkage



Structuring a Military Mission‡ using the MDMP



CONDUCT URBAN OPERATIONS

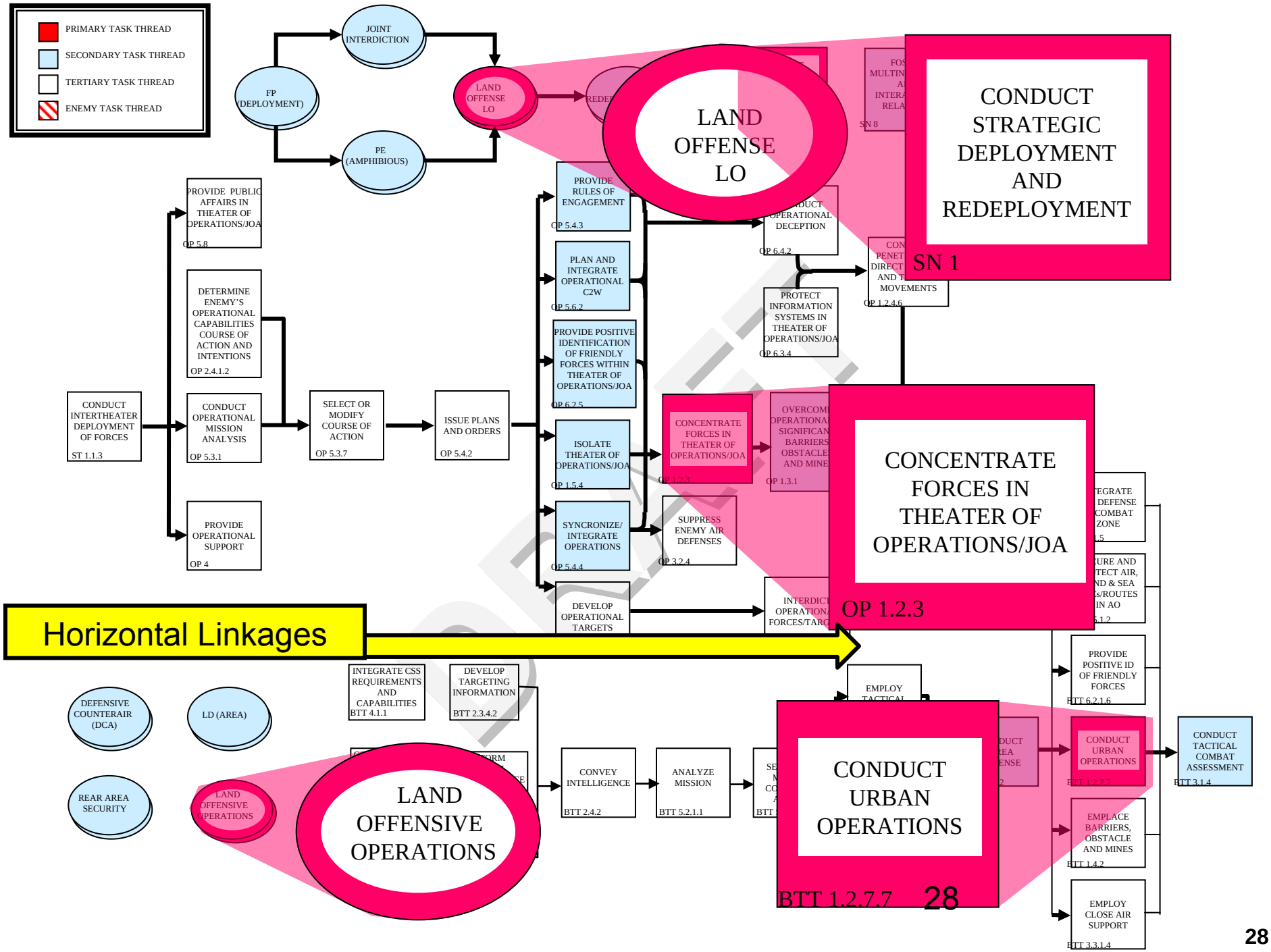
BTT 1.2.7.7

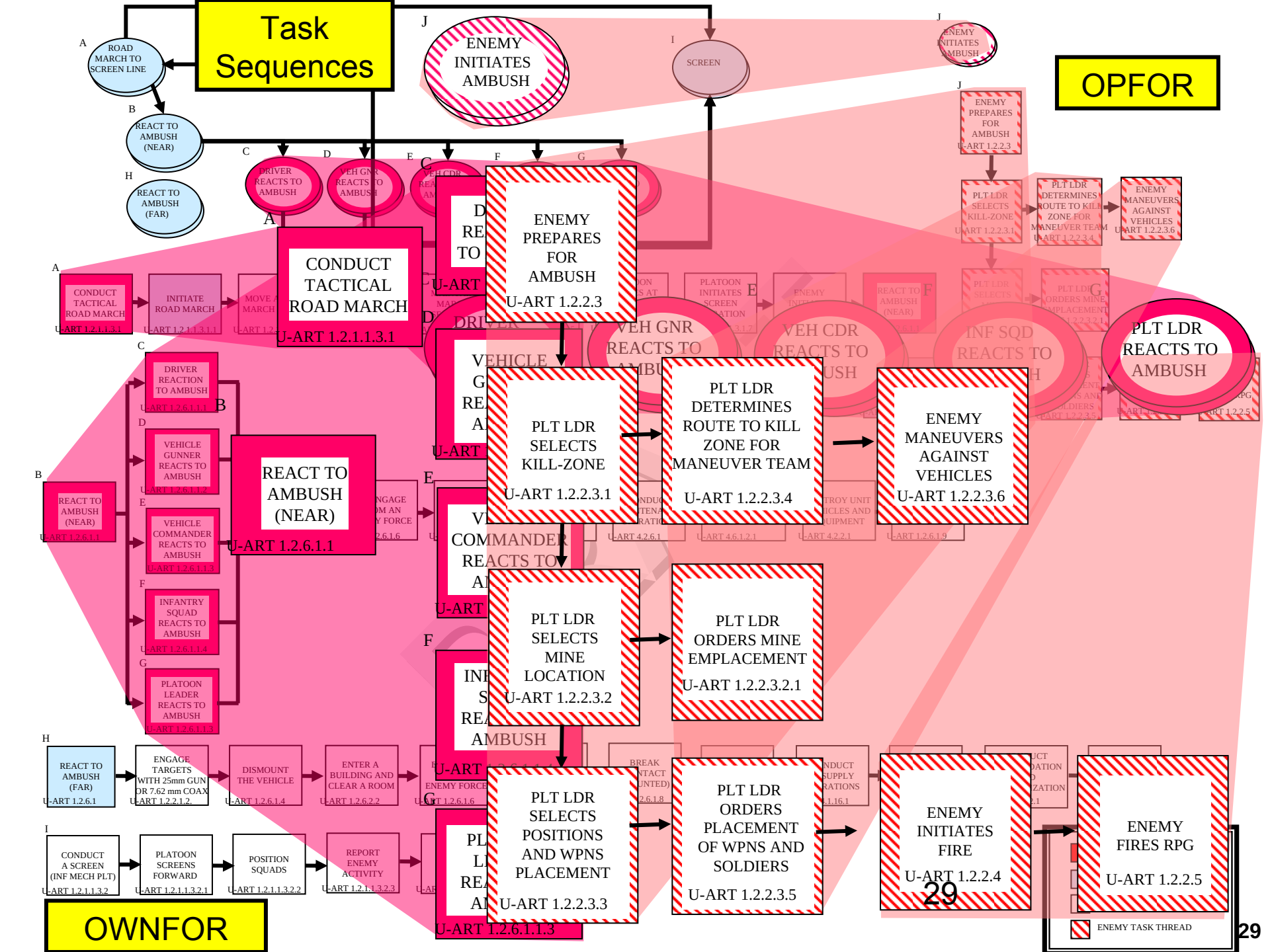
TASKS
- Strategic Level
  - Strategic National Tasks
  - Strategic Theater Tasks
- Operational Level Tasks
- Service Tactical Task Lists

