Approved for public release; distribution unlimited

An Integrating Framework for Interdisciplinary Military Analyses

NDIA ICOTE
BOEING COMPANY OFFICE
ARLINGTON, VA 22202
19 June, 2012

TECHNOLOGY DRIVEN. ***WARFIGHTER FOCUSED.***

Paul H. Deitz, Ph.D.
US AMSAA
APG, MD 21005-5071
paul.h.deitz.civ@mail.mil
410-278-2786 DSN: 298-2786

James N. Walbert, Ph.D.
SURVICE Engineering Company
jim.walbert@survice.com
703-221-7370

LTC(R) Britt E. Bray
Dynamics Research Corporation
BBray@drc.com
785-550-5573

Version Date: 17 June 2012

Problem Statement

- In the main, acquisition programs are pursued without detailed explanation of the value added in operational context, relative to higher and lower level missions, using a standard language.
- Effectiveness analyses (e.g., requirements, wargames, test, evaluation activities) are therefore not documented in a way that clearly relates system requirements to operational necessity using approved doctrinal terms.
- Absent formal mission descriptions:
  - Material and soldier performance metrics are evaluated with incomplete knowledge of risk vs. reward trade-offs
  - Acquisition activities proceed without standard, shareable performance and effectiveness metrics
  - Specific analytic and test activities are prosecuted in isolation without the ability to integrate them holistically.
  - System-of-System analyses proceed in the absence of requisite operational “team” context obtainable only from formal operational specification.

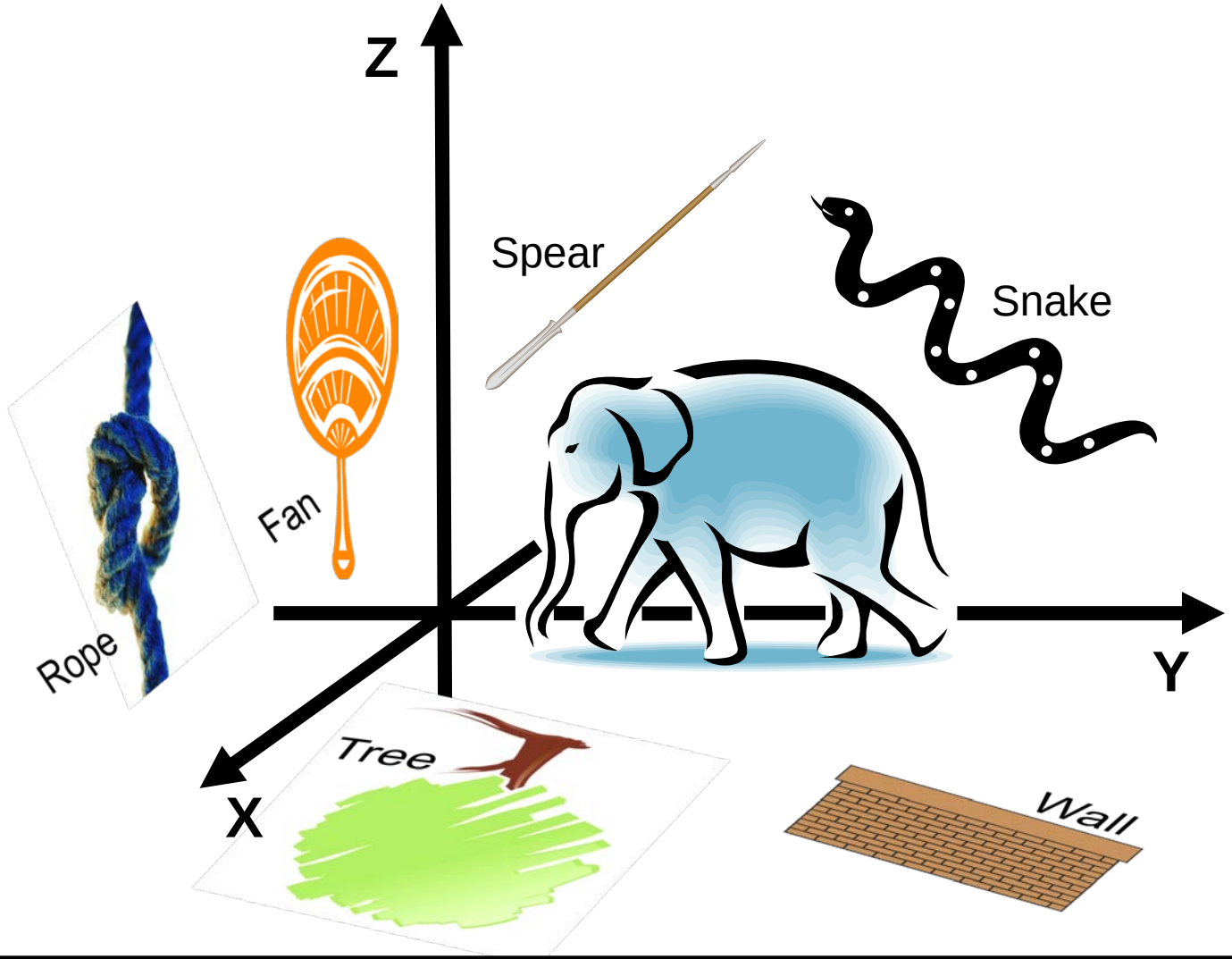
Towards a Solution

- This requires Defense-wide framework, language, and processes common to and shared by all participants
- Establish the pieces and how they fit together
- Resolve semantics and syntax issues
- Since it's about mission success, better start with the mission
- Objective elements [facts!] are inherently quantifiable
- Subjective elements [expert opinion!] must nevertheless be framed quantitatively

Everyone is entitled to his own opinions, but not his own facts!

