



# **Military Systems Analyses in an Ill-Posed World: Defining the Problem**



**The National Defense Industrial  
Association Annual National  
Test & Evaluation Conference  
The Westin Washington**

**July 22-23, 2014**

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# Outline

- **The intersection of “Ill-Posed Problems” and military systems analyses**
- **Some key problem examples**
- **An abstraction consisting of task networks which redress the stated shortcomings**
- **Elements of the task network abstraction**
- **Follow on presentations by Britt Bray (Engility), instantiating such a structure, and Chris Wilcox (ATEC/AEC), showing how task networks can inform Developmental and Operational Testing**

# Introduction [1/3]

- **What are Ill-Posed Problems?**
  - Problems which are under-specified, under-determined, or under-constrained
- **Such problems typically arise when attacked with ad hoc methods**
- **Some exemplars (illustrative vice exhaustive) of requisite context specification in military analysis:**
  - Key mission linkages across levels of war
  - Specification of relevant metrics
  - Accommodation of dynamic entities
  - Performance and effectiveness characterization of System-of-Systems (SoSes)
  - Integration of materiel and human factors

# Introduction [2/3]

**Need for overarching analytic structure/framework:**

- *Not ad hoc*
- *Not bottom up*
- *Not simply a recipe*

- **If not provable, should be plausible**
- **Captures complete mission context**
- **Supports formal language**

## Introduction [3/3]

- **How do warfighters/operators describe missions?**
  - They use the Military Decision-Making Process [MDMP]
  - One of the outputs of the MDMP is a kind of Gantt structure – a time- and dependency-based ordering of tasks to be performed; available resources (effectors) with the capability to achieve desired task outcomes are assigned to tasks
  - To avoid potential confusion over meaning, authoritative, doctrinally-based task language is now codified by formal Joint- and Service-Task Lists (w conditions and standards)

**Example: Key mission linkages  
across levels of war**

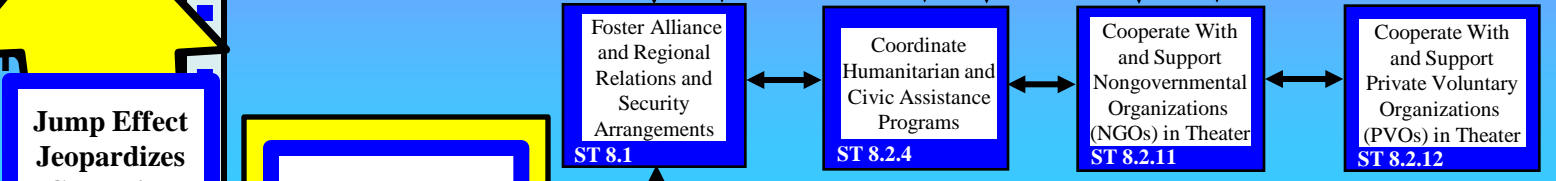
# Formulating a Mission

# MOUT Mission Decomposition<sup>‡</sup>

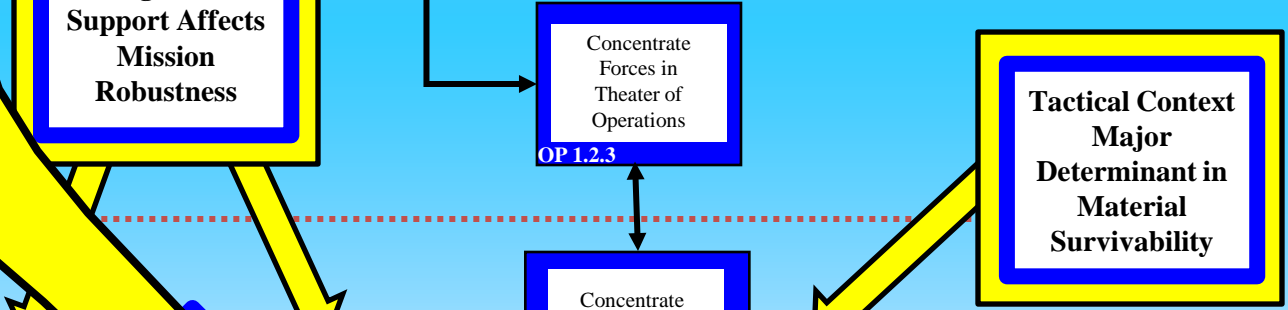
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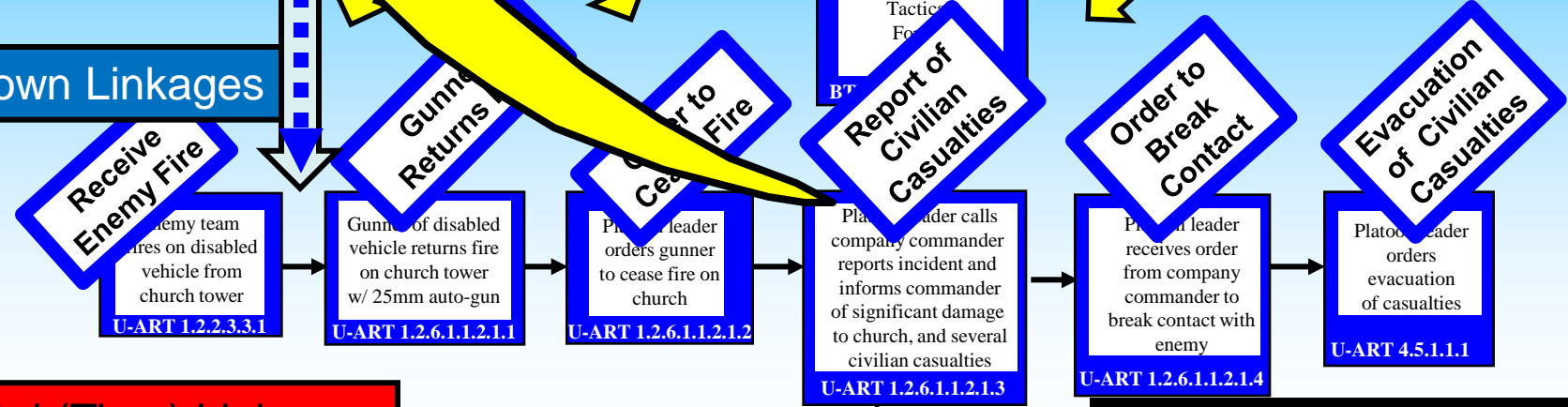


OPERATIONAL



TACTICAL

Top-Down Linkages



Horizontal (Time) Linkages

<sup>‡</sup> Mission build by Dynamics Research Corporation, Nov 2000

# Key Observation

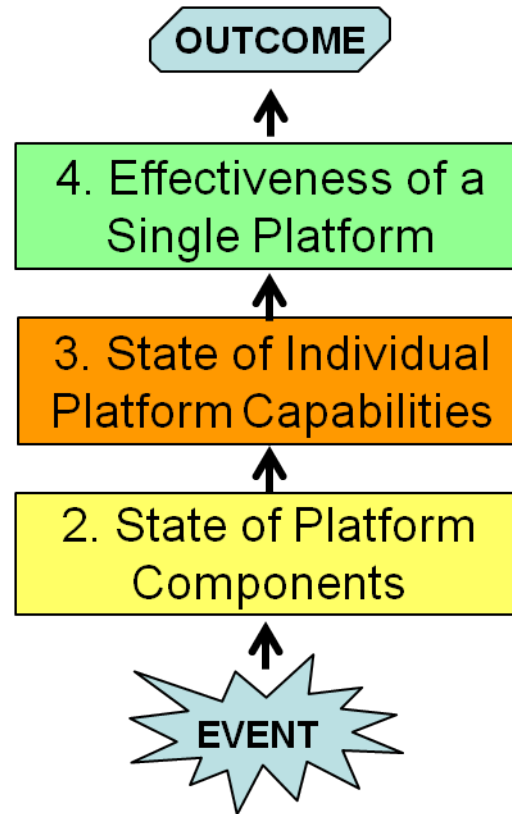
**Mission context<sup>‡</sup> and materiel behavior at all levels of war can, and do, effect mission outcomes at all levels of war!**

**‡ E.G., accessibility of materiel to combat zone, global politics, logistics posture, threats, cultural/political environment, . . .**