CONDITIONS
- Physical Environment
- Military Environment
- Civil Environment

MEASURES OF PERFORMANCE
- Measure
- Scale
- Criterion - Standard

‡ Mission Build by Dynamics Research Corporation, Nov 2000


PRIMARY TASK THREAD
SECONDARY TASK THREAD
TERTIARY TASK THREAD
ENEMY TASK THREAD
JOINT INTERDICTION
FP (DEPLOYMENT)
PE (AMPHIBIOUS)
LAND OFFENSE LO
LAND OFFENSE LO
CONDUCT STRATEGIC DEPLOYMENT AND REDEPLOYMENT
SN 1
PROVIDE PUBLIC AFFAIRS IN THEATER OF OPERATIONS/JOA
OP 5.8
DETERMINE ENEMY'S OPERATIONAL CAPABILITIES COURSE OF ACTION AND INTENTIONS
OP 2.4.1.2
CONDUCT INTERTHEATER DEPLOYMENT OF FORCES
ST 1.1.3
CONDUCT OPERATIONAL MISSION ANALYSIS
OP 5.3.1
PROVIDE OPERATIONAL SUPPORT
OP 4
SELECT OR MODIFY COURSE OF ACTION
OP 5.3.7
ISSUE PLANS AND ORDERS
OP 5.4.2
PROVIDE RULES OF ENGAGEMENT
OP 5.4.3
PLAN AND INTEGRATE OPERATIONAL C2W
OP 5.6.2
PROVIDE POSITIVE IDENTIFICATION OF FRIENDLY FORCES WITHIN THEATER OF OPERATIONS/JOA
OP 6.2.5
ISOLATE THEATER OF OPERATIONS/JOA
OP 1.5.4
SYNCRONIZE/ INTEGRATE OPERATIONS
OP 5.4.4
DEVELOP OPERATIONAL TARGETS
CONCENTRATE FORCES IN THEATER OF OPERATIONS/JOA
OP 1.2.3
SUPPRESS ENEMY AIR DEFENSES
OP 3.2.4
PROTECT INFORMATION SYSTEMS IN THEATER OF OPERATIONS/JOA
OP 6.3.4
CONCENTRATE FORCES IN THEATER OF OPERATIONS/JOA
OP 1.2.3
Horizontal Linkages
DEFENSIVE COUNTERAIR (DCA)
LD (AREA)
REAR AREA SECURITY
LAND OFFENSIVE OPERATIONS
INTEGRATE CSS REQUIREMENTS AND CAPABILITIES
BTT 4.1.1
DEVELOP TARGETING INFORMATION
BTT 2.3.4.2
CONVEY INTELLIGENCE
BTT 2.4.2
ANALYZE MISSION
BTT 5.2.1.1
LAND OFFENSIVE OPERATIONS
CONDUCT URBAN OPERATIONS
BTT 1.2.7.7
28
PROVIDE POSITIVE ID OF FRIENDLY FORCES
BTT 6.2.1.6
CONDUCT URBAN OPERATIONS
BTT 1.2.7.7
EMPLACE BARRIERS, OBSTACLE AND MINES
BTT 1.4.2
EMPLOY CLOSE AIR SUPPORT
BTT 3.3.1.4
CONDUCT TACTICAL COMBAT ASSESSMENT
BTT 3.1.4


Task Sequences
OPFOR
OWNFOR
ROAD MARCH TO SCREEN LINE
REACT TO AMBUSH (NEAR)
REACT TO AMBUSH (FAR)
ENEMY INITIATES AMBUSH
SCREEN
DRIVER REACTS TO AMBUSH
VEH GNR REACTS TO AMBUSH
ENEMY PREPARES FOR AMBUSH
U-ART 1.2.2.3
CONDUCT TACTICAL ROAD MARCH
U-ART 1.2.1.1.3.1
PLT LDR SELECTS KILL-ZONE
U-ART 1.2.2.3.1
PLT LDR DETERMINES ROUTE TO KILL ZONE FOR MANEUVER TEAM
U-ART 1.2.2.3.4
ENEMY MANEUVERS AGAINST VEHICLES
U-ART 1.2.2.3.6
VEH CDR REACTS TO AMBUSH
INF SQD REACTS TO AMBUSH
PLT LDR REACTS TO AMBUSH
U-ART 1.2.2.5
INITIATE ROAD MARCH
U-ART 1.2.1.1.3.1.1
DRIVER REACTION TO AMBUSH
U-ART 1.2.6.1.1.1
VEHICLE GUNNER REACTS TO AMBUSH
U-ART 1.2.6.1.1.2
VEHICLE COMMANDER REACTS TO AMBUSH
U-ART 1.2.6.1.1.3
INFANTRY SQUAD REACTS TO AMBUSH
U-ART 1.2.6.1.1.4
PLATOON LEADER REACTS TO AMBUSH
U-ART 1.2.6.1.1.3
REACT TO AMBUSH (NEAR)
U-ART 1.2.6.1.1
REACT TO AMBUSH (NEAR)
U-ART 1.2.6.1.1
PLT LDR SELECTS MINE LOCATION
U-ART 1.2.2.3.2
PLT LDR ORDERS MINE EMPLACEMENT
U-ART 1.2.2.3.2.1
REACT TO AMBUSH (FAR)
U-ART 1.2.6.1
ENGAGE TARGETS WITH 25mm GUN OR 7.62 mm COAX
U-ART 1.2.2.1.2.
DISMOUNT THE VEHICLE
U-ART 1.2.6.1.4
ENTER A BUILDING AND CLEAR A ROOM
U-ART 1.2.6.2.2
CONDUCT A SCREEN (INF MECH PLT)
U-ART 1.2.1.1.3.2
PLATOON SCREENS FORWARD
U-ART 1.2.1.1.3.2.1
POSITION SQUADS
U-ART 1.2.1.1.3.2.2
REPORT ENEMY ACTIVITY
U-ART 1.2.1.1.3.2.3
PLT LDR SELECTS POSITIONS AND WPNS PLACEMENT
U-ART 1.2.2.3.3
PLT LDR ORDERS PLACEMENT OF WPNS AND SOLDIERS
U-ART 1.2.2.3.5
ENEMY INITIATES FIRE
U-ART 1.2.2.4
ENEMY FIRES RPG
U-ART 1.2.2.5
U-ART 1.2.6.1.1.3
ENEMY TASK THREAD
29