The Blind Men & the Elephant

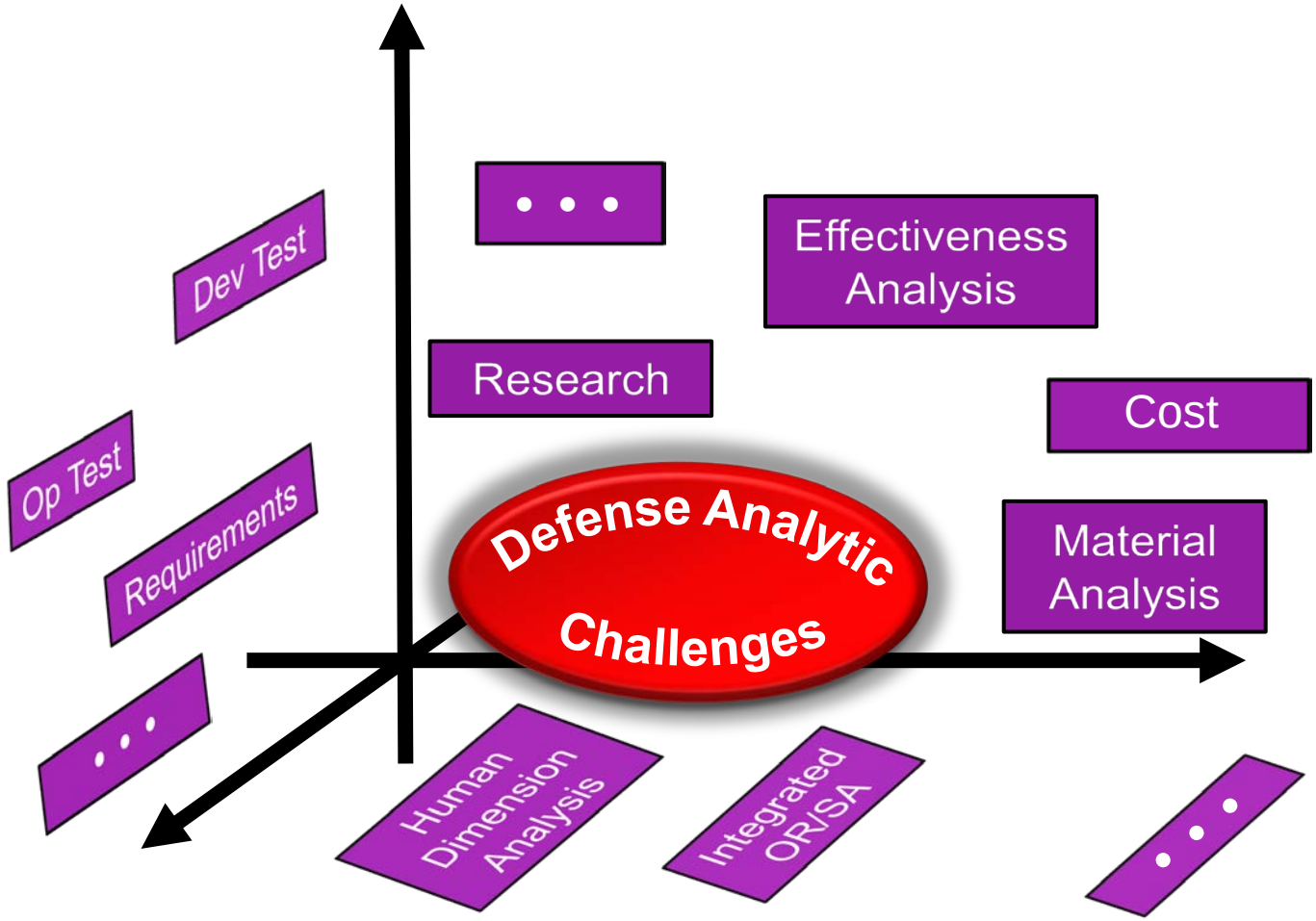
— The “bottom-up” conundrum —



Single Object: Multiple Perceived Projections

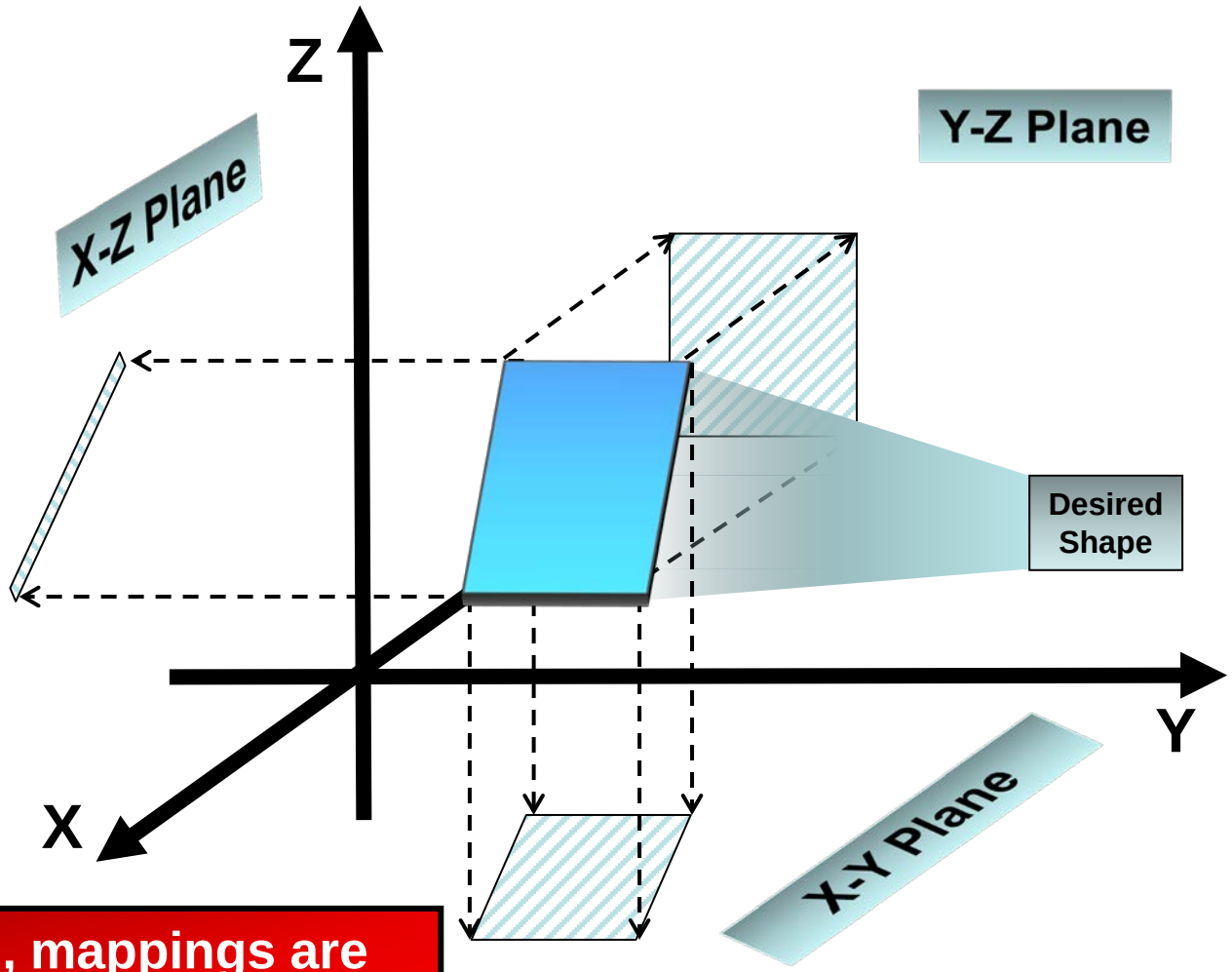
Today's World: Multiple Defense Analytics

— Metrics still developed in an *ad hoc*, "bottom-up" fashion —



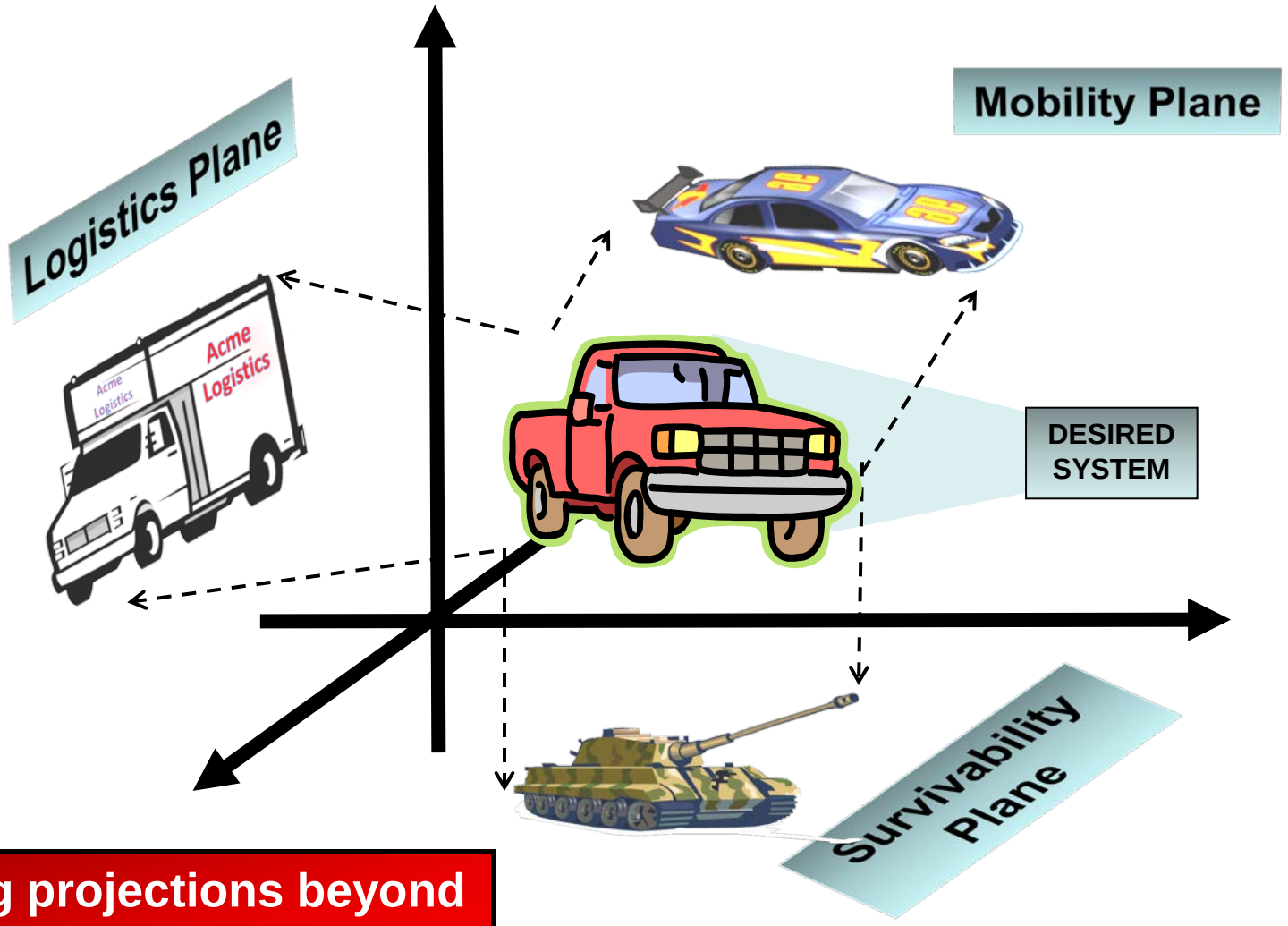
No Single Reference Object, *ad hoc* Connections

Three Mappings from 3-D to 2-D Spaces



In general, mappings are only defined from higher to lower spaces!

Materiel in n Space



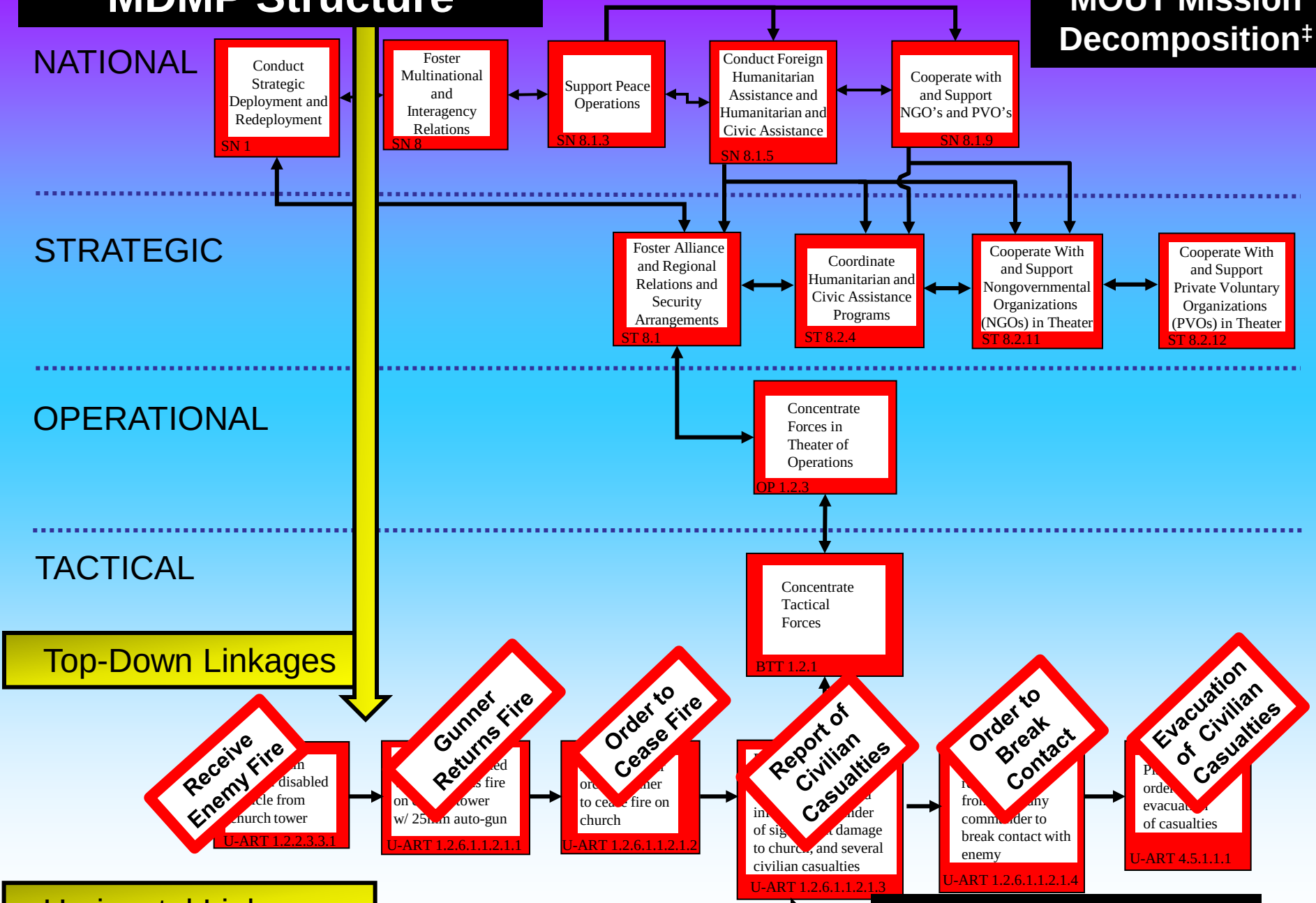
Taking projections beyond 3-D geometry to abstract spaces!

How are missions prosecuted?

