Using M&S to Predict, Describe, Design and Execute Weapons Performance

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DOT&E Letter on M&S
(Mr. Christie, 4 June 2002)

- **Test as We Fight:**
  - Real warriors employing real combat systems conducting realistic missions and tasks in a representative physical environment.
- **Core T&E Processes:**
  - Prediction (hypothesis), planning (test design), data collection (test event), analysis (data verification), reporting (conclusion).
- **M&S Supports – but does not Replace – Testing:**
  - Before (sizing, scoping, design), during (stimulation, response), after (interpretation, significance, assessment).
- **Holistic:**
  - Constructive participation and engagement of key stakeholders through the iterative model, test, simulate, evaluate, cycle

Operational Challenges

Actionable, timely information is power in the battlespace:

- **Global reach to provide close support in complex terrain drives up the scope of sensor coverage while simultaneously requiring greater sensor resolution.**
- **Increased stand-off ranges and decreased collateral damage drives munition size down and precision delivery up.**
- **Each leap in scope, resolution, stand-off, and precision generates unprecedented need for integration and interoperability both across and within echelons**

  There is a compelling need for disciplined modeling, testing, simulation, and evaluation of operational concepts, materiel architectures, and mission utility throughout the product life-cycle.

Systems Engineering Challenges

Deciding what to become, what to build, and why is the most difficult (and highest risk) part of any transformation effort:

- **Non-information-technology components of materiel solutions are expensive, slowly evolving, long-lead elements both in development and manufacture.**
- **The underlying C4ISR technology is changing faster than operational capabilities can be conceived and implemented.**
- **The current state-of-the-practice is to generate voluminous requirements wish lists which:**
  - Have limited internal consistency and completeness enforcement,
  - Are alternately too vague to really specify or so detailed as to obscure the real need, and
  - No mere mortal could consume in a single lifetime.
- **Modeling languages and tools abound:**
  - Need rigorous, enforceable procedures to support semantic integration and substantive information exchange.

Domain Perceptions of Effectiveness Issues

For those that “build munitions for a living”

- **Lethality**
  - Stand-off ranges and sensitivity to collateral damage drives trades to small warheads with precision targeting
  - Range and precision drive cost/performance
  - “a hit is not necessarily a kill”
- **Vulnerability, Need**
  - Consistent methods for same weapon type, multiple target types (to assess applicability of a particular munition to the range of targets)
  - Consistent methods for same target type, multiple weapon types (to assess which of many weapons to pair with a particular target)
  - “a kill may not be needed to be effective”

Domain Perceptions of Survivability Issues

For those that “build targets for a living”

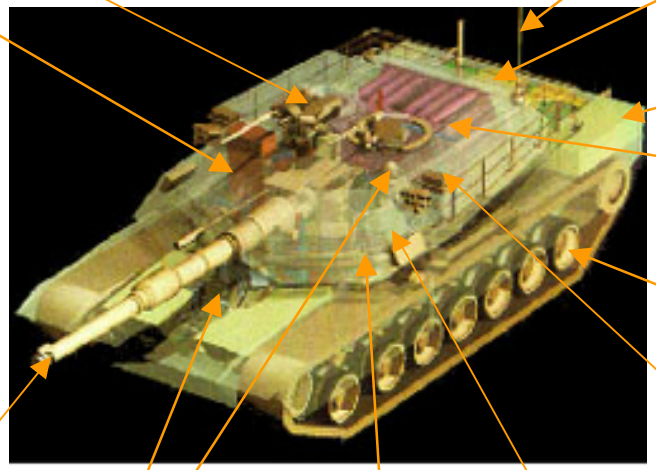
- **Fixed-Wing Aviation Targets**
  - “a hit is a kill”
  - Susceptibility reduction is the key to survivability
  - Av methodology focuses on single bullet/fragment vulnerability
- **Ground Warfare Targets**
  - “hits are inevitable”
  - Survivability is not feasible without vulnerability reduction features
  - AJEM* methodology focuses on multiple bullet/fragment vulnerability
- **Shipboard Maritime Targets**
  - “an intercept may not be enough”
  - Damage control is essential for survival
  - ASAP methodology focuses on collateral damage to redundant systems

***Advanced Joint Effectiveness Model**

Experimentation, Testing Challenges

- New and unconventional threats
- Substantial increase in operational mission complexity and required integration
- External encroachment on existing testing ranges and exercise facilities in the face of significant increases in geographic stand-off between new and emerging operational systems and targets
- Desire to simultaneously reduce the time-to-field new concepts/systems and reduce life-cycle systems costs
- Desire to increase experimentation, testing, and training realism while simultaneously reducing costs, and
- Need to integrate modeling and simulation into field experiments and exercises.