**Task networking at a single  
level of war**

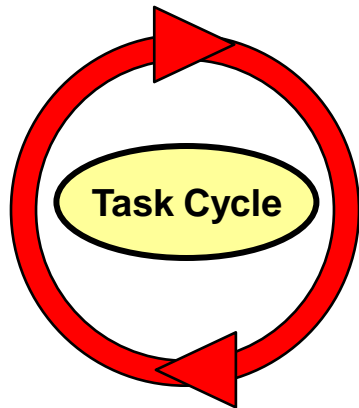
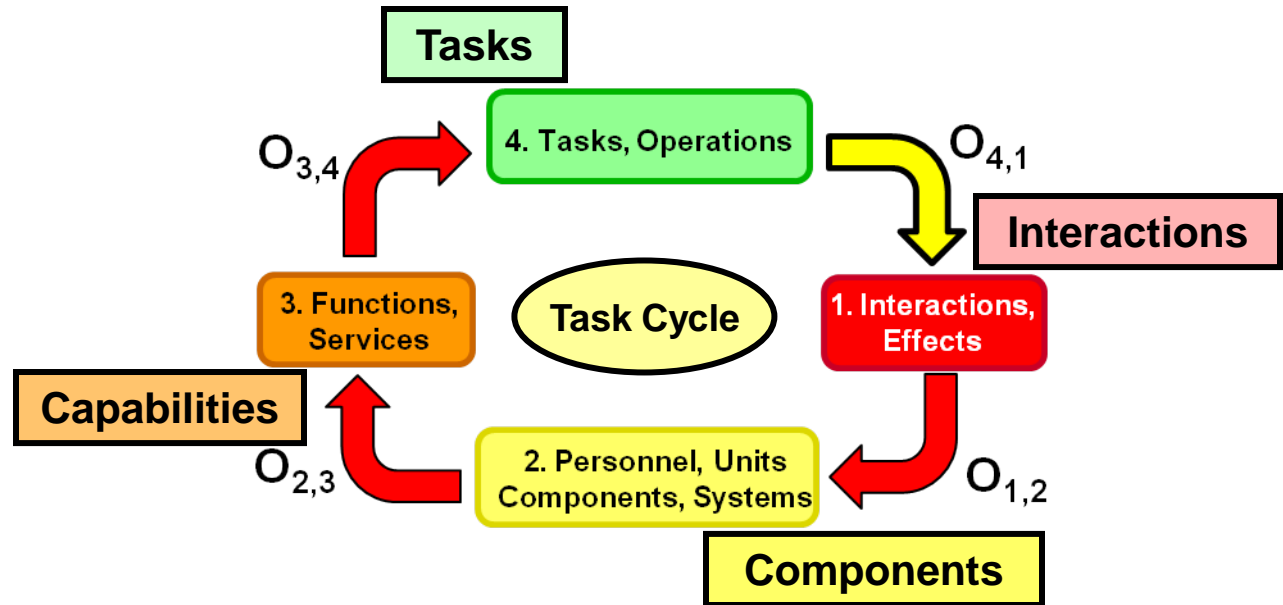
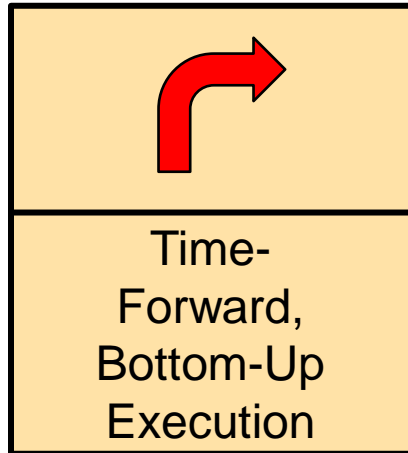
# The Beginnings of Task Execution in V/L Analysis



Describing ballistic events at the Microscale of combat

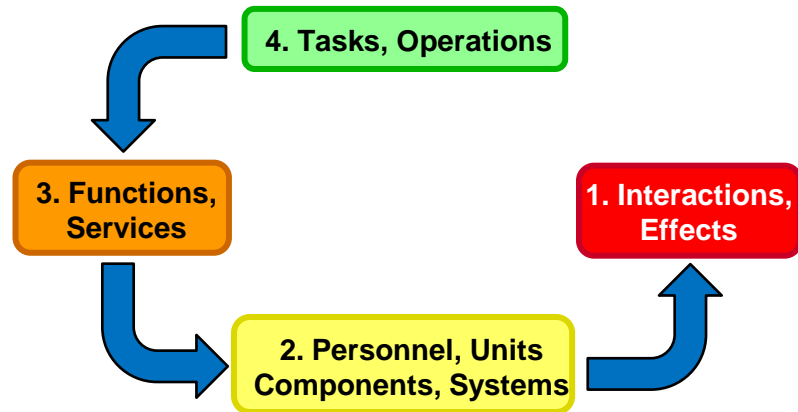
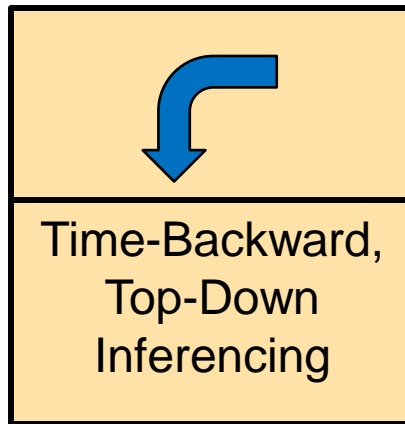
Proper characterization of effectiveness was an open question!

# Task Cycling via MMF, circa 2001



- Results of Bottom-Up task execution are assessed using measures of effectiveness derived during Top-Down mission planning
- Task execution generates interactions. The resulting effects are compared with the plan, and they drive selection of follow-on tasks to form cycles
- Execution process is Time-Forward and Bottom-Up