Example: Time-Ordered Event List

SEQ #	TIME	ACTIVITY
	0200-0400	**PHASE I**
P101		MCS A in AP Muldraugh and preparing for movement to OBJ APPLE
P102		C2V establishes ACA MAPLE, min alt 500 ft AGL, max alt 1000 ft AGL, ES860930, ET850050, ET880050, ES890940, eff 0200-0600
P103		C2V disseminates ACA MAPLE coordinates to CAB
P104		C2V launches UAV 1 from AP Muldraugh vic ES864943
P105		UAV 1 travels from AP Muldraugh (ES 864943) to perform route reconnaissance. Route ACPs: ES865945 (SP) to ET 883011 to ES866957 to ET875045 (OBJ APPLE)
P106		C2V monitors incoming data from UAV 1 visual and sensor feeds as it travels north along AXIS MAPLE
P107		MCS A plts conduct perimeter security in AP Muldraugh with their respective ARV-Rs
P108		MCS A plts perform precombat checks in preparation for movement north to OBJ APPLE
P109		UAV 1 remains on OBJ APPLE and conducts reconnaissance of TAI's 1 and 2. UAV 1 Route ACPs: ET876050, ET856040, ET880005, ET876050. UAV performs continuous loop on OBJ APPLE
P110		C2V monitors incoming data from UAV 1 visual and sensors feeds as it conducts reconnaissance of OBJ APPLE
P111	**Interaction 1**	*UAV 1 detects suspected enemy activity vic TAI 2 with IR sensor*
P112		UAV 1 sends sensor report to C2V
P113		C2V receives IR sensor report of enemy activity vic TAI 2
P114		C2V updates the COP and informs MCS A Cdr
P115		Updated COP disseminated to higher and lower echelons
P116		C2V continues to monitor UAV 1 sensor feeds
P117		C2V tasks UAV 1 to stare at suspected enemy activity position to achieve better fidelity for target identification
P118		UAV 1 IFF sensor does not confirm friendly force
P119	**Interaction 2**	*UAV 1 detects elements of a suspected enemy INF squad vic ET 877036*
P120		UAV 1 transmits information to C2V
P121		C2V receives UAV 1 information and cannot confirm or deny enemy forces and continues to monitor activity
P122		UAV 1 maintains surveillance of TAI's 1 and 2 and OBJ APPLE
P123		MCS plts begin to assemble in order of march formation and prepare for tactical movement
P124		NLOS-C/M receives updated COP and plans targeting data for TAI 2.
P125		C2V and MCS A Hq prepares for movement toward OBJ APPLE
P126		MCS A plts task ARV-R 2 & 3 to move north along AXIS MAPLE with a limit of advance of 3km from plt main body and conduct reconnaissance. ARV-R 2 will travel route ES871948 (SP), ES873966, ES876987, ET875008, ET878018 ARV-R 3 will travel route ES862951 (

Need something readable here!

Task Sequences

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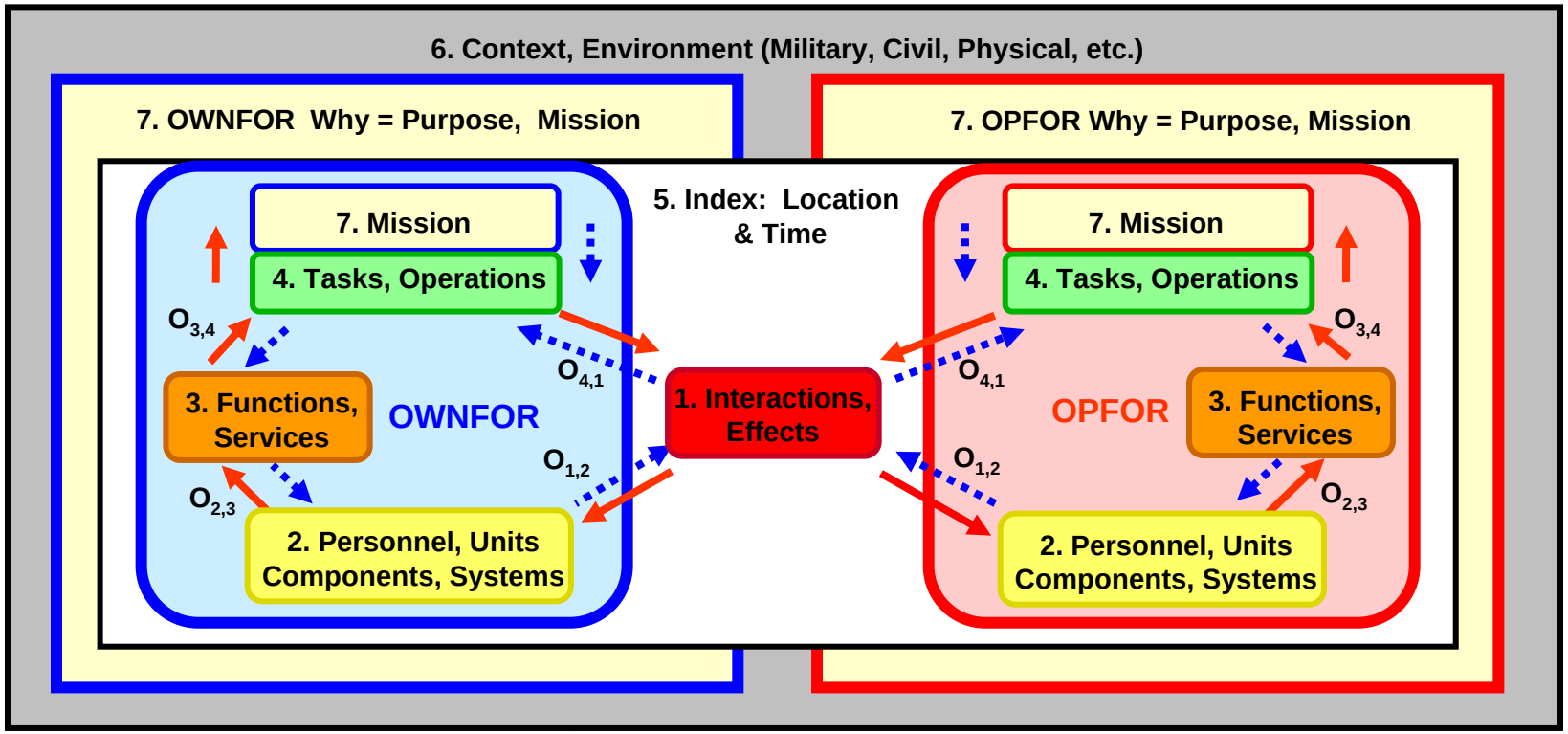
MMF Iconic Representation