Example: Platform Configuration
Level 2



Secondary Armament

Early Warning Sensors (LWR, RWR, MWR)

Move

Shoot

Communicate

Main Armament

Crew

Millimeter Wave Radar Antenna

Commo Equipment

Target Acquisition/Engagement Sights

Commo Equipment

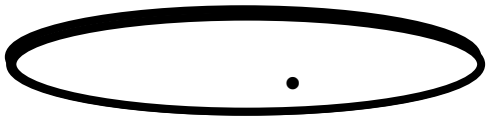
Wheels/Track

Ammo Compartment

Fuel

Engine Compartment

Abstraction: Platform Configuration
Level 2

Level 2] 

$v_2[C_1, C_2, \ldots, C_c, C_d, \ldots, C_i, C_k, \ldots, C_m, C_n]$

Crew Ammo Fuel Msn Crit

Re-Armed and Re-Fueled

H + 7 Hour

Military Operations Context

- Tactics
- Doctrine
- Scenario
- etc. (Global Variables)

Testing for Platform Capabilities

Level 3

Move

Communicate

Sense

Engage

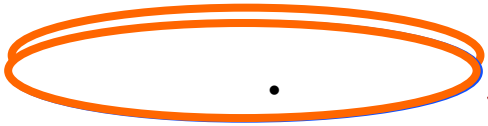
Replenish

Abstraction: Platform Capabilities
Level 3

Military Operations Context

v_3[Top Speed, Max Range, Rough Terrain Capability, ...
Rate of Fire, Time to Acquire Tgt, Hit Dispersion, ...
ata Rate, Data Latency, ...]

Level 3]

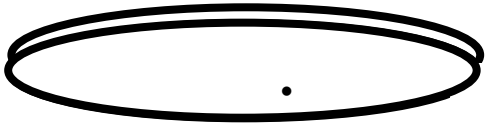


- Tactics
- Doctrine
- Scenario
- etc.

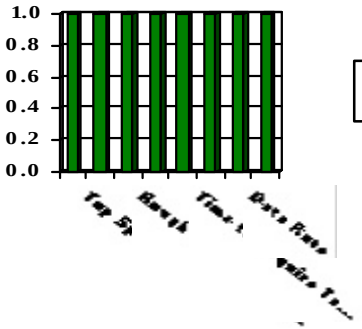
(Global Variables)

$O_{2,3}$ Operator

Level 2]



Context Data



H + 7

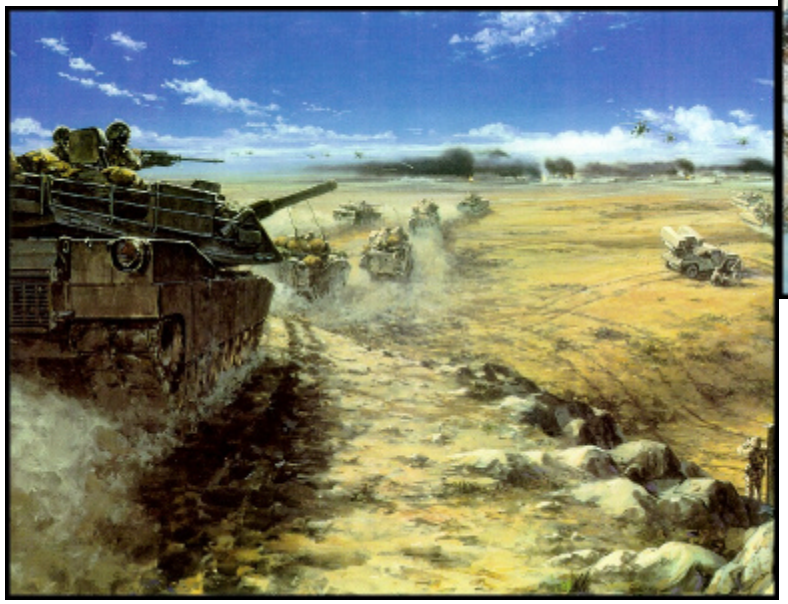
Mission Utility from Capabilities

Level 4

Effectiveness?

Performance?

Lethality ?