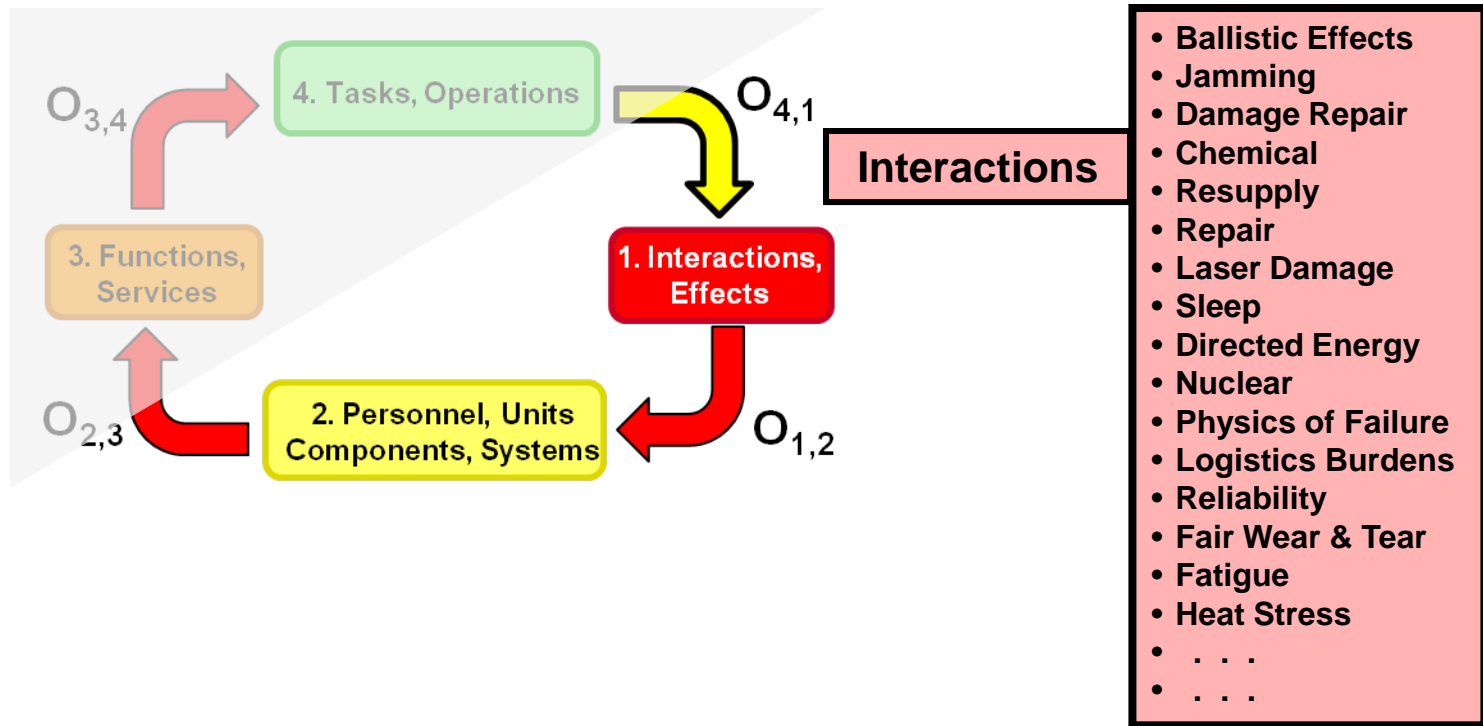
# Developing Relevant Metrics Top Down



## Relevant Metrics by Top-Down Inferencing

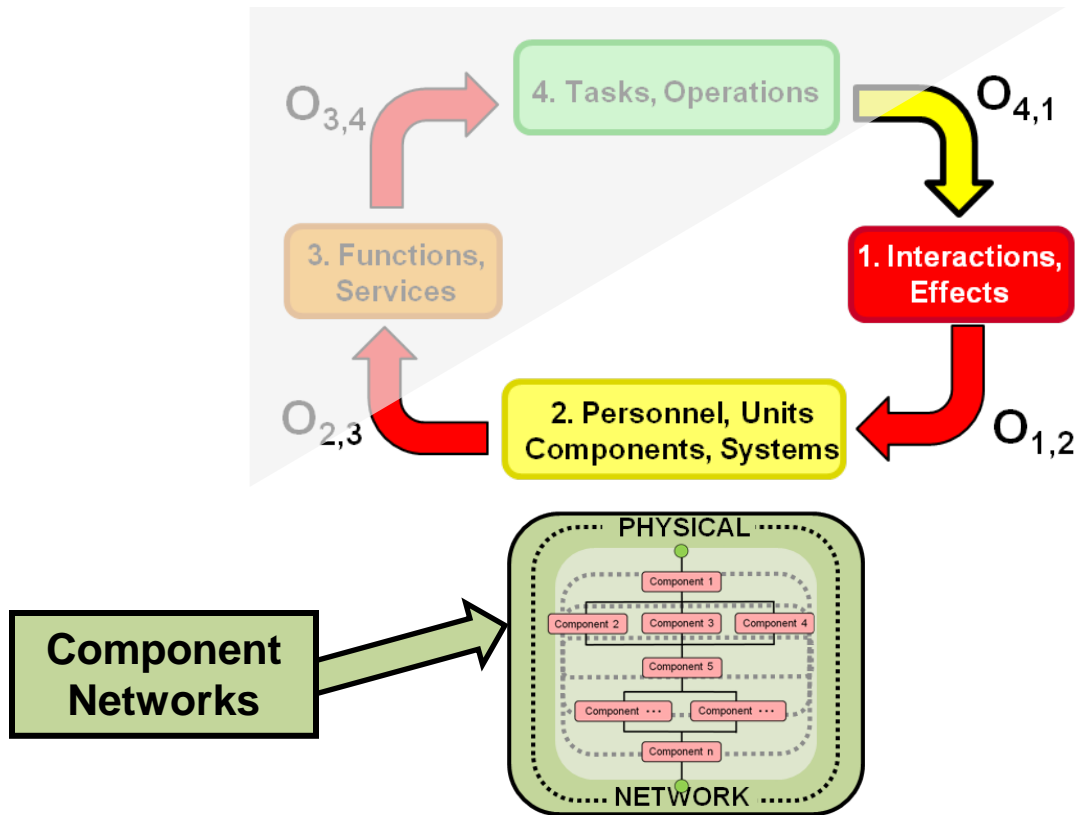
- Define task(s) included in operational plan
- Infer requisite Services/Capabilities (through mission analysis and wargaming)
- Identify critical entities (people/material), and
- Identify critical Interactions to avoid/enhance (through wargaming and rehearsal)

# Dynamic Geometry/Material [1/3]

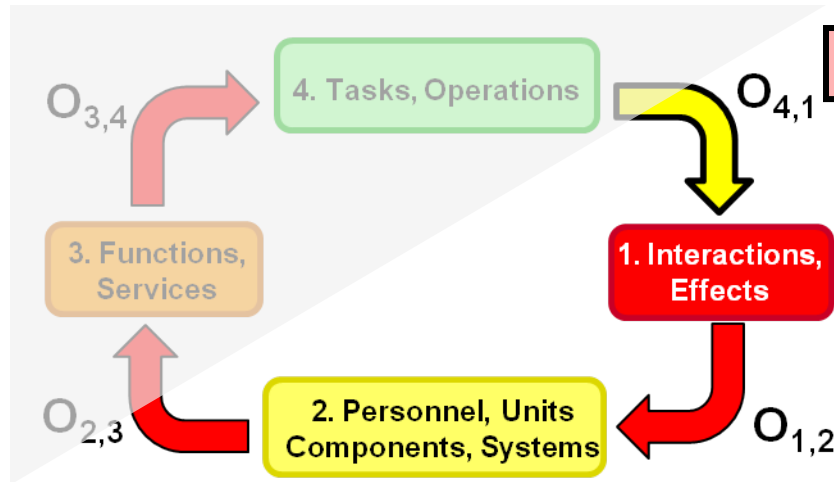


**Many interaction mechanisms can induce change (damage/fix) in entities (people/material).**

# Dynamic Geometry/Material [2/3]



# Dynamic Geometry/Material [3/3]



- A sequence of interactions is tracked at Level 2
- At any given time, the component state space is mapped to Level 3 to assess capability
- Then mapped to Level 4 to assess mission effectiveness

Sequential interactions must integrate at Level 2. Then evaluated for:

Performance

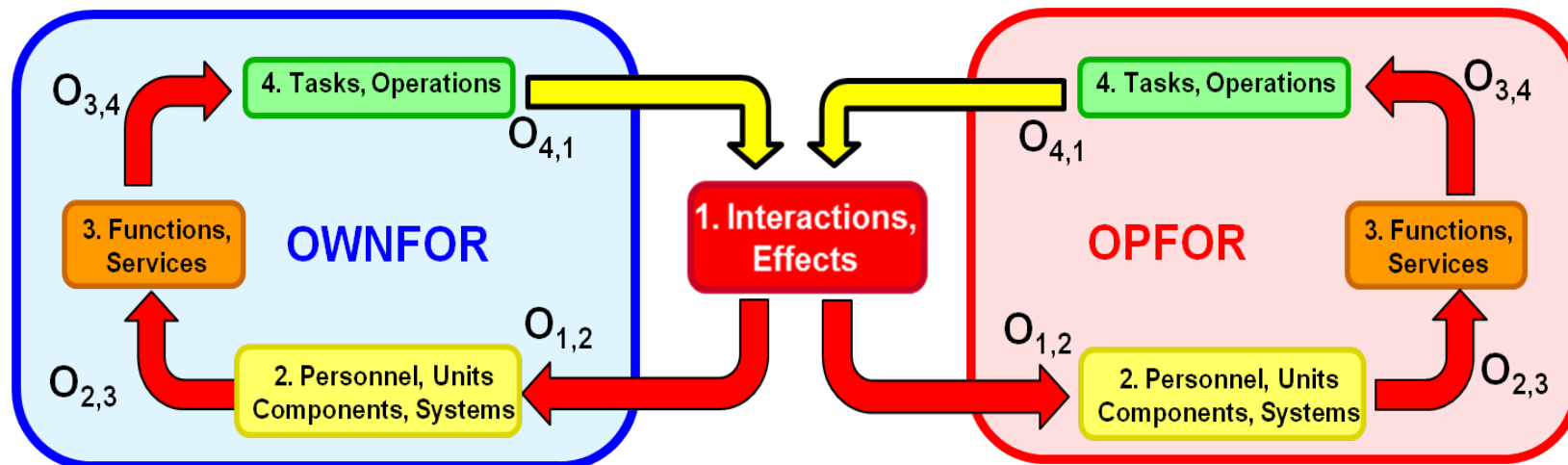
3. Functions, Services

and Effectiveness

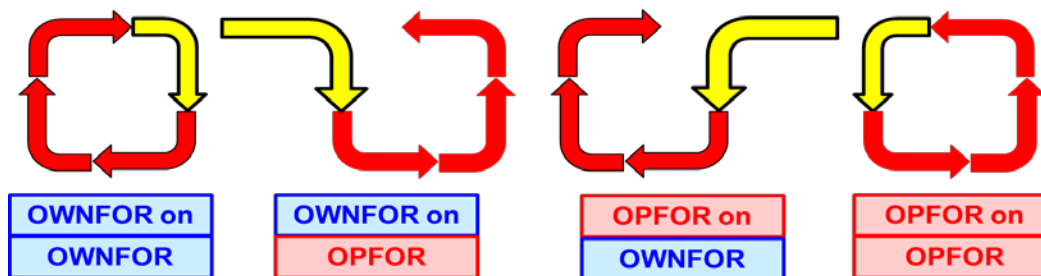
4. Tasks, Operations

# Adding: a) Context for Single Level of War, and b) an OPFOR

An Opposing Force was added

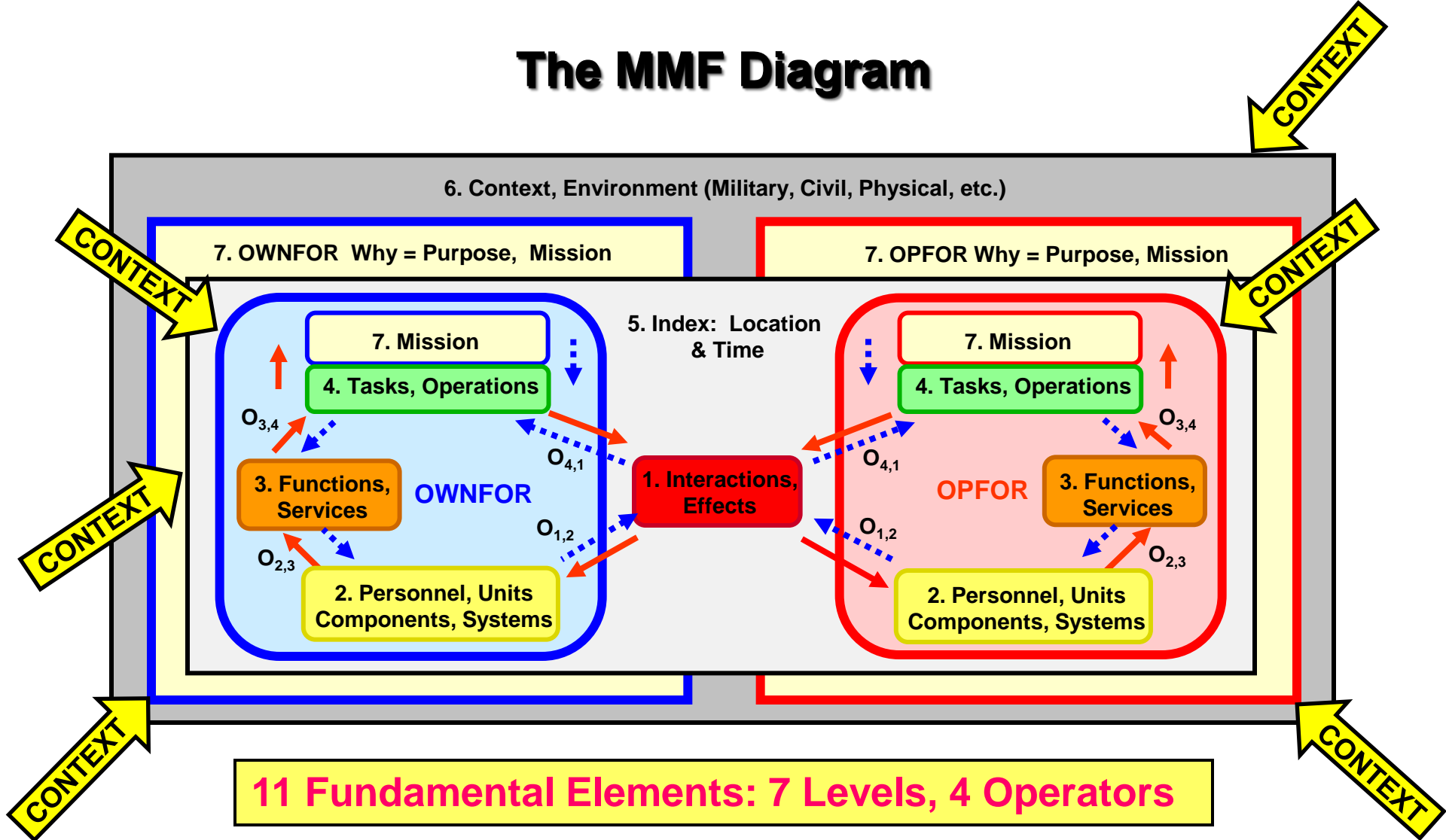


## Task Path Variants





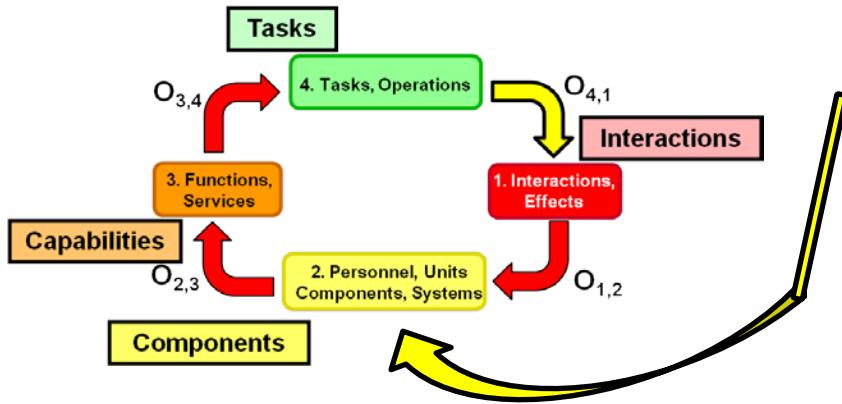
# The MMF Diagram



**11 Fundamental Elements: 7 Levels, 4 Operators**

**All of the underlying layers are about Context!**

# Task Prosecution and DT/OT



- **All Interaction Mechanisms** must focus on component state change
- **Aggregation** of multiple mechanisms (over time) must take place at the platform component level

**Interaction Mechanisms**

- 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
- . . .
- . . .

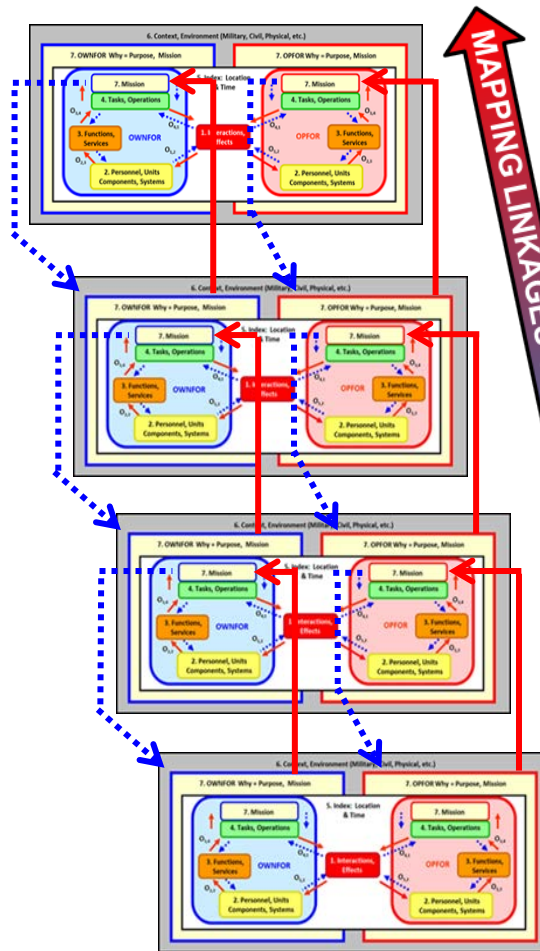
- In **Developmental Testing**:
  - Identify expected interaction mechanisms based on mission profile
  - Confirm ability to model/simulate via test
- In **Operational Testing and M&S**:
  - Vary the time sequence and frequency of interaction effects based on mission profile