11 Fundamental Elements: 7 Levels, 4 Operators



Planning

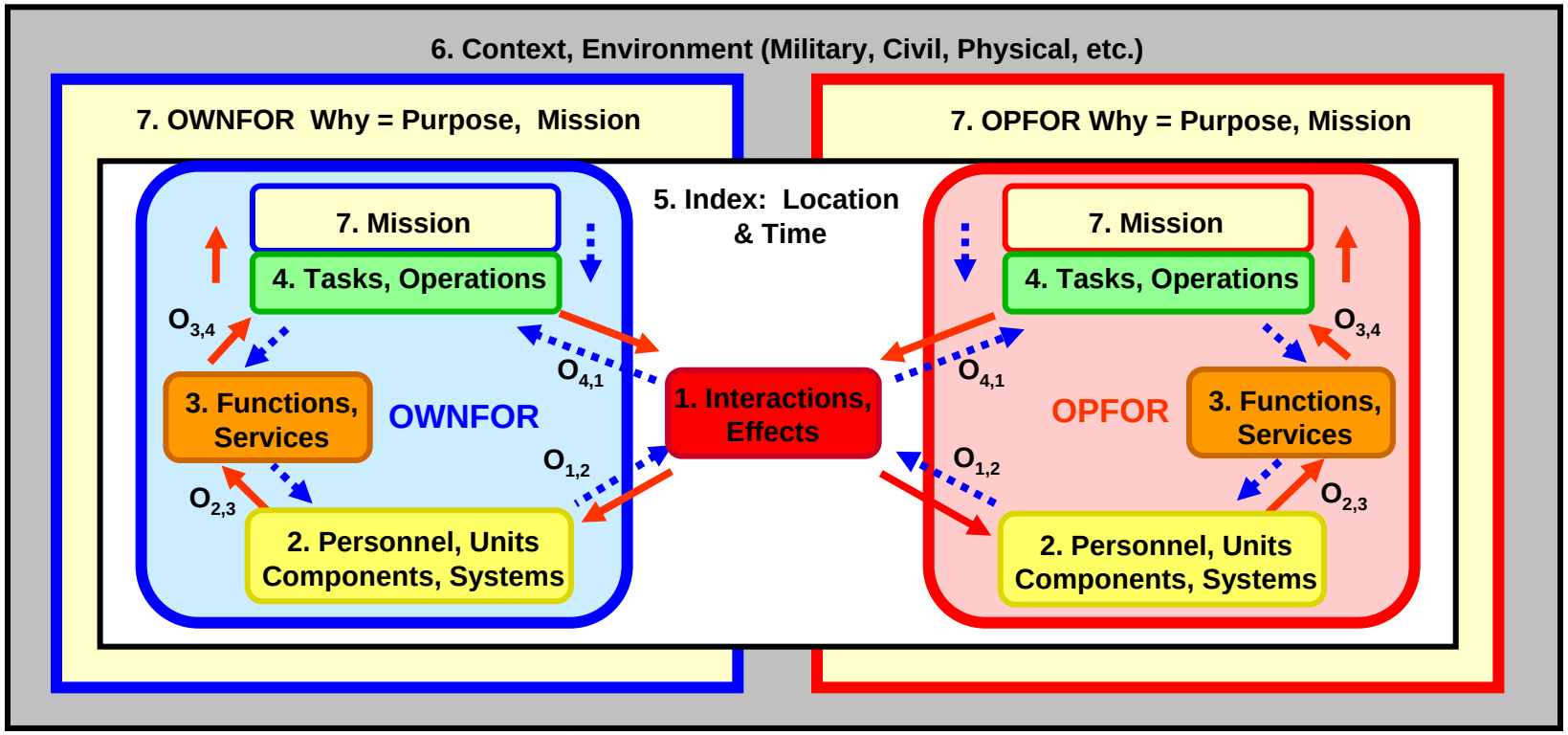
Employment

Parts, Taxonomies

Packages, Networks

JCIDS via MMF Representation [1/3]