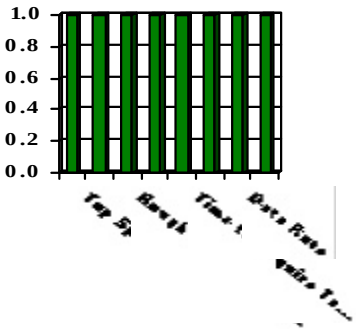


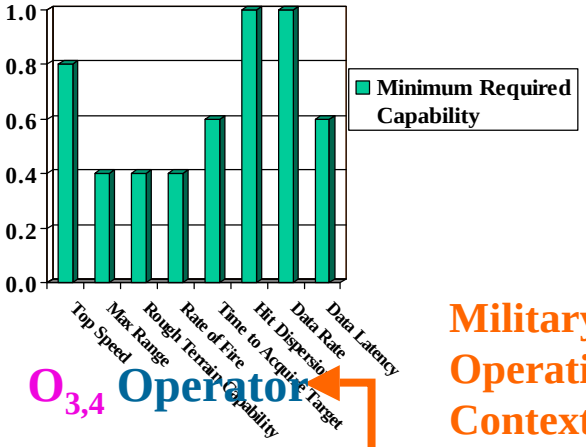
Survivability ?

Loss/Exchange ?

Readiness ?

Abstraction: Platform Utility
Level 4





Level 4]

H + 7

Level 2]

$O_{3,4}$ Operator

Msn Cap Reqs

Military Operations Context

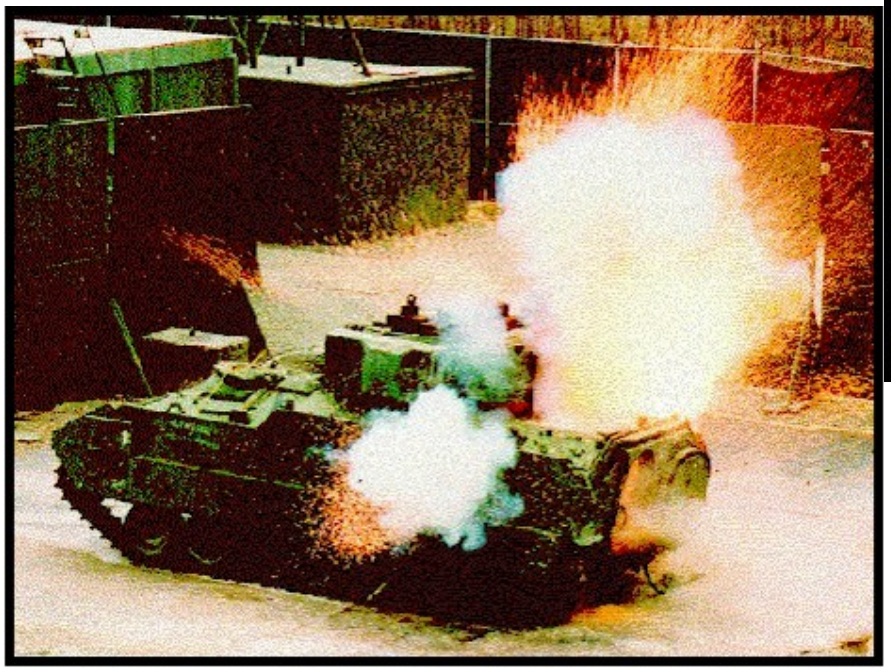
- Tactics
- Doctrine
- Scenario
- etc.

(Global Variables)