- How do the professionals do it?
- For many years, warfighters have used the Military Decision-Making Process [MDMP] as the underlying structure for planning, structuring, organizing, and executing all manner of missions (whether “kinetic” or not).

MDMP Structure

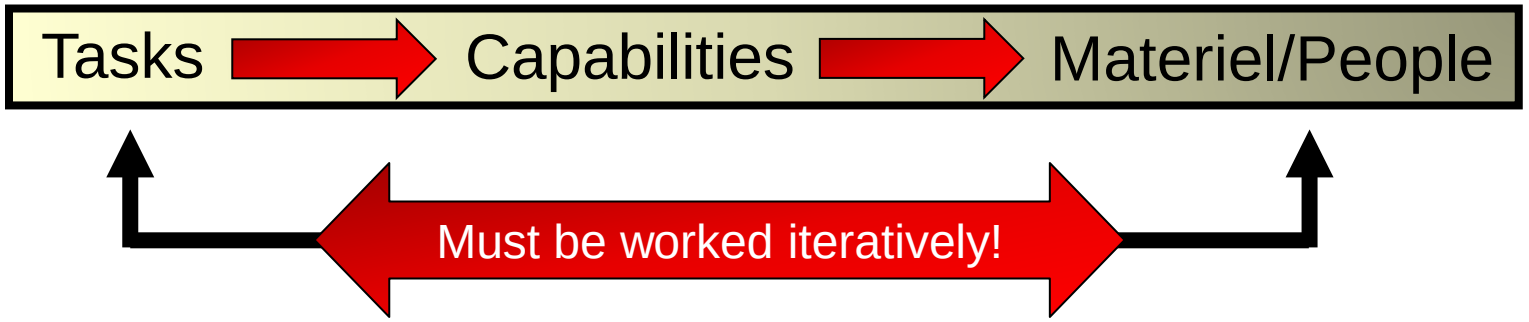
MOUT Mission Decomposition‡



‡ Mission build by Dynamics Research Corporation, Nov 2000

The Military Decision-Making Process [MDMP]

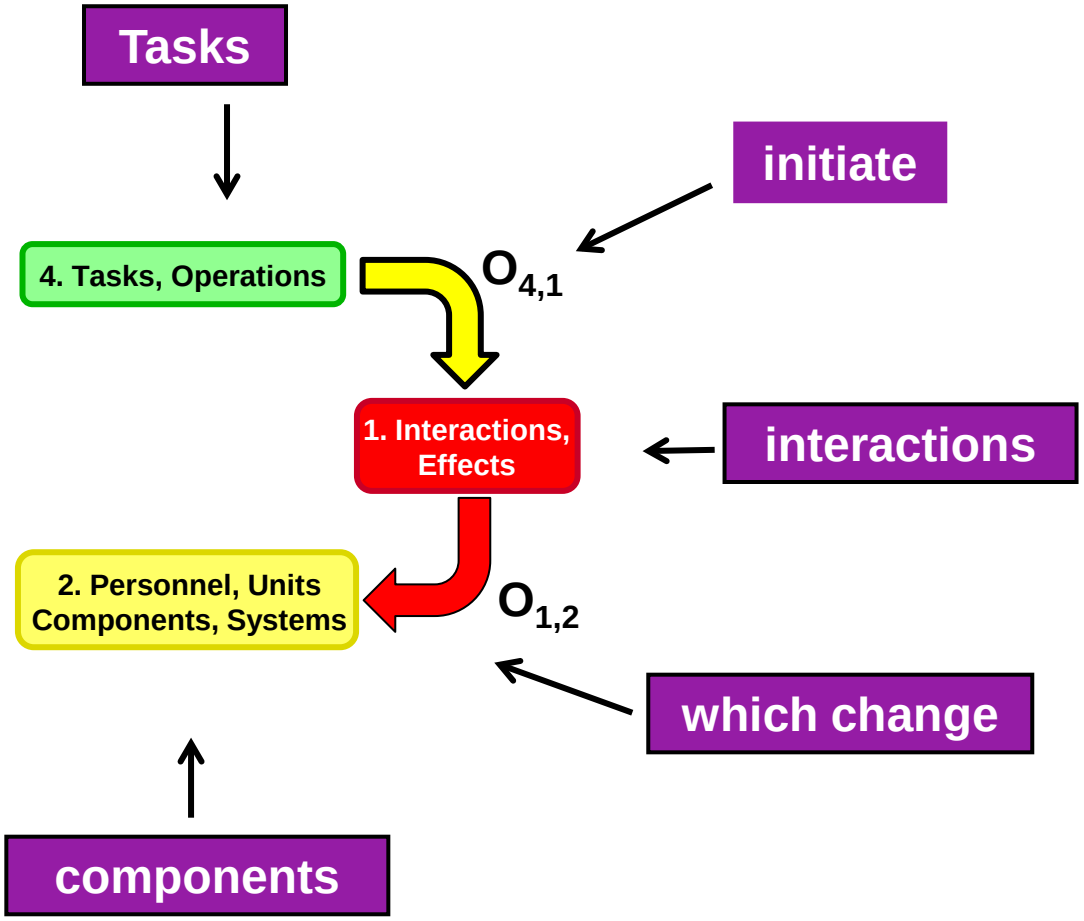
- The MDMP is all about mission planning and task execution, monitoring results and assessment of progress against mission objectives. Tasks are ubiquitous!
- When informed by key *reference missions*, the MDMP should serve as the single integrating framework for the community.
- Materiel Requirements should derive from successful task execution, under appropriate conditions and standards.



The MDMP & MMF

- Since the LF programs of the 1980s, Army V/L modelers have searched for supporting frameworks/data structures
- An early structure, the “V/L Taxonomy”, was developed in 1985
- The “Missions & Means Framework” [MMF] followed in 2002
  - The MMF is an attempt to formalize the MDMP!
  - Some of the MMF structure and symbolism will be used in what follows

So how are Tasks executed? [1/2]

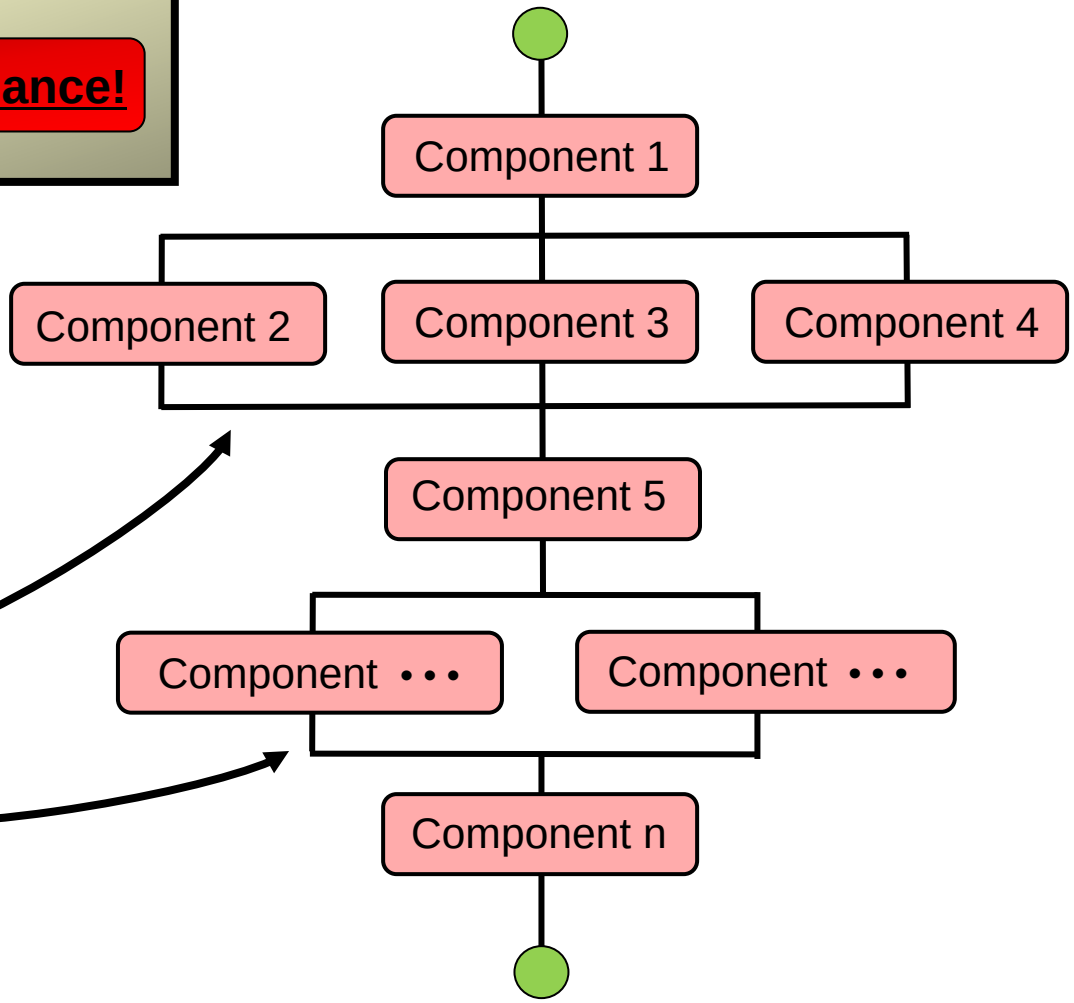


Intraplatform Component Linkage

2. Personnel, Units Components, Systems

Platform assessment based on

Individual Task Performance!