11 Fundamental Elements: 7 Levels, 4 Operators



Planning

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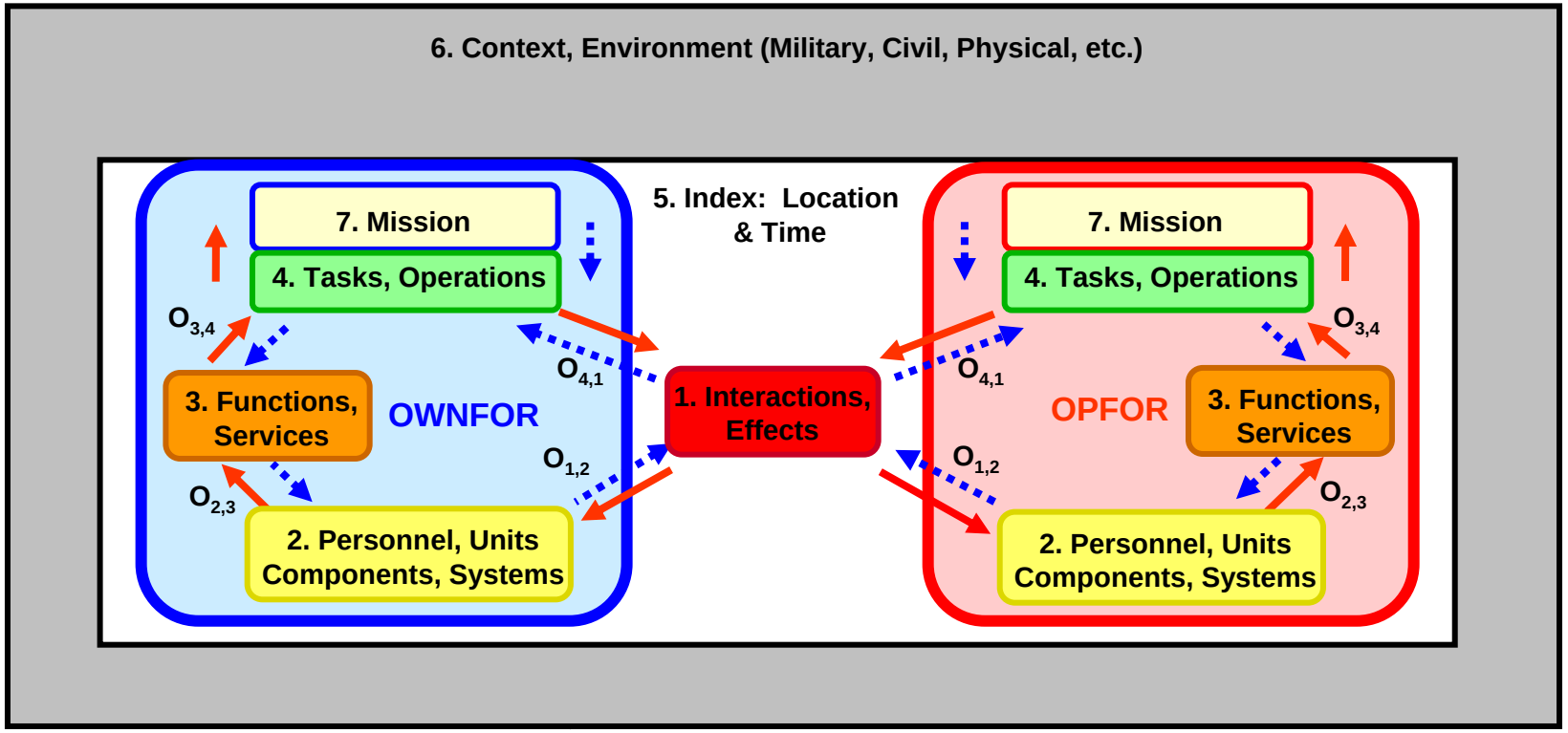
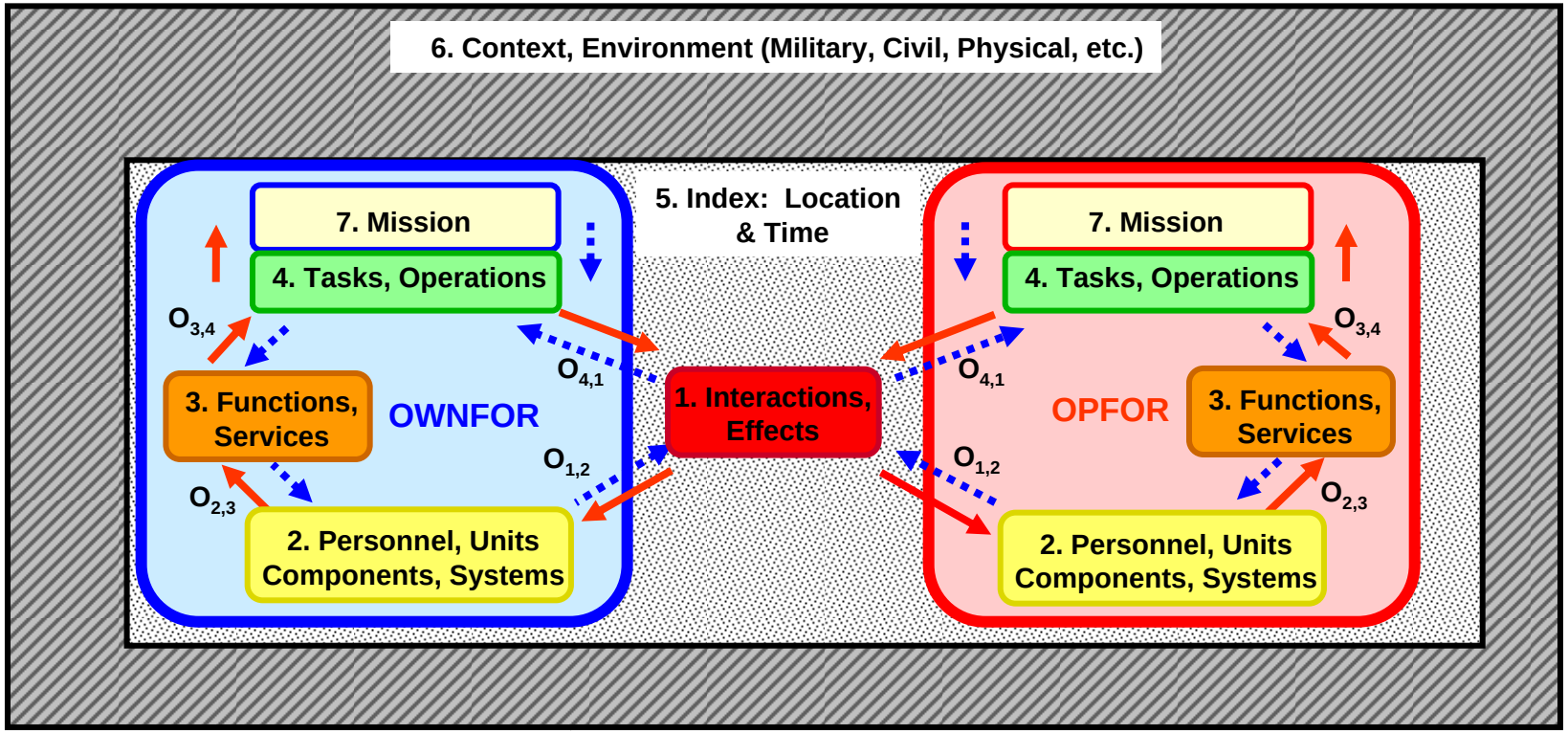
JCIDS via MMF Representation [2/3]



JCIDS via MMF Representation [3/3]