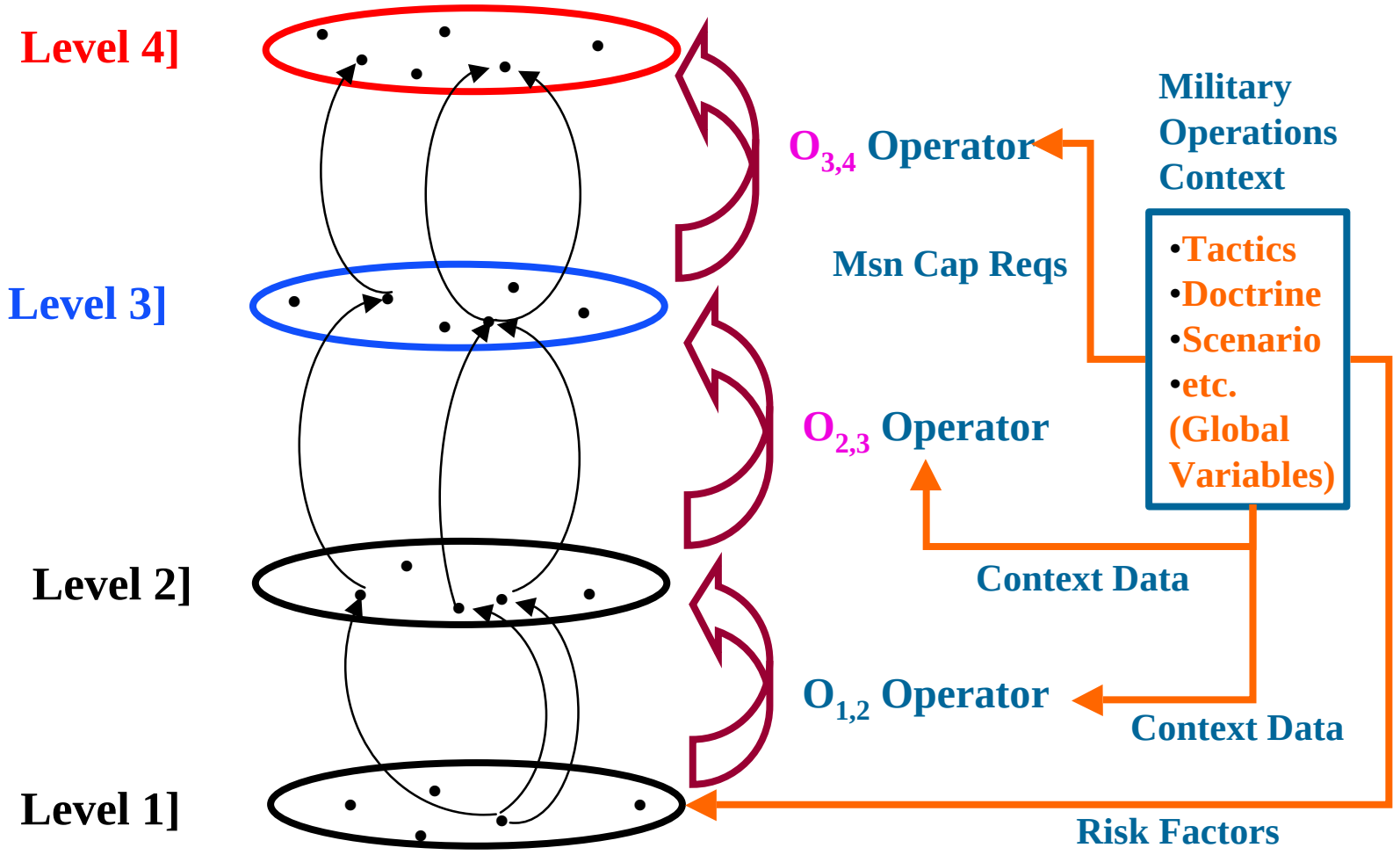
$O_{2,3}$ Operator

Context Data

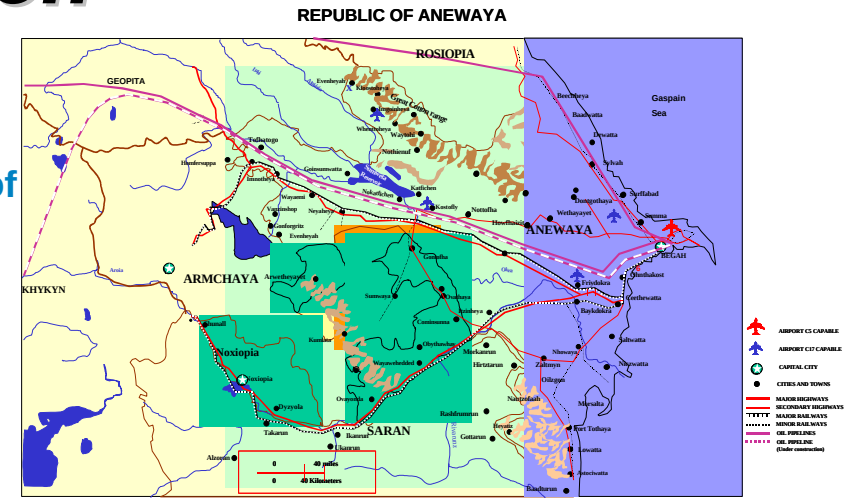
Physical Analogues for the O1,2 Operator



Abstraction: Platform Live-Fire Test Operator



Situation



Road to War

- Legitimate, pro-Western Government of Country of Interest is overthrown by radical elements and forced into exile.
- Majority of Country of Interest conventional military forces are loyal to new government.
- United States and its coalition partners believe national interests and regional stability are threatened. They take military action to deter Hostile Country involvement in Country of Interest, to remove radical elements from power, restore legitimate, pro-western government, and to stabilize region and protect US and coalition vital interests.