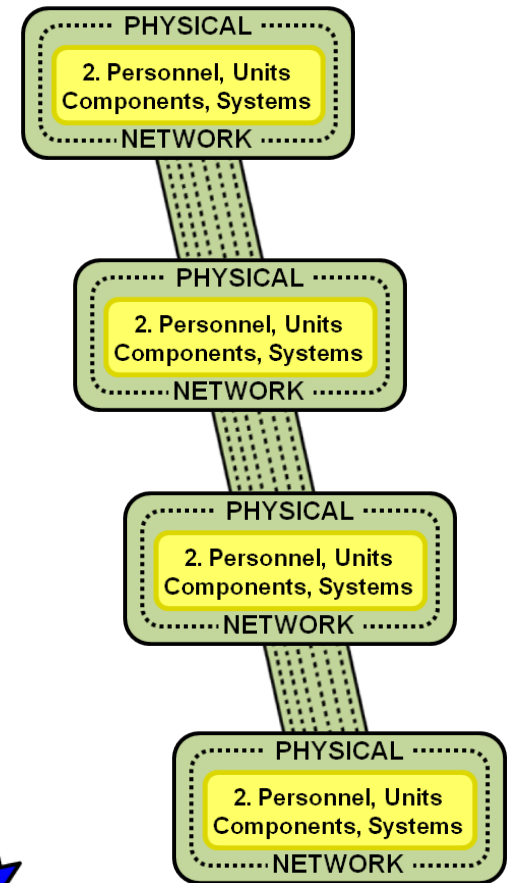
# Task Network Abstractions In the Macrospace