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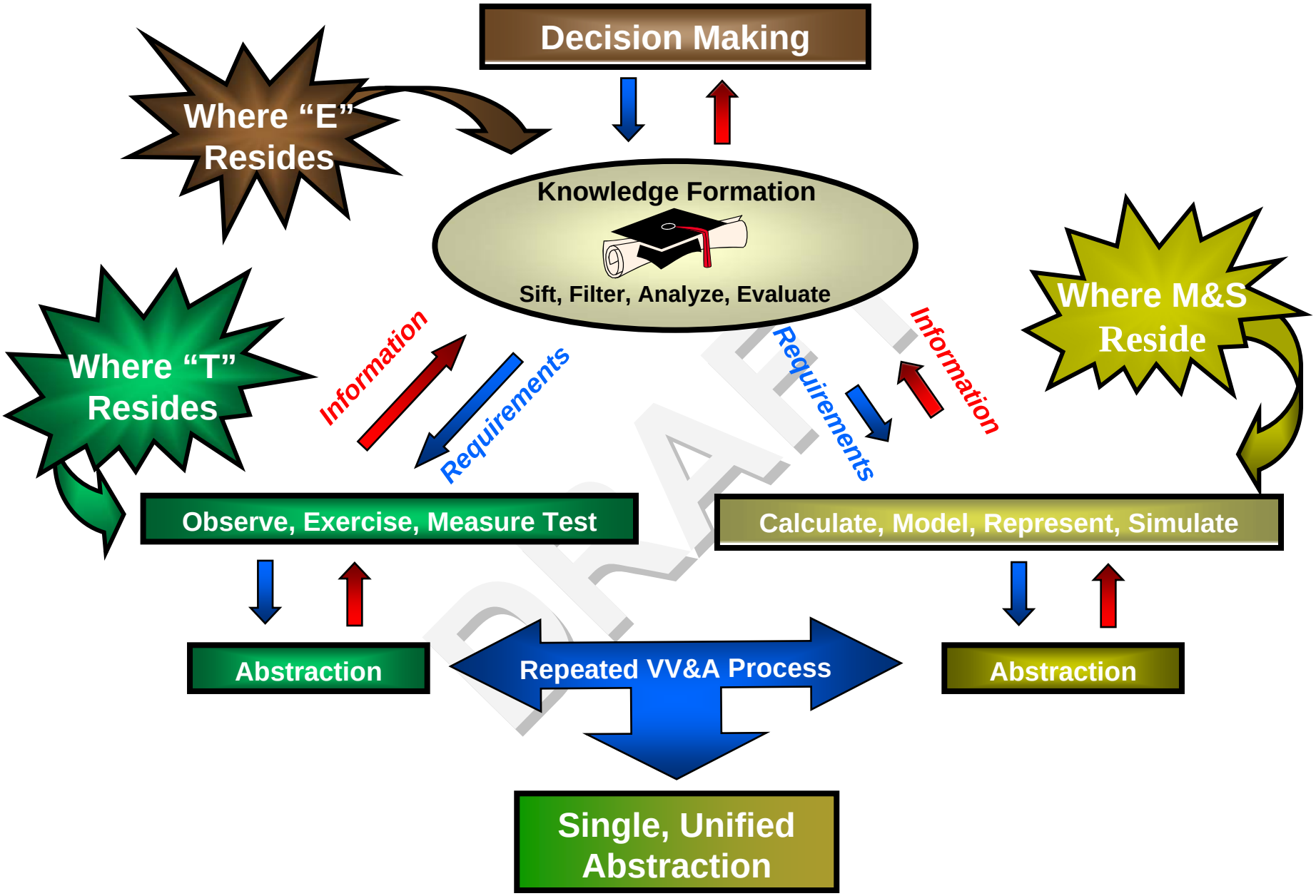
Subsets of Corresponding MMF Data


Decision Making
Where "E" Resides
Knowledge Formation
Sift, Filter, Analyze, Evaluate
Where "T" Resides
Information
Requirements
Requirements
Information
Where M&S Reside
Observe, Exercise, Measure Test
Calculate, Model, Represent, Simulate
Abstraction
Repeated VV&A Process
Abstraction
Single, Unified Abstraction
DRAFT

Outline [1/2]

- In this symposium, the focus has been directed to requirements and how other disciplines such as T&E and M&S can improve the acquisition process.

- A myriad of analytic fields have developed largely independently in what might be characterized as a bottom-up evolution. To wit:
  - An array of analytic areas characterized by collections of metrics in which sharing or exclusion across areas is not known.
  - Where state changes to systems or components of systems (i.e., due to invoked damage or repair) are conflated with system performance and further conflated with system effectiveness.
  - Where mission context is absent, making effectiveness estimates ambiguous at best.

- Clearly, the many elements which comprise this problem set must be cast into a single framework capable of supporting the full dimensionality not only of requirements, but research, DT/OT activities, materiel, human dimension, and effectiveness analyses.