Linkages can be:

- Mechanical
- Electrical
- Hydraulic
- Radiative
- Conductive

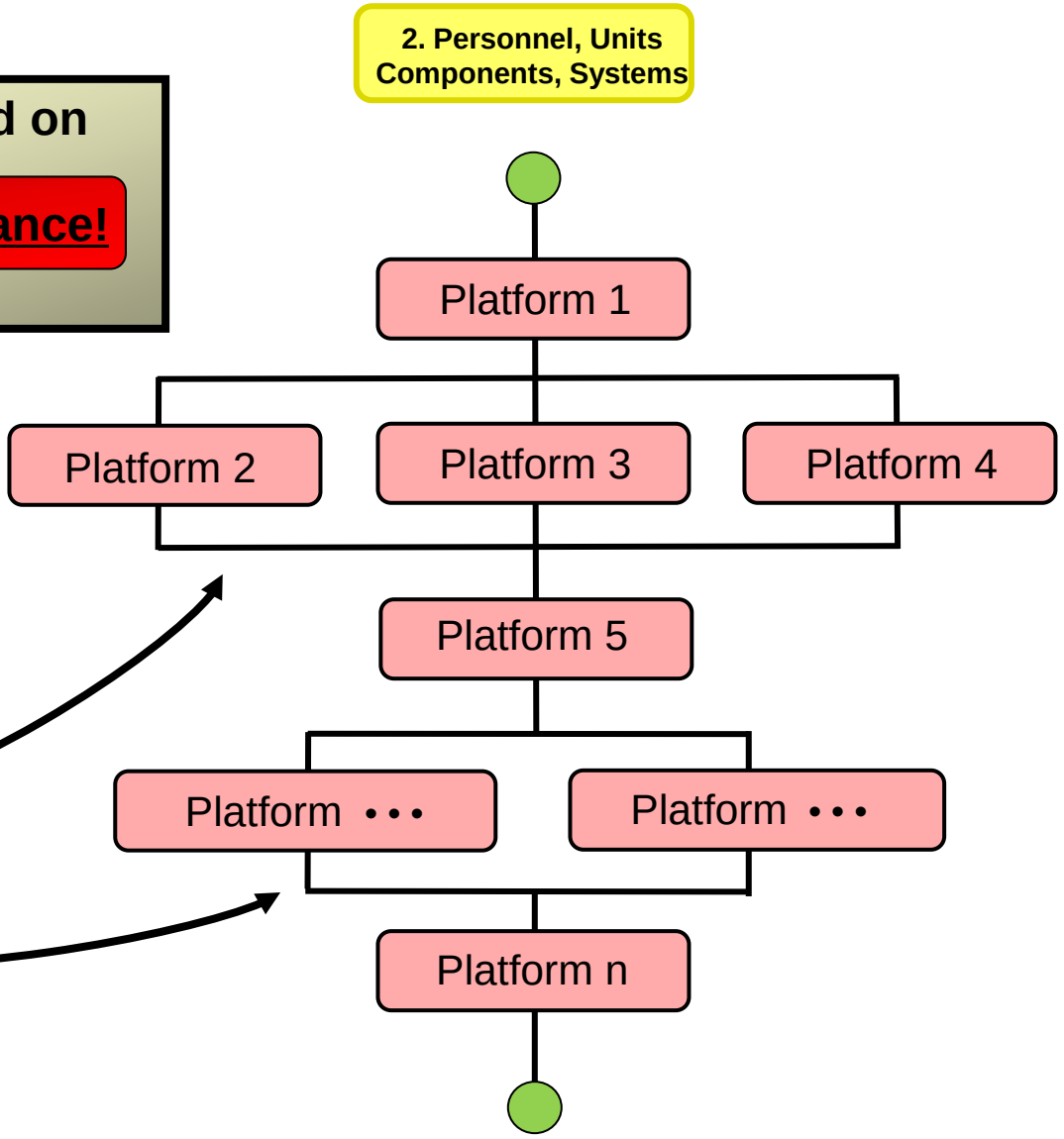
•
•
•

Interplatform Linkage: Key SoS Construct

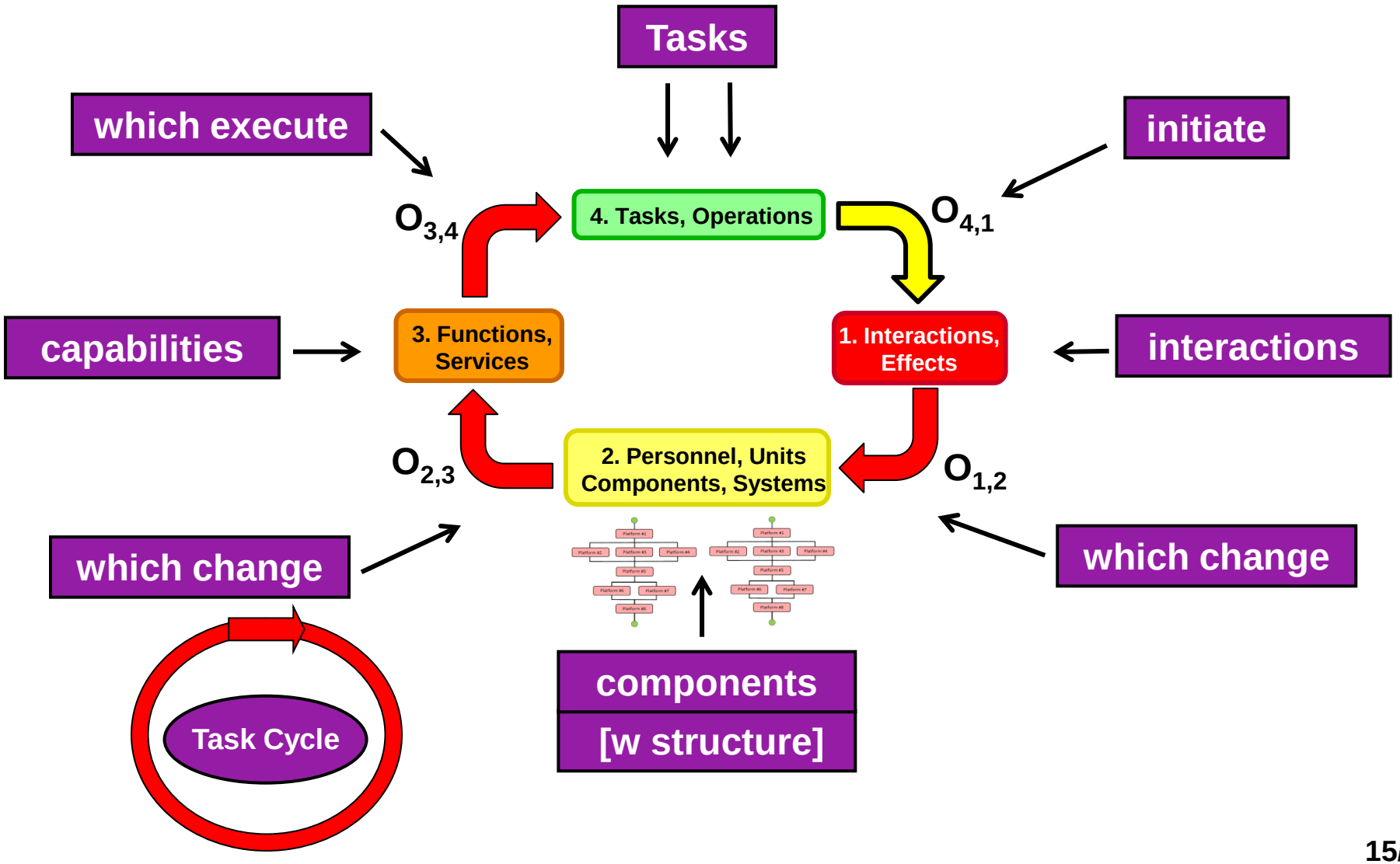
SoS assessment based on

Collective Task Performance!

Linkages can be:
- Time Based
- Event Based
- Effects Based
- Mechanical
- Electrical
- Hydraulic
- Radiative
- Conductive

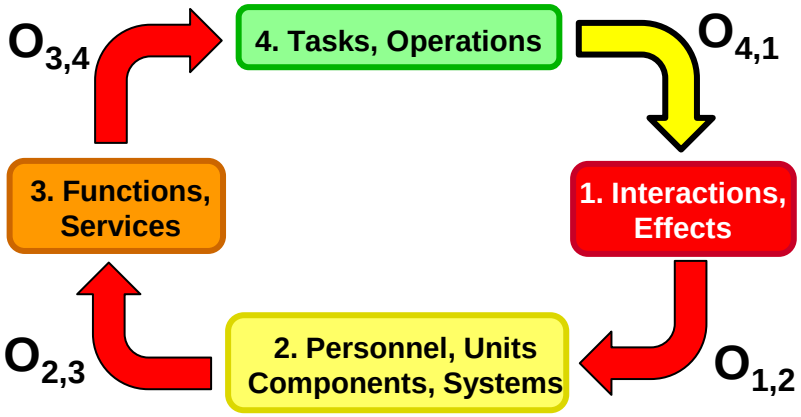


So how are Tasks executed? [2/2]



Supporting Contexts‡ [1/4]

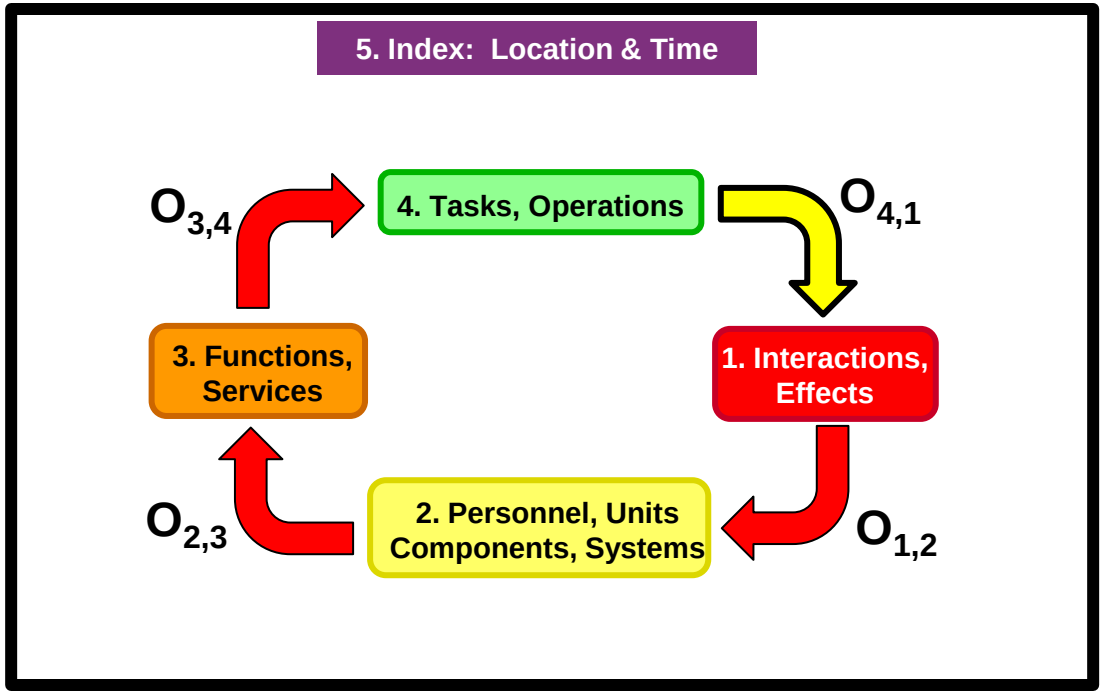
These Principal Elements are necessary, but not sufficient, to define a full representation of the MDMP.



‡ The OPFOR is not shown!