**Combat Abstraction by Level-of-War**

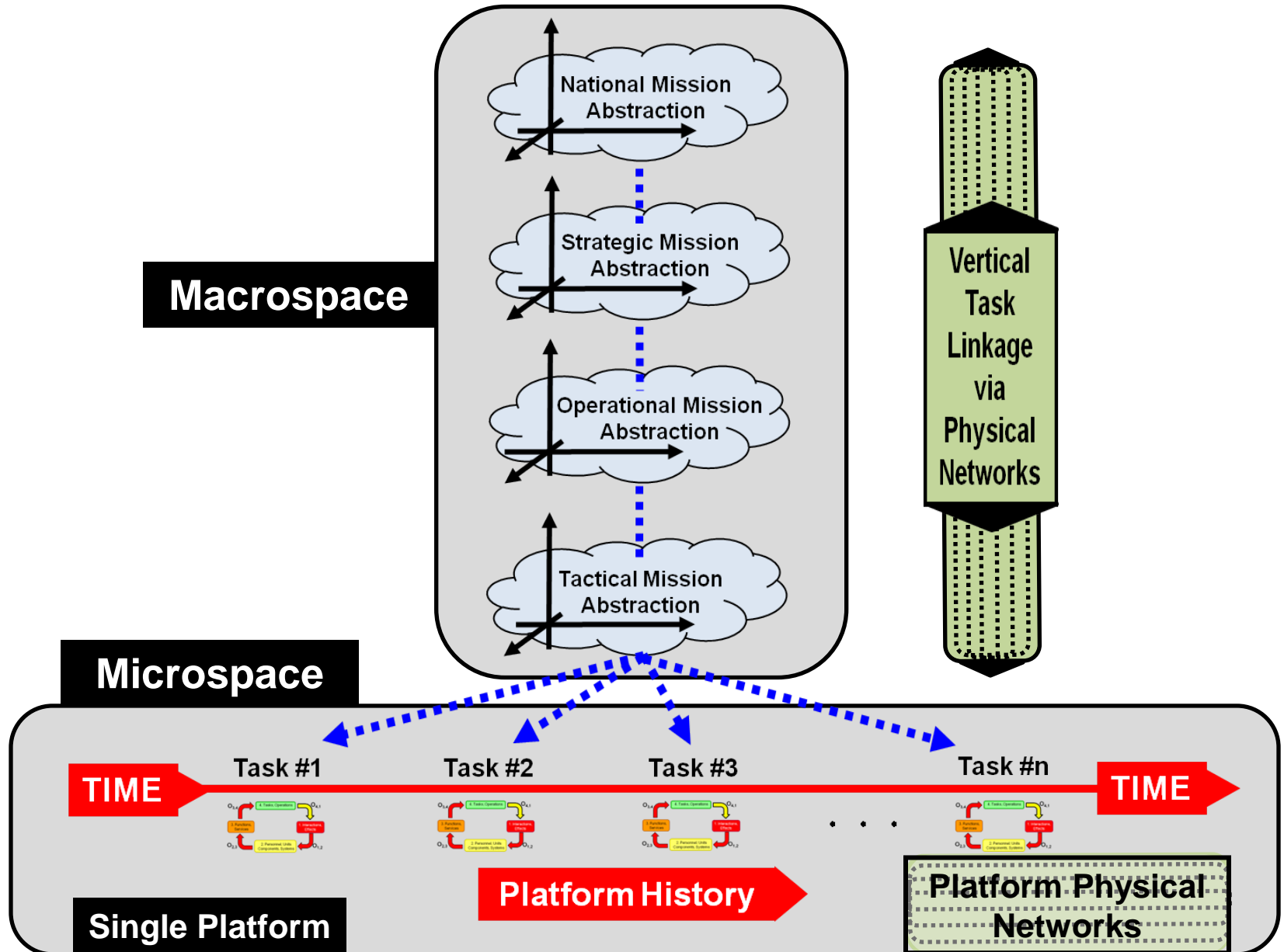


**Combat Abstraction by MDMP/MMF**

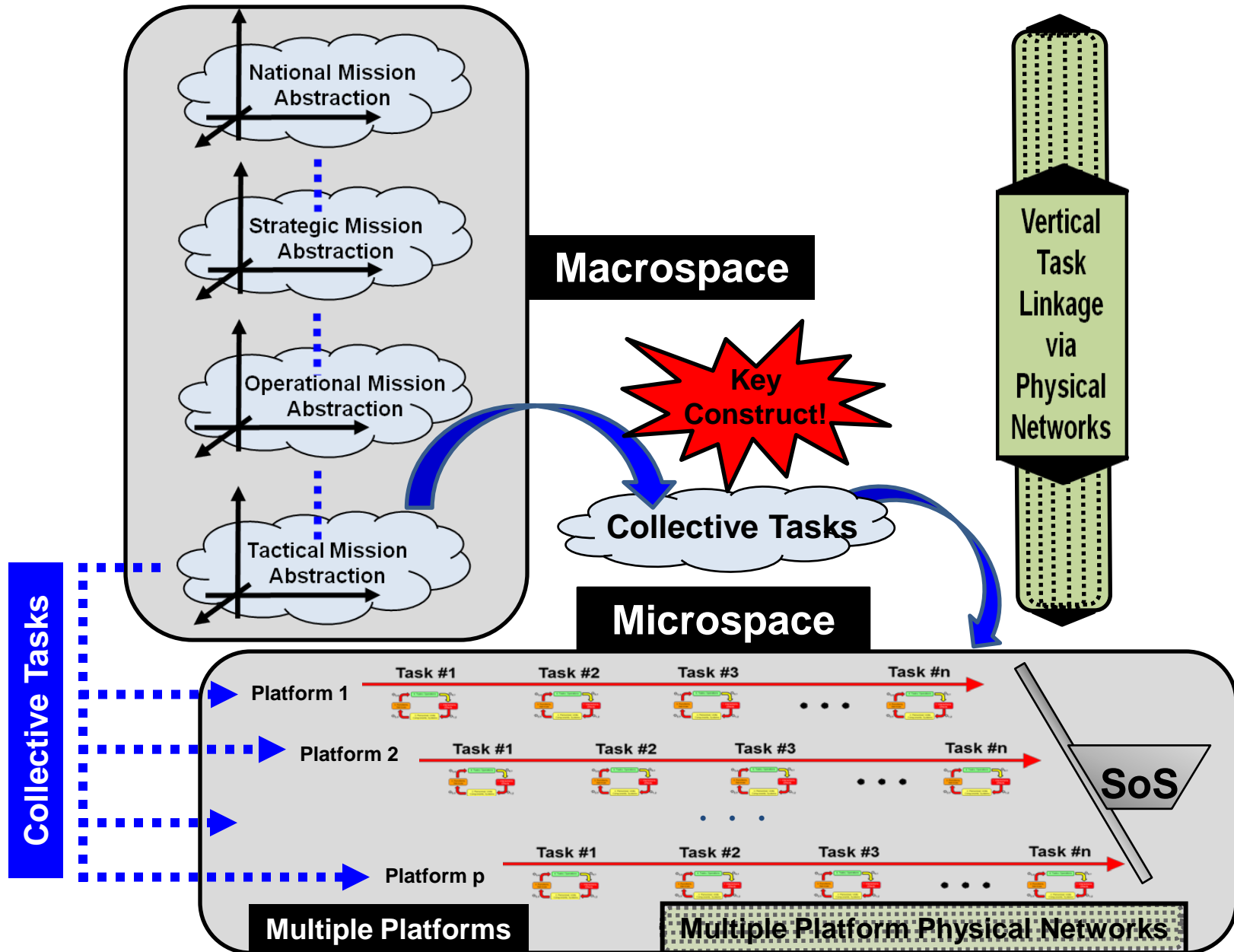


**Combat Represented by Physical Layers**

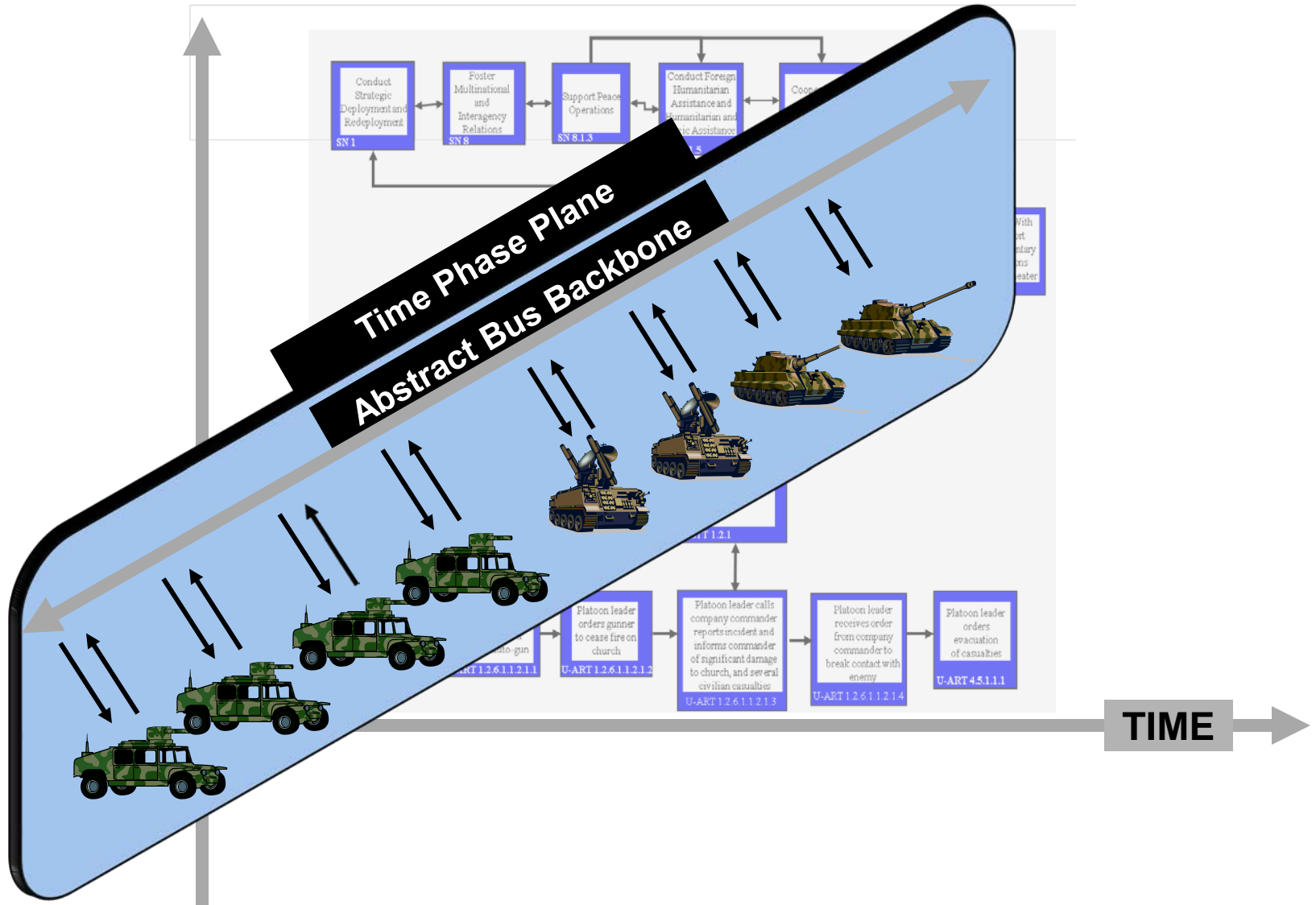
# Task Abstractions For a Single Platform



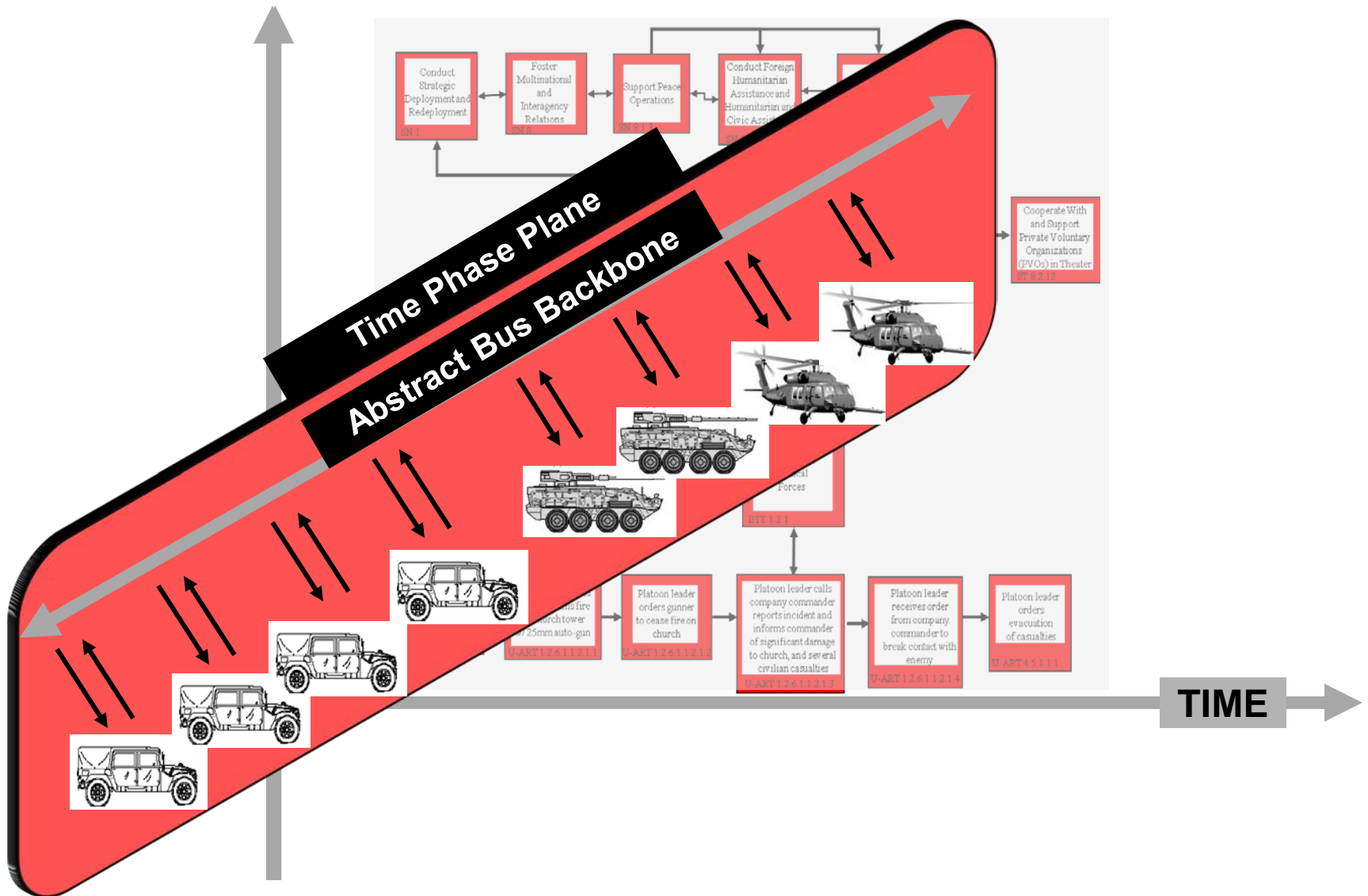
# Task Abstractions for Multiple Platforms