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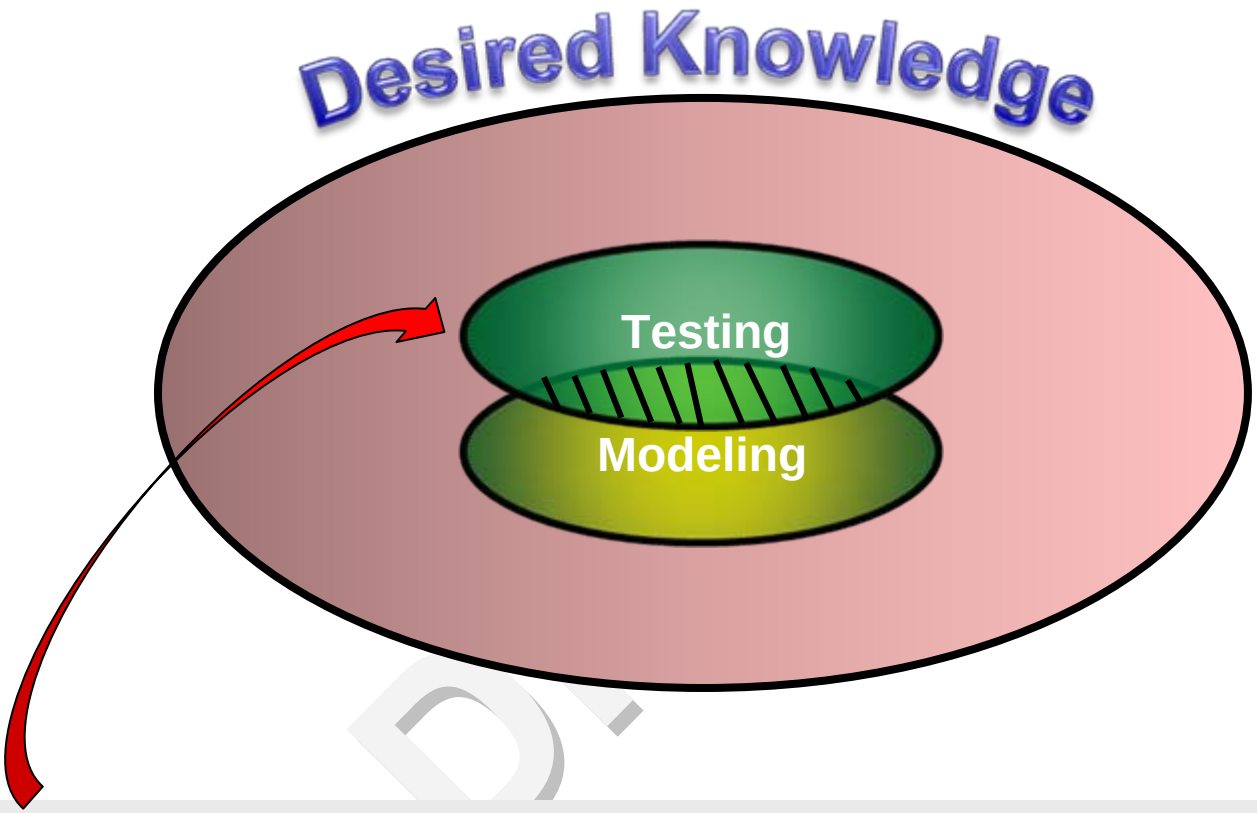
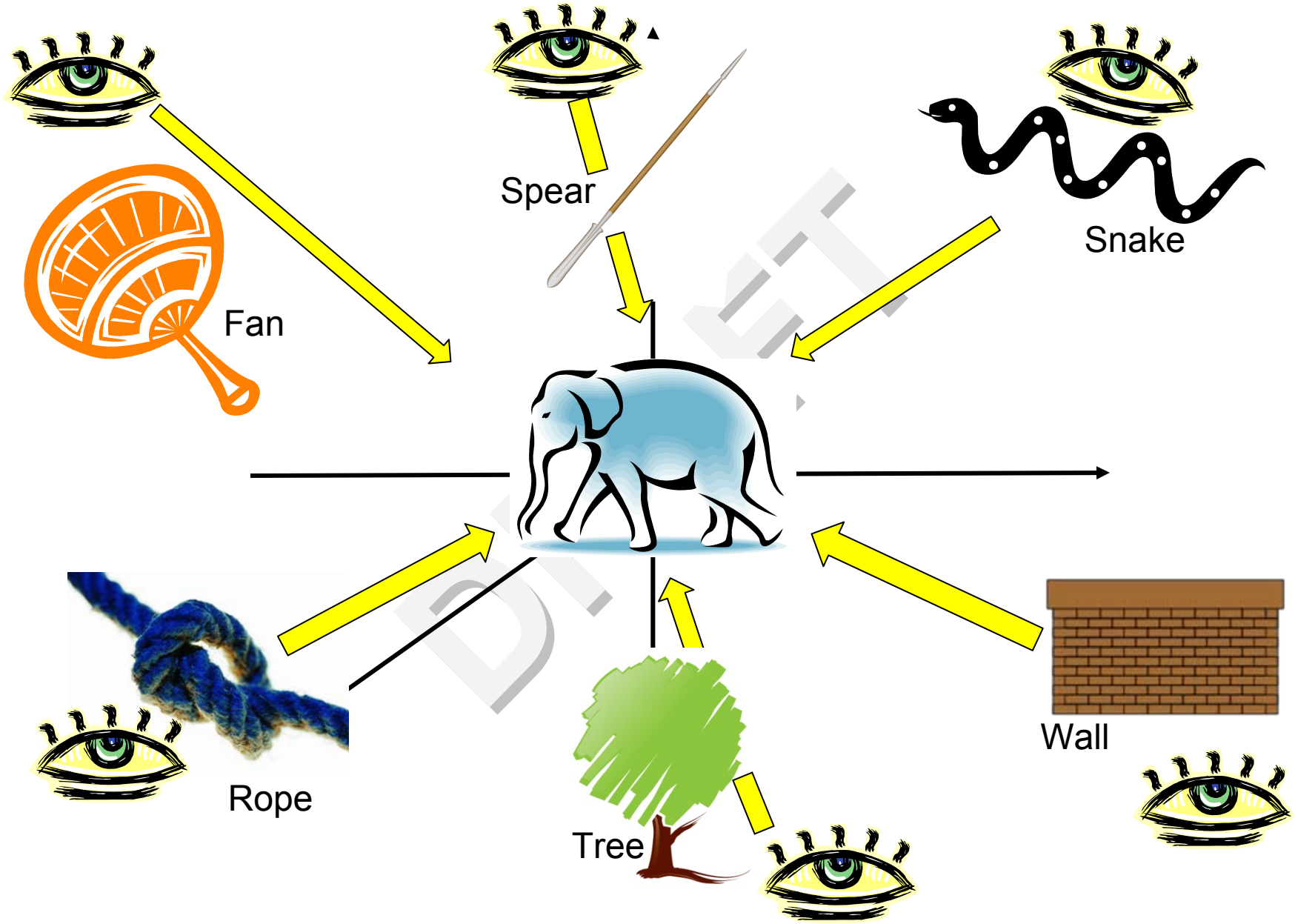
Knowledge



Note:

- **The logical intersection is a small subset of the logical union**
- **The intersection is the only domain in which Validation can take place!**

The Blind Men and the Elephant



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Outline [1/2]

- In this symposium, the focus has been directed to requirements and how other disciplines such as T&E and M&S can improve the acquisition process.

- A myriad of analytic fields have developed largely independently in what might be characterized as a bottom-up evolution. To wit:
  - An array of analytic areas characterized by collections of metrics in which sharing or exclusion across areas is not known.
  - Where state changes to systems or components of systems (i.e., due to invoked damage or repair) are conflated with system performance and further conflated with system effectiveness.
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Outline [1/2]

- How can the T&E Community support the Requirements Process?
- What constitute valid, measureable (i.e. testable), realistic and achievable requirements?
- How can multiple disciplines be used in combination to effect acquisition-related decisions?
- Clearly, the many elements which comprise this problem set must be cast into a single framework capable of supporting the full dimensionality not only of requirements, but research, DT/OT activities, materiel, human dimension, and effectiveness analyses.