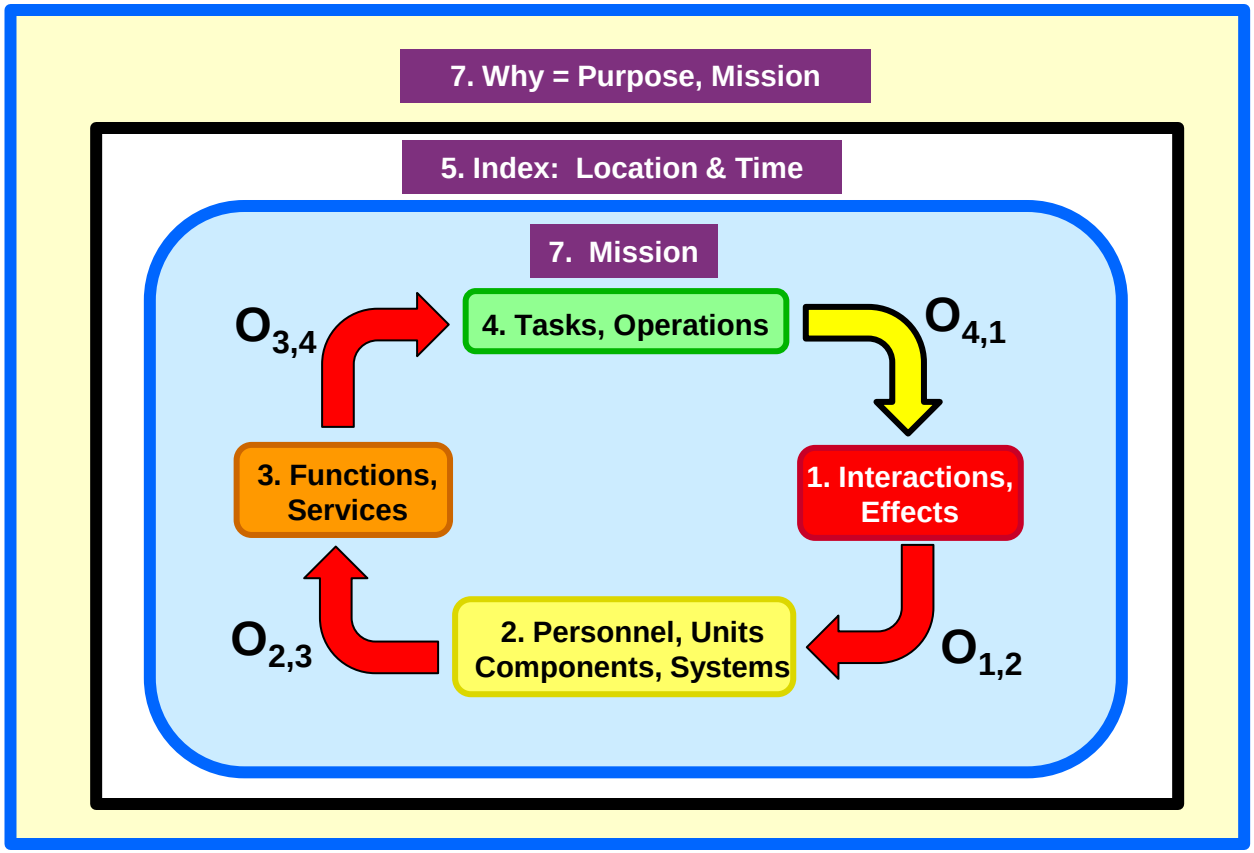
Supporting Contexts [2/4]

Level 5: Index- Location & Time



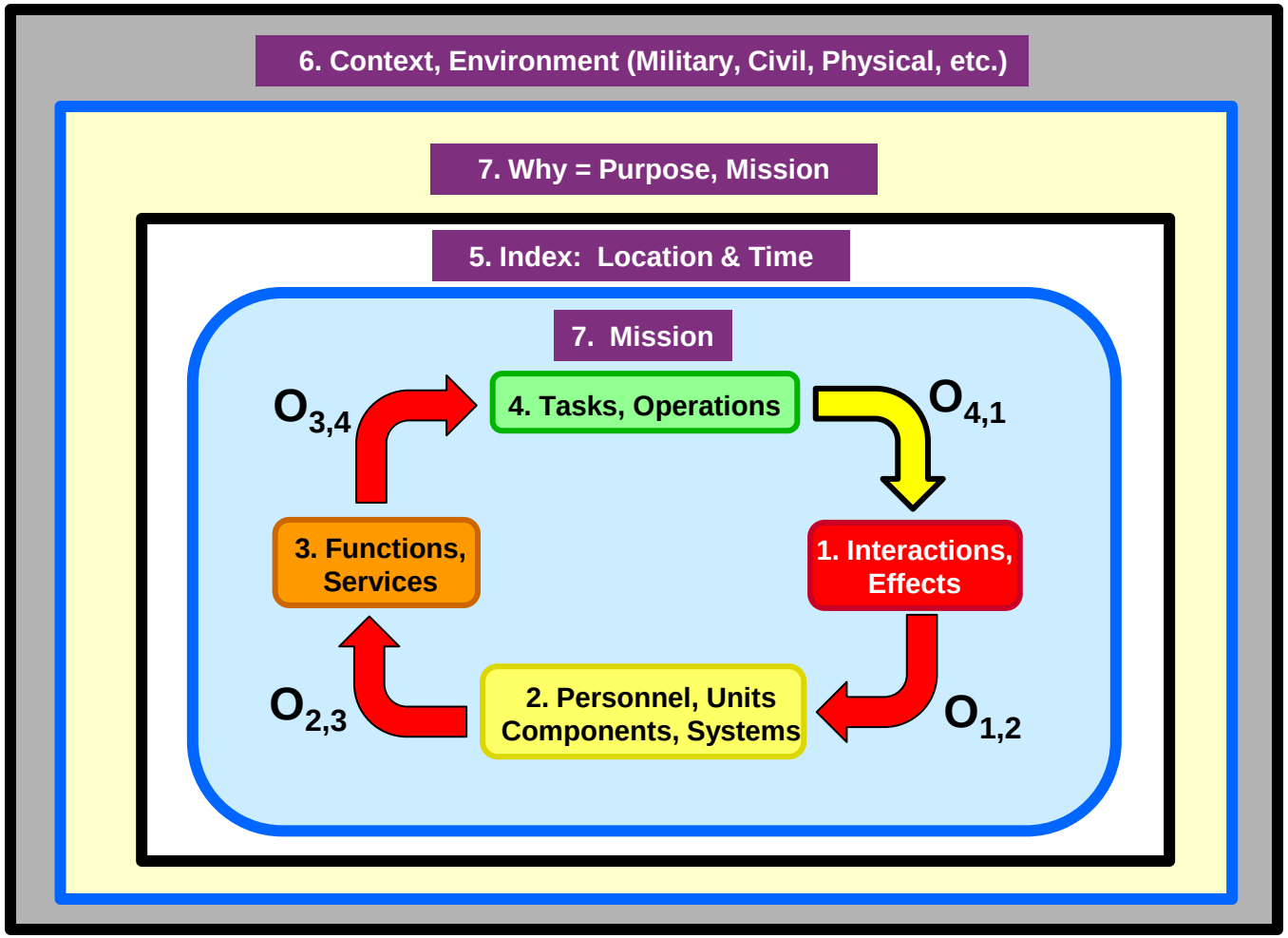
Supporting Contexts [3/4]

Level 7: OWNFOR Purpose, Mission



Supporting Contexts [4/4] ‡

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

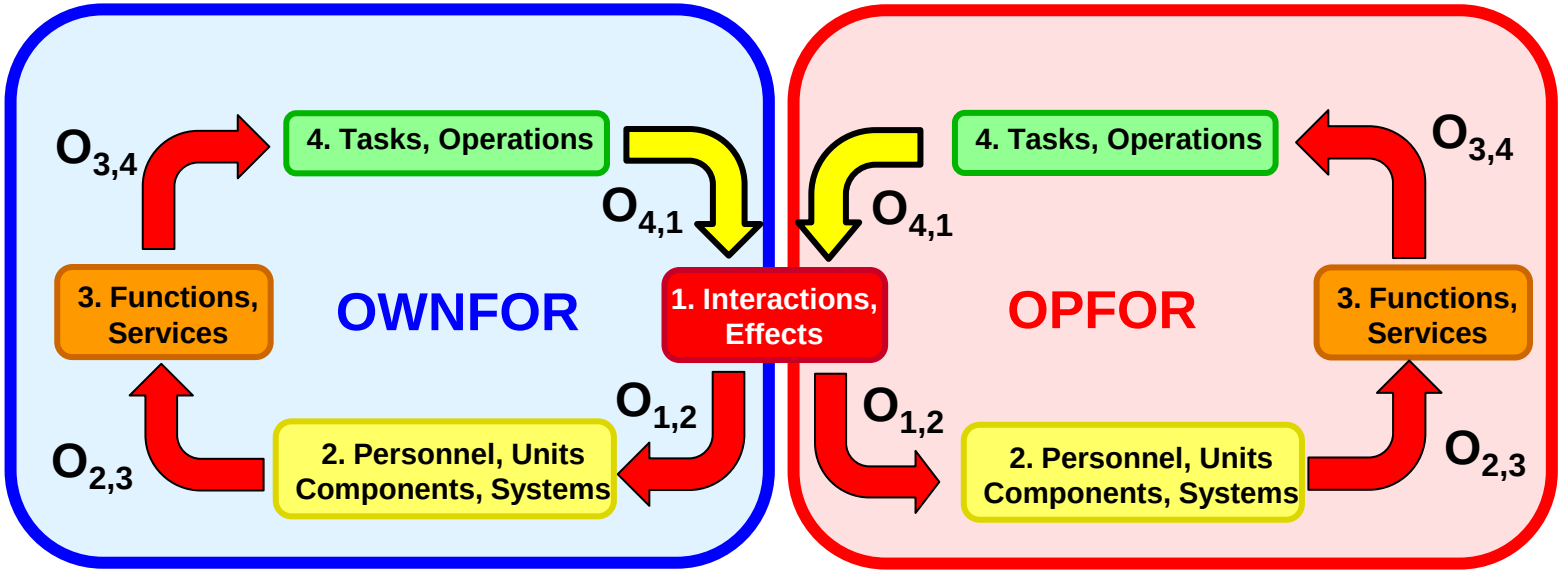


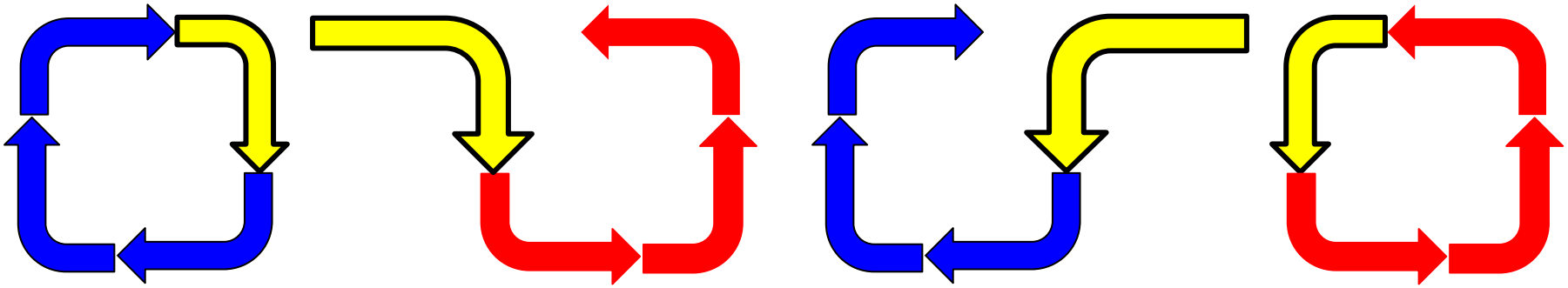
‡ The OPFOR is not shown!