# OWNFOR Material Connects to Task Network

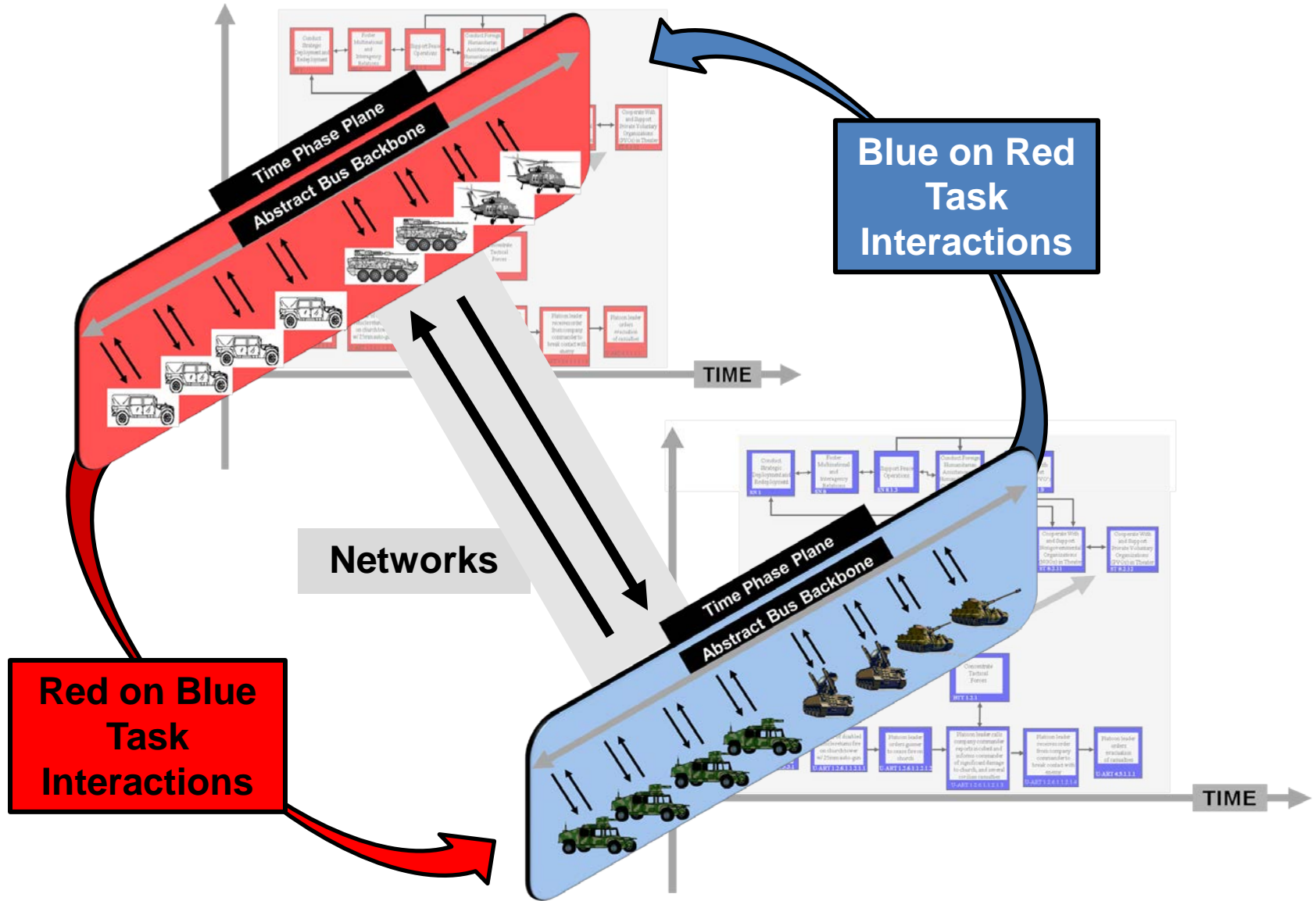


# OPFOR Material Connects to Task Network





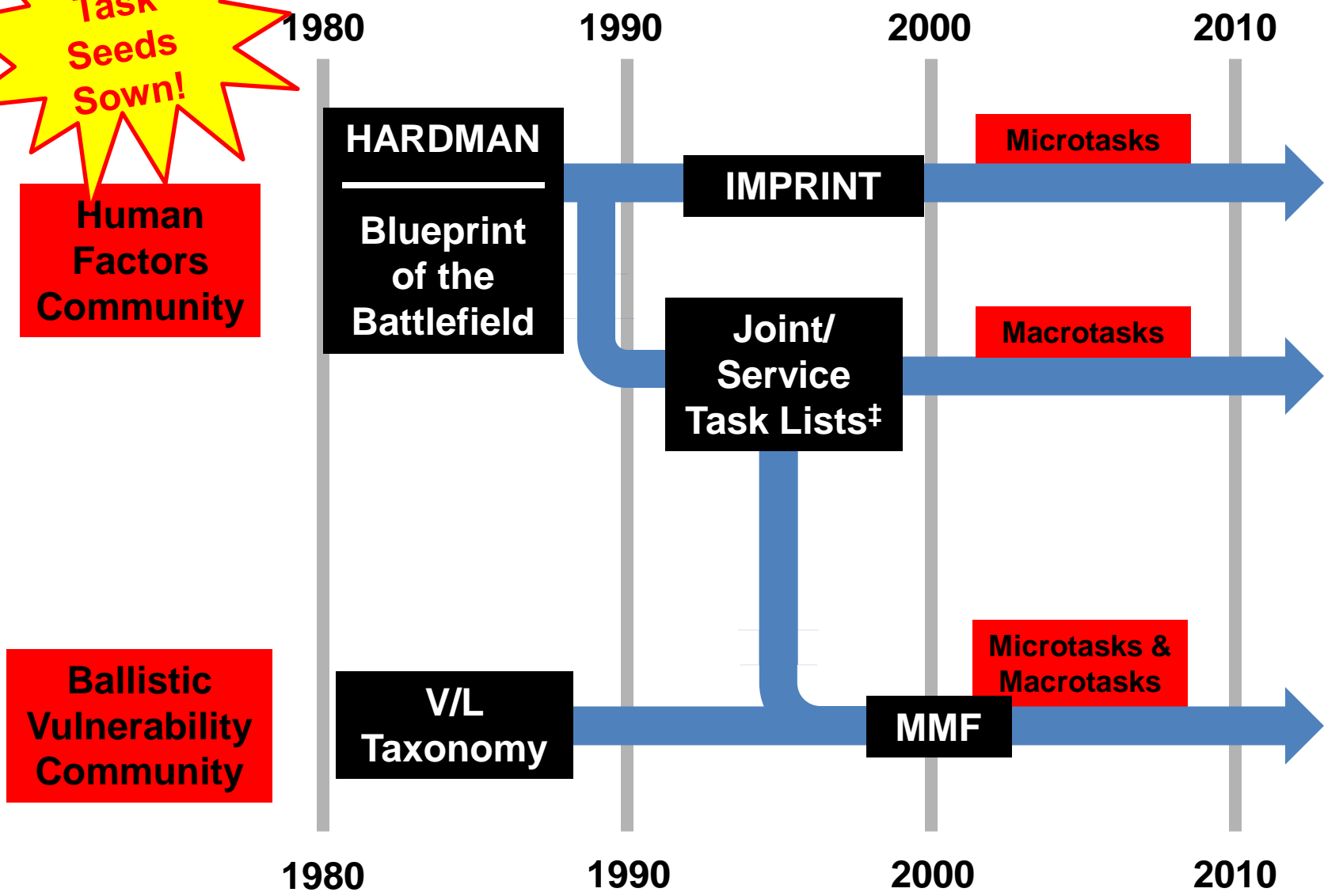
# OWNFOR and OPFOR Interact over Time





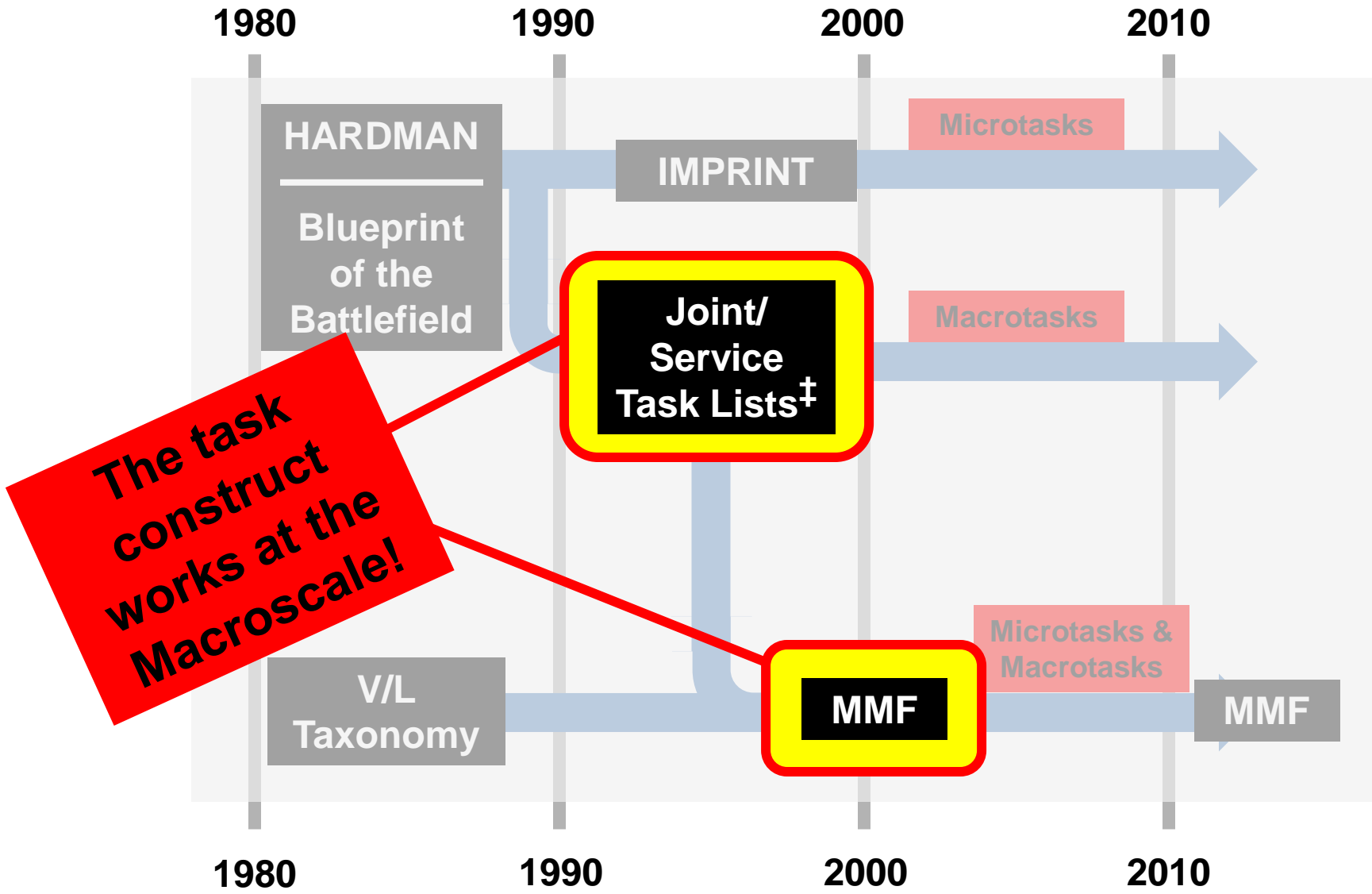
**The connection between Materiel  
and Human Performance**

# Origins/Applications of Military Task Formalism



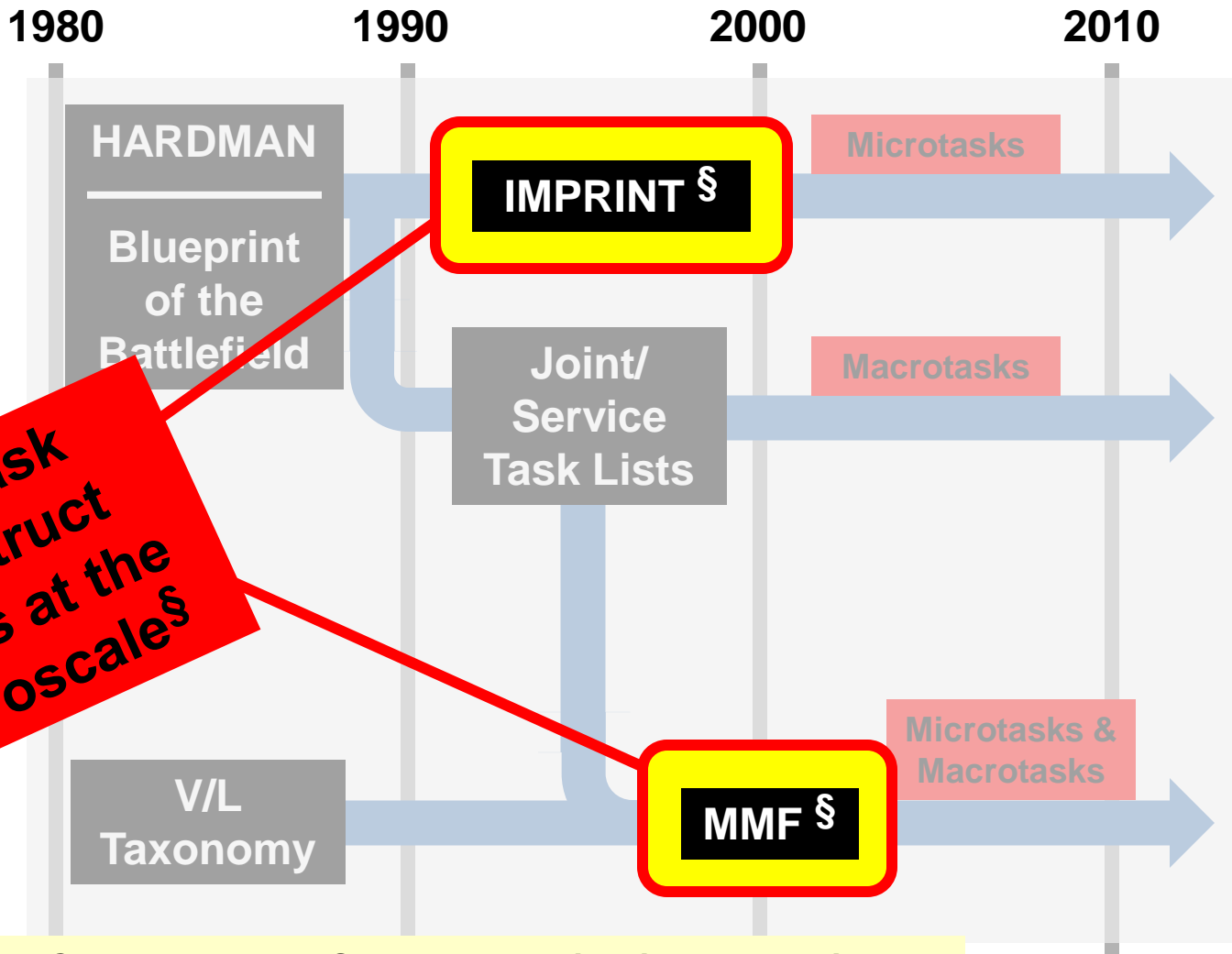
‡ In support of the MDMP

# Task Networks Infuse All Structures [1/2]



† In support of the MDMP

# Task Networks Infuse All Structures [2/2]



The task construct works at the Microscale§

§ *Mission Centered Human System Analysis*, Diane Kuhl Mitchell [Army Research Laboratory/ HRED] and Gene Brennan [Alion Science and Technology], 19 March 2008.

2010

# Summary [1/3]

- Many ORSA problems are Ill-Posed
- Using the MDMP:
  - Task networks [OWNFOR and OPFOR] linked by level-of-war/time
  - Interactions may occur between all platforms; need to accommodate dynamic component geometry.
  - Many possible networks, e.g. digital, mechanical, electrical, hydraulic, optical/visual, acoustic, . . .
- Mission success rolls up from task performance at DT/atomic level to task results at OT/collective levels

## Summary [2/3]

- **Top-down inferencing of task cycles provides the relevant measures of success, capability and material properties.**
- **Task interactions, both destructive and constructive, occur between both friendly and opposing forces.**
- **The methods employed by the Human Dimension community [IMPRINT] are fully integrable into the MMF construct.**
- **The fate of one platform can potentially affect any other.**

## Summary [3/3]

- **The effect of platform change depends on mission context. Criticality of platform damage/dysfunction is determined by closest logical proximity.**
- **The MDMP, though ubiquitous among Warfighters, is seldom used by the ORSA Community (e.g. in DT, LFT&E, OT, Mission-Based T&E) or to provide links to Human Factors analysis.**
- **Both the Macro and Micro worlds would be far richer were their task network analyses integrated and linked!**

**END**