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Outline [2/2]

- A single paradigm is capable of supporting all of these seemingly disparate focus areas; it is called the Military Decision Making Process (MDMP) and has been a part of the warfighters lexicon and practice for years

- Over the past 14 years, considerable efforts have been expended to:
  - developing a formal structure for MDMP in order to reduce/eliminate ambiguity in representation
  - establish top-down linkages (per level of war),
  - establish horizontal linkages (e.g., System-of-Systems),
  - establish an executable framework (so that this can be automated), and
  - represent an OPFOR in addition to an OWNFOR so that multiple sides can be played against each other

- We call this the Missions and Means Framework (MMF)
- MMF (read the MDMP) has applicability to a wide range of defense-related analyses
- MMF (read the MDMP) relates material/people to performance to effectiveness to event initiation, to interactions with material/people, to . . .

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Top-down vice bottom-up strategies

Clearly, the many elements which comprise this problem set must be cast into a single framework capable of supporting the full dimensionality not only of requirements, but research, DT/OT activities, materiel, human dimension, and effectiveness analyses.

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Advanced Concepts and Requirements (ACR), Research, Development & Acquisition (RDA), and Training Exercises and Military Operations (TEMO) represent three domains which do not map fully to a superset representation

The MDMP as the Center Piece of Analysis [1/2]

Purpose: Provide a methodology for explicitly specifying the military mission and quantitatively evaluating the mission utility of alternative warfighting DOTMLPF services and products.

Objective: Provide a disciplined procedure to explicitly specify the mission, allocate means, and assess mission accomplishment by:

- Unifying the warfighter, engineer, and comptroller understanding of missions and means
- Accounting for traditional testing and evaluation factors and traditional warfighter expertise factors that constitute mission success.
- Being sufficiently credible, timely, and affordable to make hard decisions that stay made.
- Being consistent, concise, repeatable, and scalable.
- Providing a disciplined process to implement the Defense Secretary's transformation guidance and associated acquisition reform.

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Formalizing the MDMP Structure

- Over the past 14 years, considerable efforts have been expended to:
  - establish top-down linkages (per level of war),
  - establish horizontal linkages (e.g., System-of-Systems),
  - represent an OPFOR in addition to an OWNFOR so that multiple sides can be played against each other
  - reduce/eliminate ambiguity in representation by developing a formal structure for MDMP (including executable tasks and executing people/material) in order to
  - establish an executable framework (so that this can be automated)

- We call this the Missions and Means Framework (MMF)
- MMF (read the MDMP) has applicability to a wide range of defense-related analyses
- MMF (read the MDMP) relates material/people to performance to effectiveness to event initiation, to interactions with material/people, to . .

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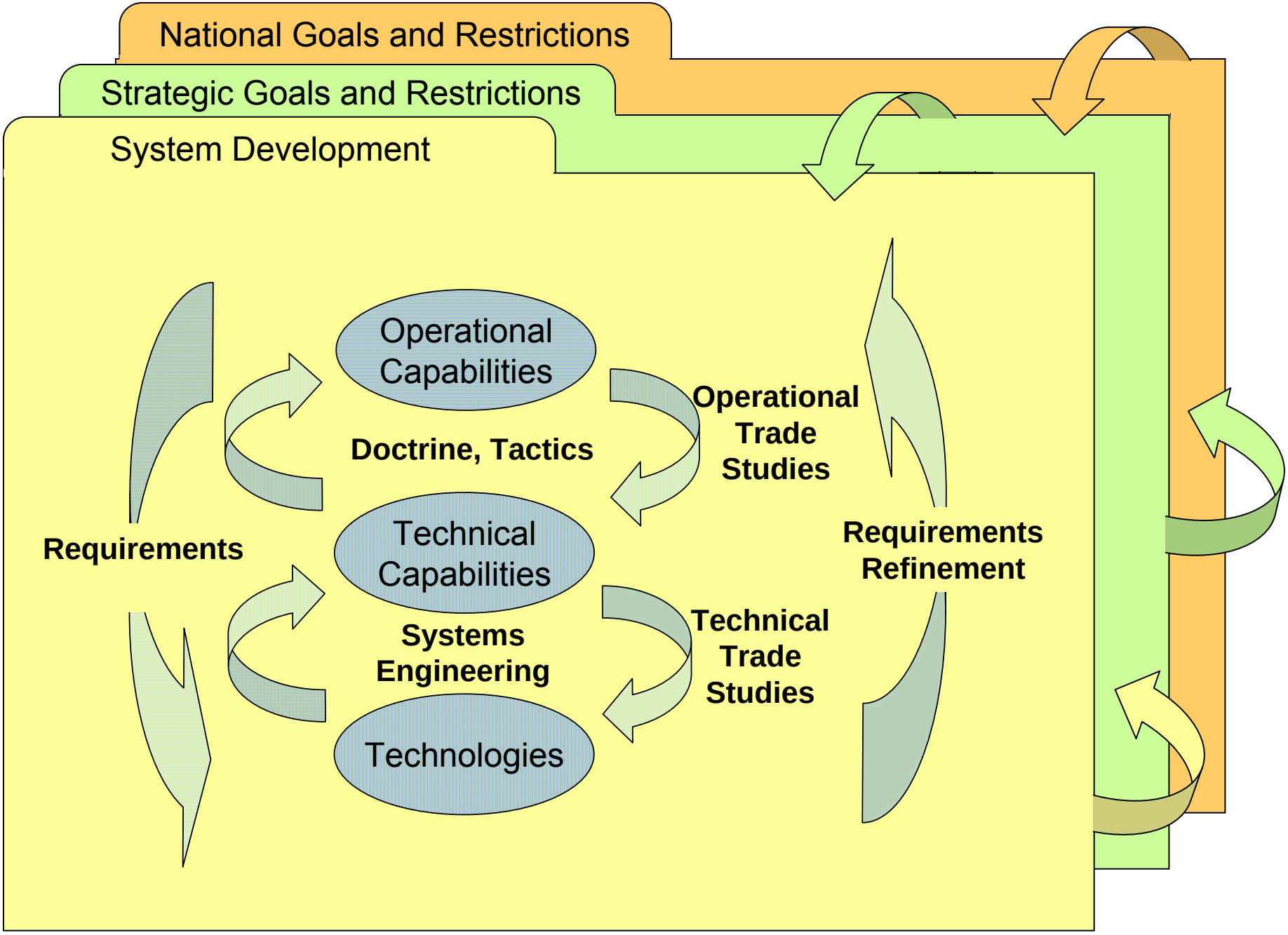
National Goals and Restrictions
Strategic Goals and Restrictions
System Development
Operational Capabilities
Doctrine, Tactics
Technical Capabilities
Systems Engineering
Technologies
Requirements
Operational Trade Studies
Technical Trade Studies
Requirements Refinement