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

Interactions between Opposing Forces

Self and Cross Interactions

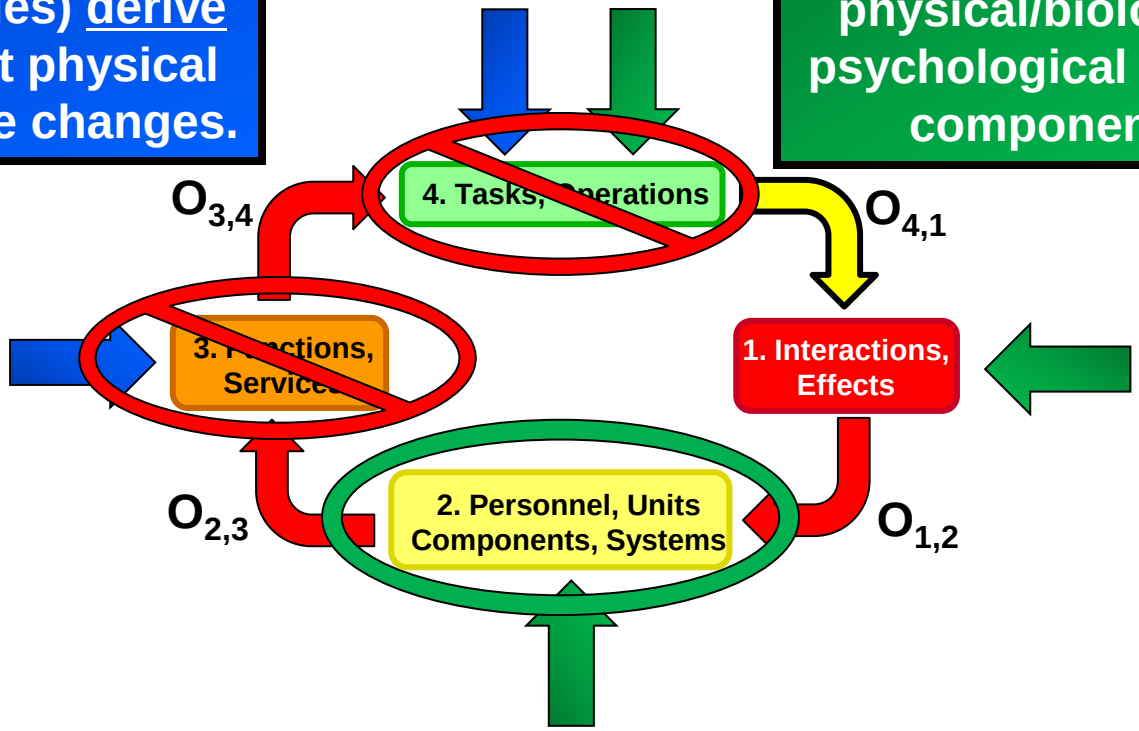




Important Takeaway

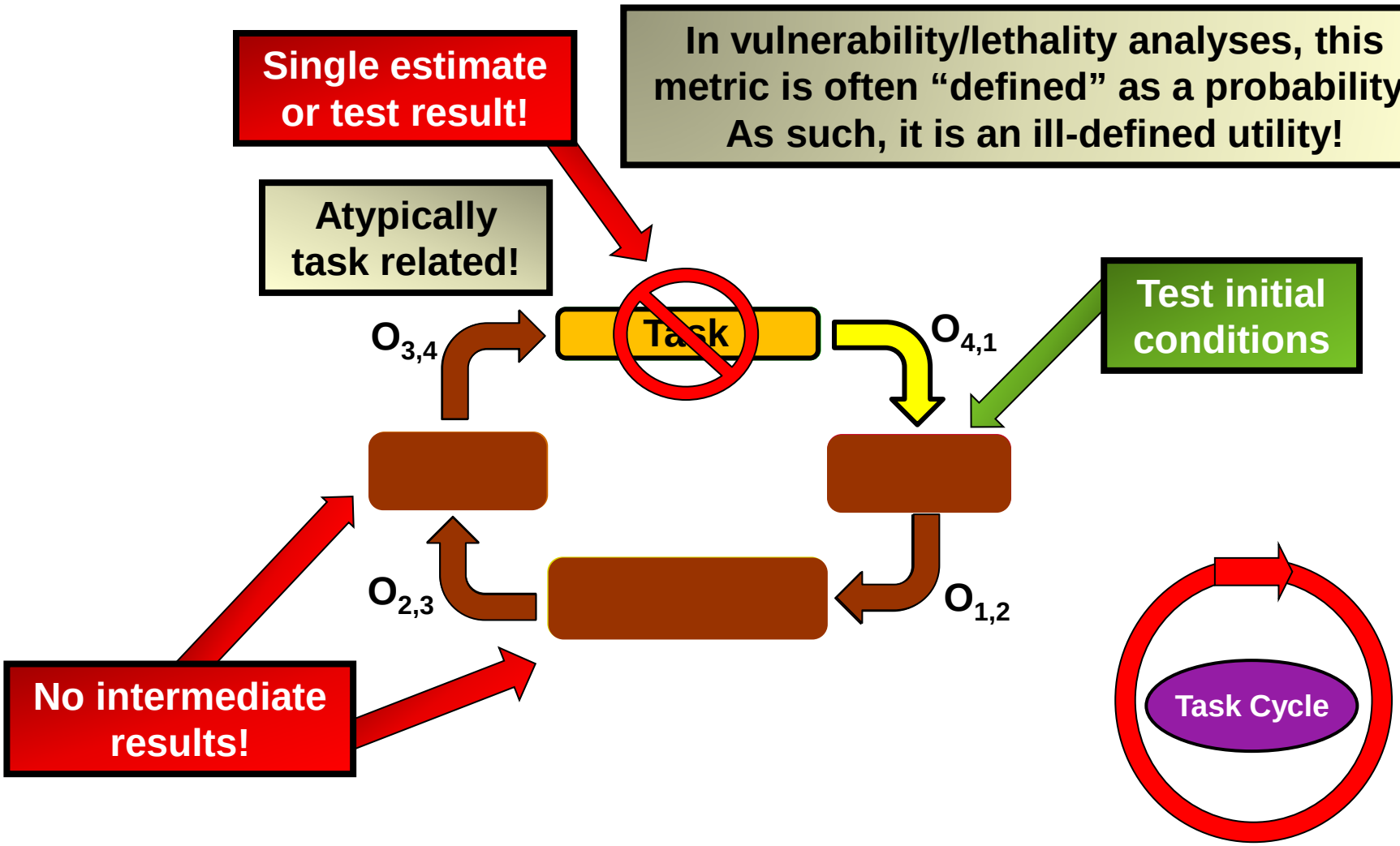
Capabilities (Functions) & Tasks (i.e., Utilities) derive from component physical & functional state changes.

Note: Tasks initiate interactions which directly change the physical/biological/ psychological state of components!



Aggregation/integration of multiple interactions/effects must take place at Level 2., NOT Levels 3. or 4.!

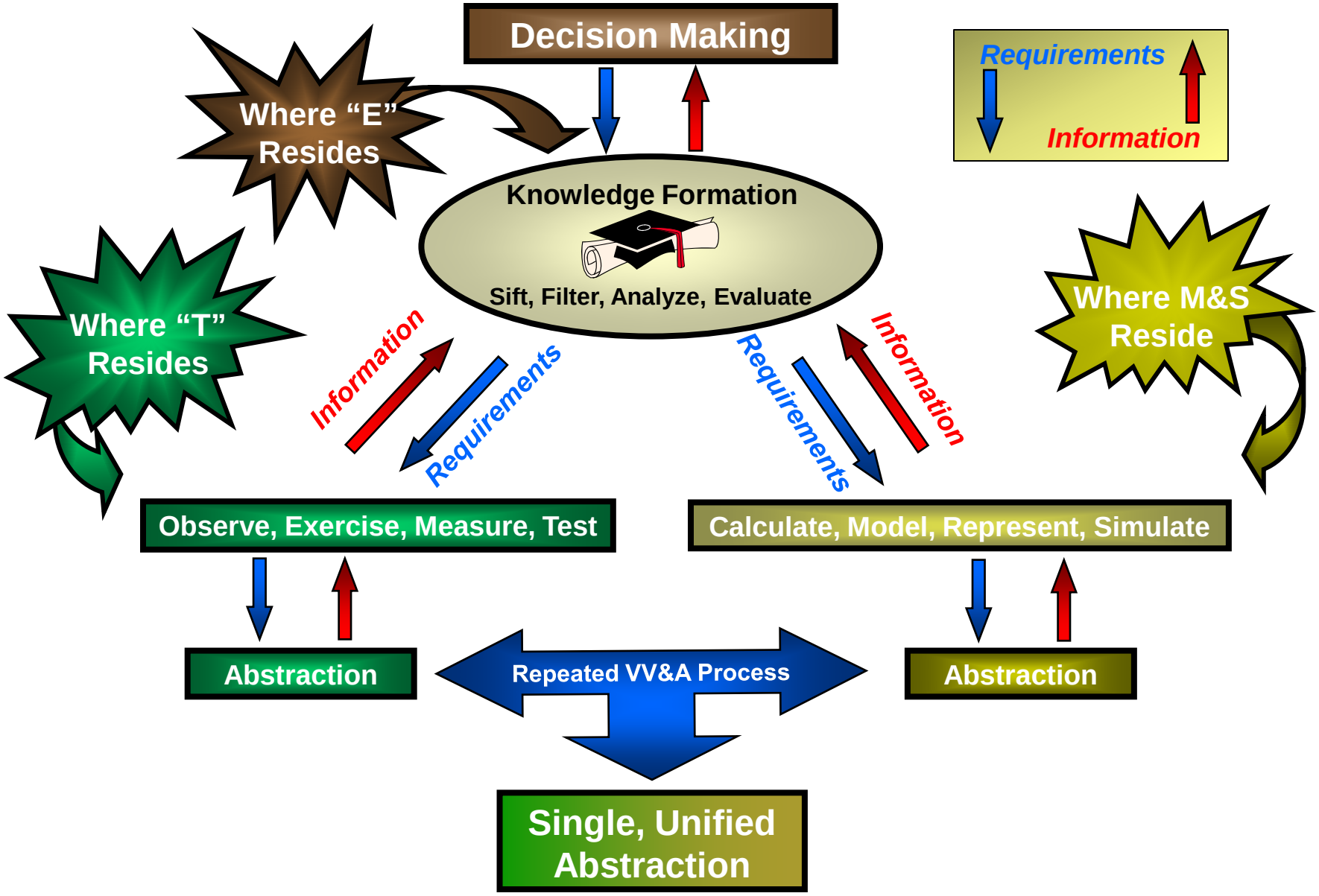
Typical Lumped-Task Simulation [1/2]



Typical Lumped-Task Simulation [2/2]

- Lumped metrics are problematic wrt both interpretation and integration with other parameters!
- Without context and intermediate results, the contribution of each of the three components (physical state change, capability change, change in mission challenge) cannot be apportioned to create data extensibility.
- The inability to define the “PK” metrics objectively/ quantitatively as well as lack of objective intermediate damage and performance metrics contributed greatly to the Live Fire Program issues in the 1980s.

Test/Abstraction Parity

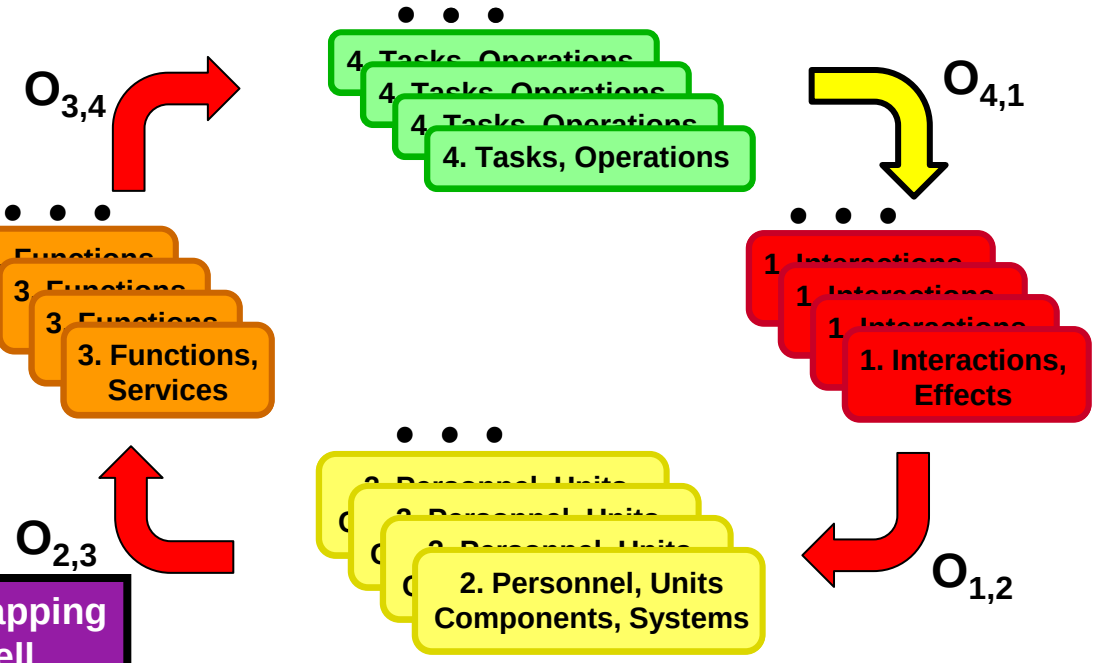


A "Lego" Collection of Mission/Performance Elements

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

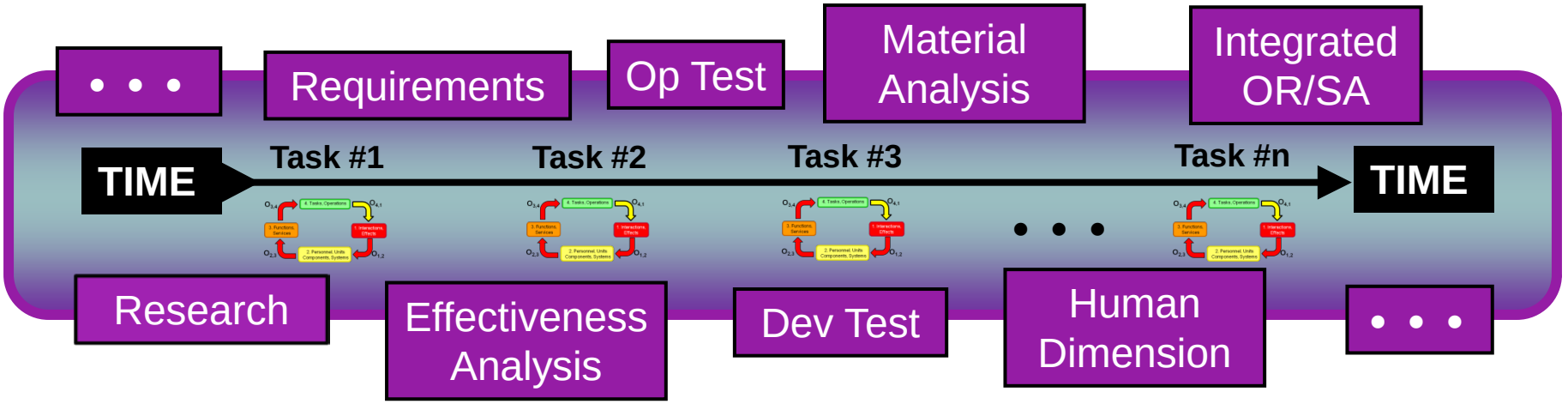


- Ballistic Effects
- Jamming
- Damage Repair
- Chemical
- Resupply
- Repair
- Laser Damage
- Sleep
- Directed Energy
- Nuclear
- Physics of Failure
- Logistics Burdens
- Reliability
- Fair Wear & Tear
- Fatigue
- Heat Stress
- . . .
- . . .

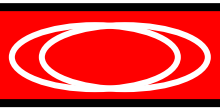
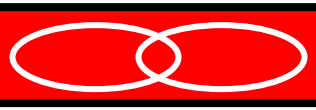
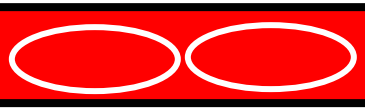
Degraded States Mapping Methodology well established

Unlimited geometric & material configurations/structures

Sequence of Task Cycles Forms a TOEL



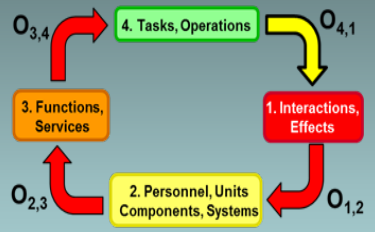
- Missions are composed of task sequences
- Following task initiation, an event cycle occurs
- As a result, material, capability, and utility changes may follow
- When the “lego” elements are developed at this level of resolution, they can be combined endlessly with great extensibility
- All communities 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

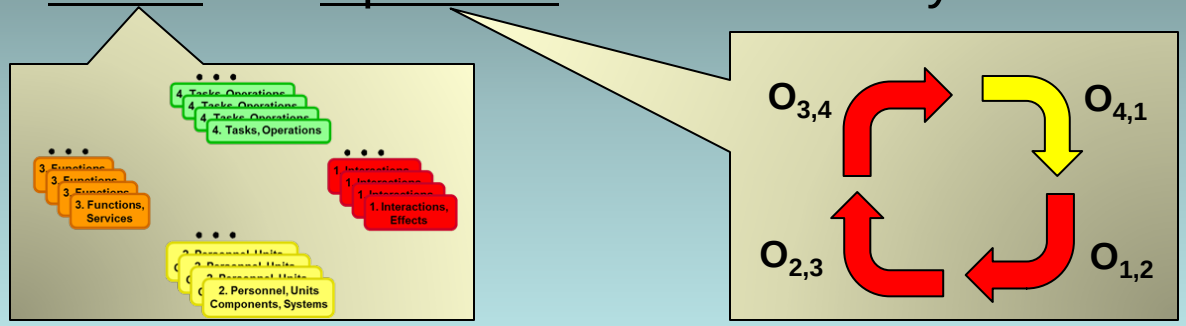
Individual lego elements combine into task cycles, define model elements, and focus Developmental Testing

Model Assessment Test Planning



A single DT cycle

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



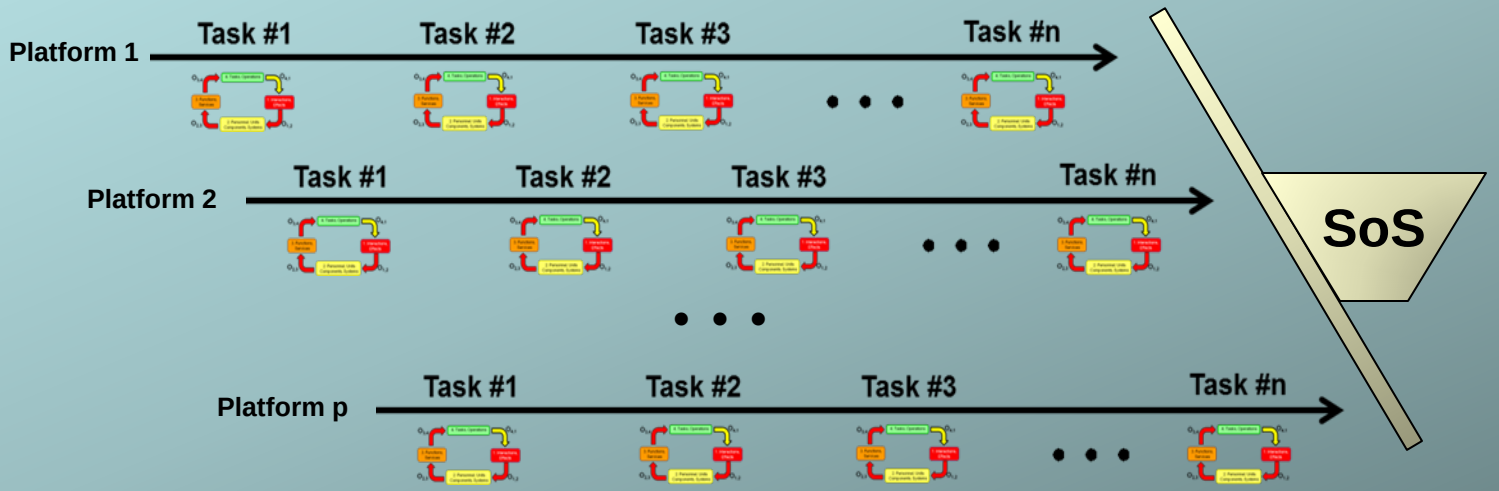
Analysis, Evaluation & OT Issues

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



The Survivor Sum Rule

For fifty years, vulnerability analysts and modelers have been taking Level 4., so-called "probabilities", and combining them using the Survivor Sum Rule,‡ e.g.:

Ballistic Vulnerability Example

Total P_K for an n-shot ballistic volley:

$$P_{K\text{Total}} = 1 - \{ [1 - P_{K1}] \times [1 - P_{K2}] \times \ldots [1 - P_{Kn}] \}$$

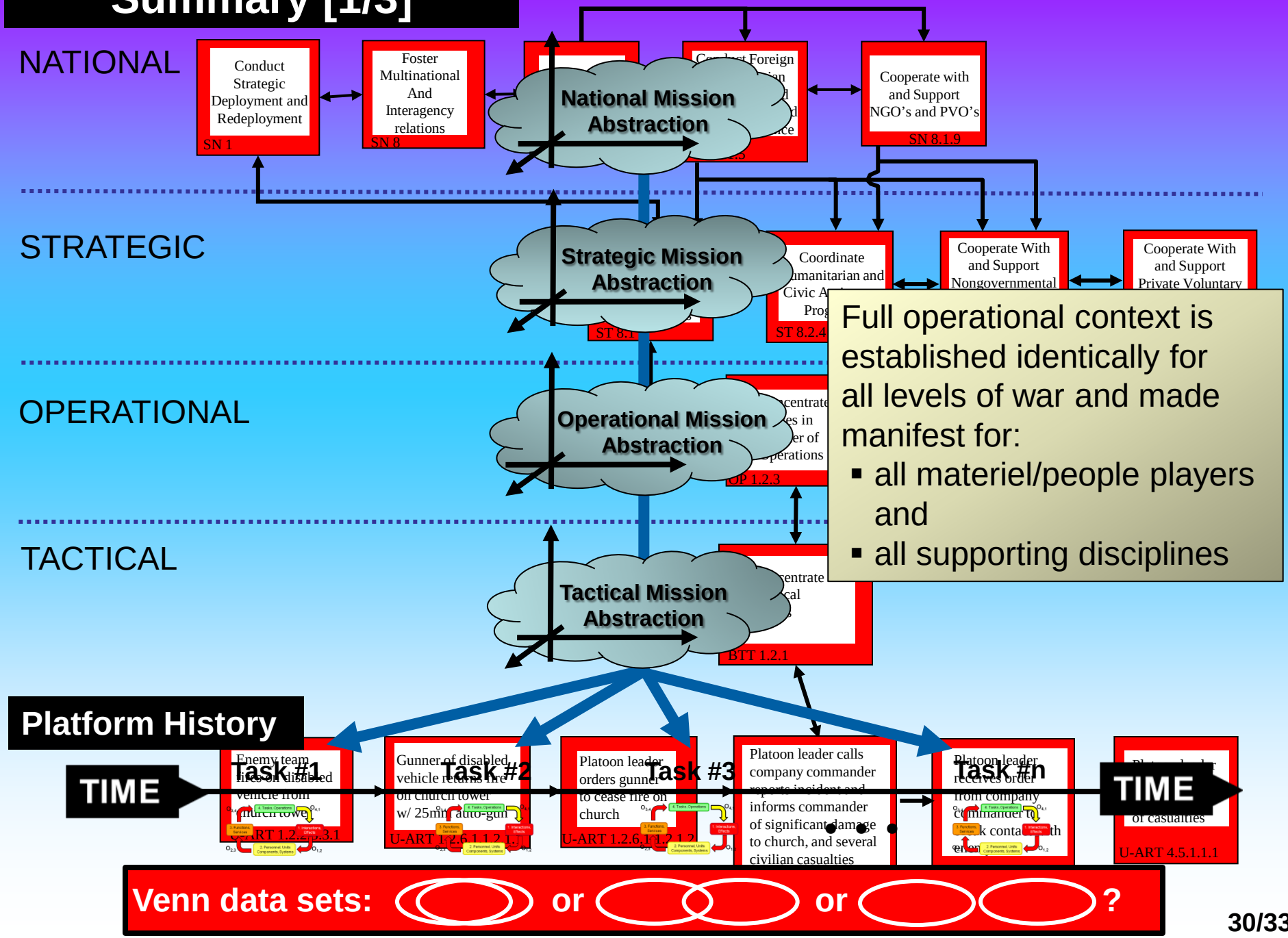
Survivability Example

Total P_S for n survivability-related events (e.g., encounter, engagement, hit, damage, kill):

$$P_{S\text{Total}} = 1 - \{ [1 - P_{E1}] \times [1 - P_{E2}] \times \ldots [1 - P_{En}] \}$$

‡ Caveat Emptor: The Survivor Sum Rule applies only when metrics are both true probabilities and independent! Here, neither condition holds!

Summary [1/3]

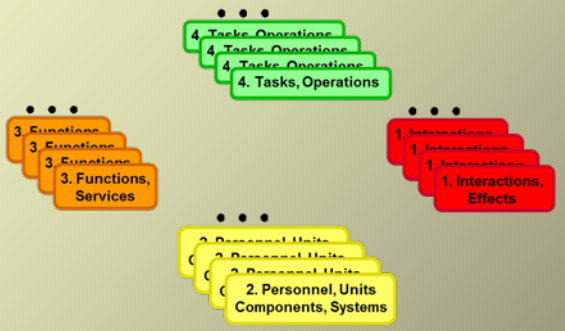

NATIONAL
STRATEGIC
OPERATIONAL
TACTICAL
Conduct Strategic Deployment and Redeployment
SN 1
Foster Multinational And Interagency relations
SN 8
National Mission Abstraction
Cooperate with and Support NGO's and PVO's
SN 8.1.9
Strategic Mission Abstraction
Coordinate
Cooperate With and Support Nongovernmental
Cooperate With and Support Private Voluntary
ST 8.1
ST 8.2.4
Operational Mission Abstraction
OP 1.2.3
Tactical Mission Abstraction
BTT 1.2.1
Full operational context is established identically for all levels of war and made manifest for:
all materiel/people players and
all supporting disciplines
Platform History
TIME
Task #1
Enemy team fires on disabled vehicle from
Task #2
Gunner of disabled vehicle returns fire on church tower w/ 25mm auto-gun
U-ART 1.2.6.1.1.2.1.1
Task #3
Platoon leader orders gunner to cease fire on church
U-ART 1.2.6.1.1.2.1.2
Platoon leader calls company commander reports incident and informs commander of significant damage to church, and several civilian casualties
Task #n
Platoon leader receives order from company
TIME
of casualties
U-ART 4.5.1.1.1
Venn data sets:
or
or
?

Summary [2/3]

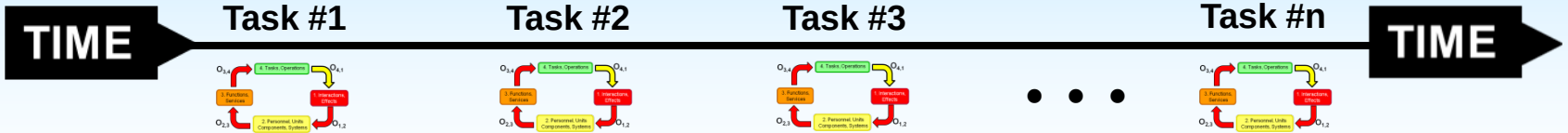
Standard semantics and syntax are established across all levels

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

The lego element abstractions are identically applicable to analysis and test, establishing key symmetry requisite for validation.



Platform History



Summary [3/3]

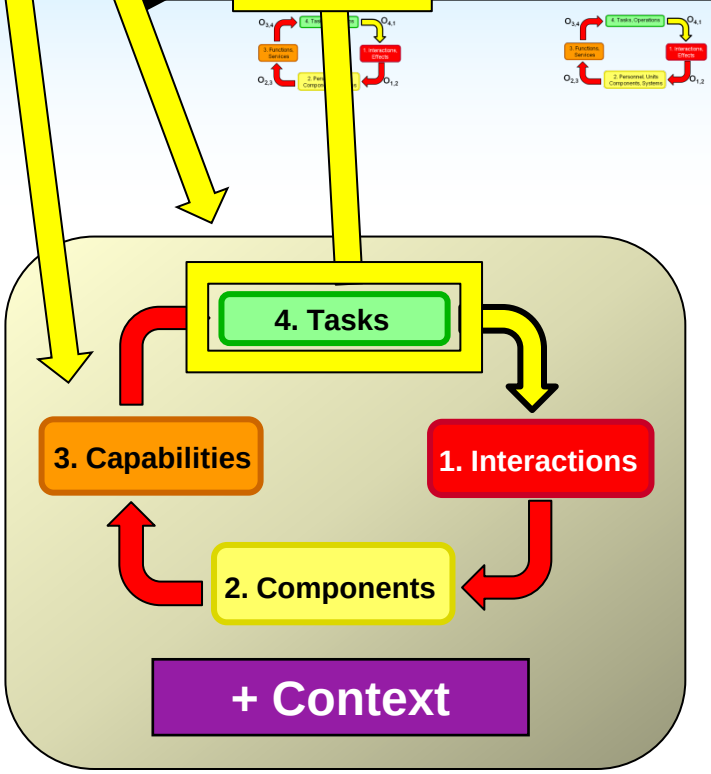
An Integration Strategy

Defense Analytic Challenges

Capabilities described in task-compatible metrics

Tactical Mission Abstraction

Task #1 **Task #2** **Task #3** **Task #n**



- Link Task Definition to Task Execution
- Share Task Execution methods, measures & data structures across the Community

Material/People Interactions

Geometry/Materiel Specifications

Capabilities matched to Tasks

- 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
- . . .
- . . .

Approved for public release; distribution unlimited

An Integrating Framework for Interdisciplinary Military Analyses

NDIA ICOTE
BOEING COMPANY OFFICE
ARLINGTON, VA 22202
19 June, 2012

TECHNOLOGY DRIVEN. ***WARFIGHTER FOCUSED.***

Paul H. Deitz, Ph.D.
US AMSAA
APG, MD 21005-5071
paul.h.deitz.civ@mail.mil
410-278-2786 DSN: 298-2786

James N. Walbert, Ph.D.
SURVICE Engineering Company
jim.walbert@survice.com
703-221-7370

LTC(R) Britt E. Bray
Dynamics Research Corporation
BBray@drc.com
785-550-5573

Version Date: 17 June 2012