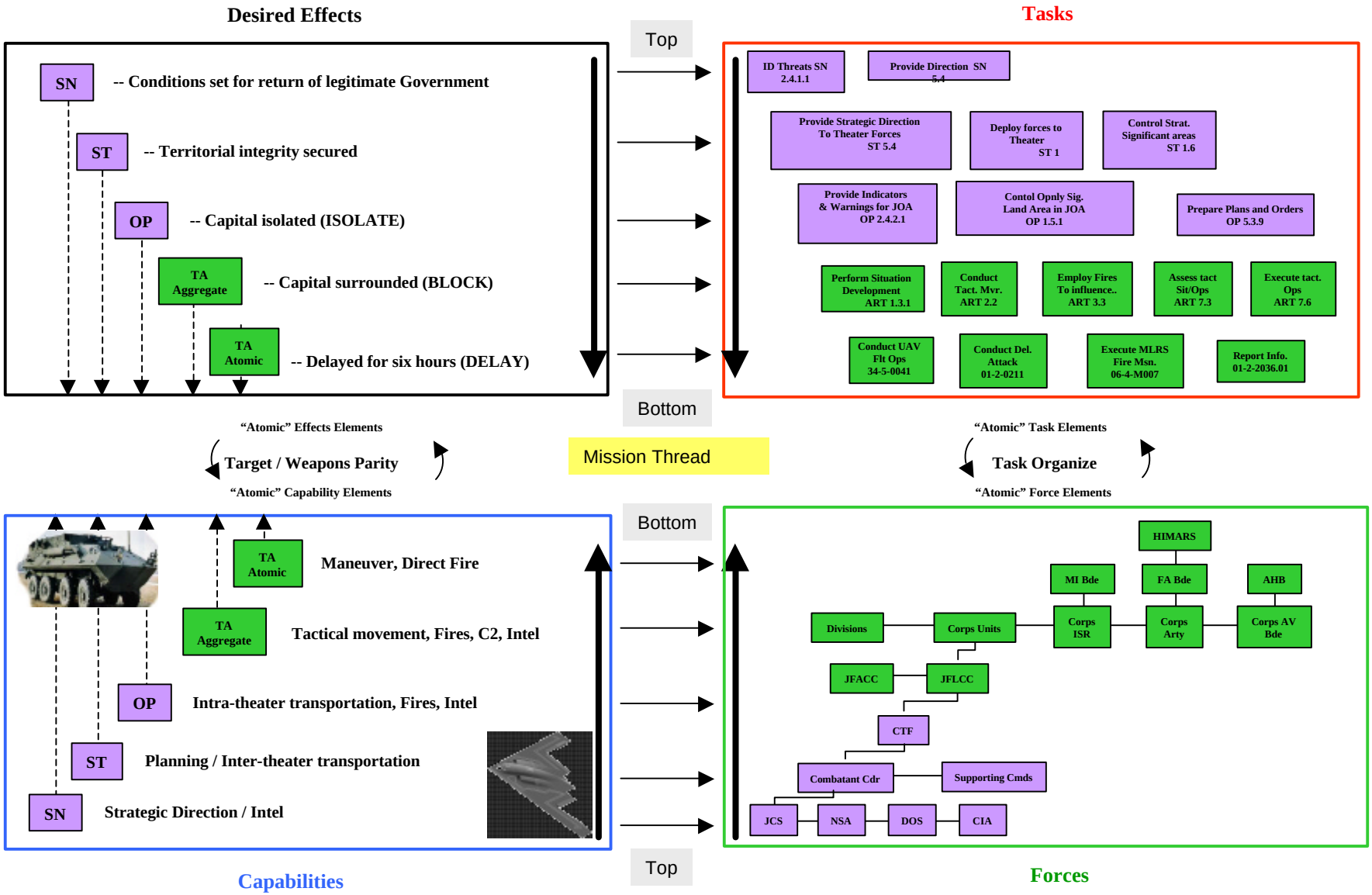
Current Situation

- Coalition forces have commenced offensive ground operations in Country of Interest to defeat conventional forces loyal to radical government and isolate radical government leadership inside Capital of Country of Interest.
- Conventional forces from Hostile Country to the south, have begun massing on the border with Country of Interest.

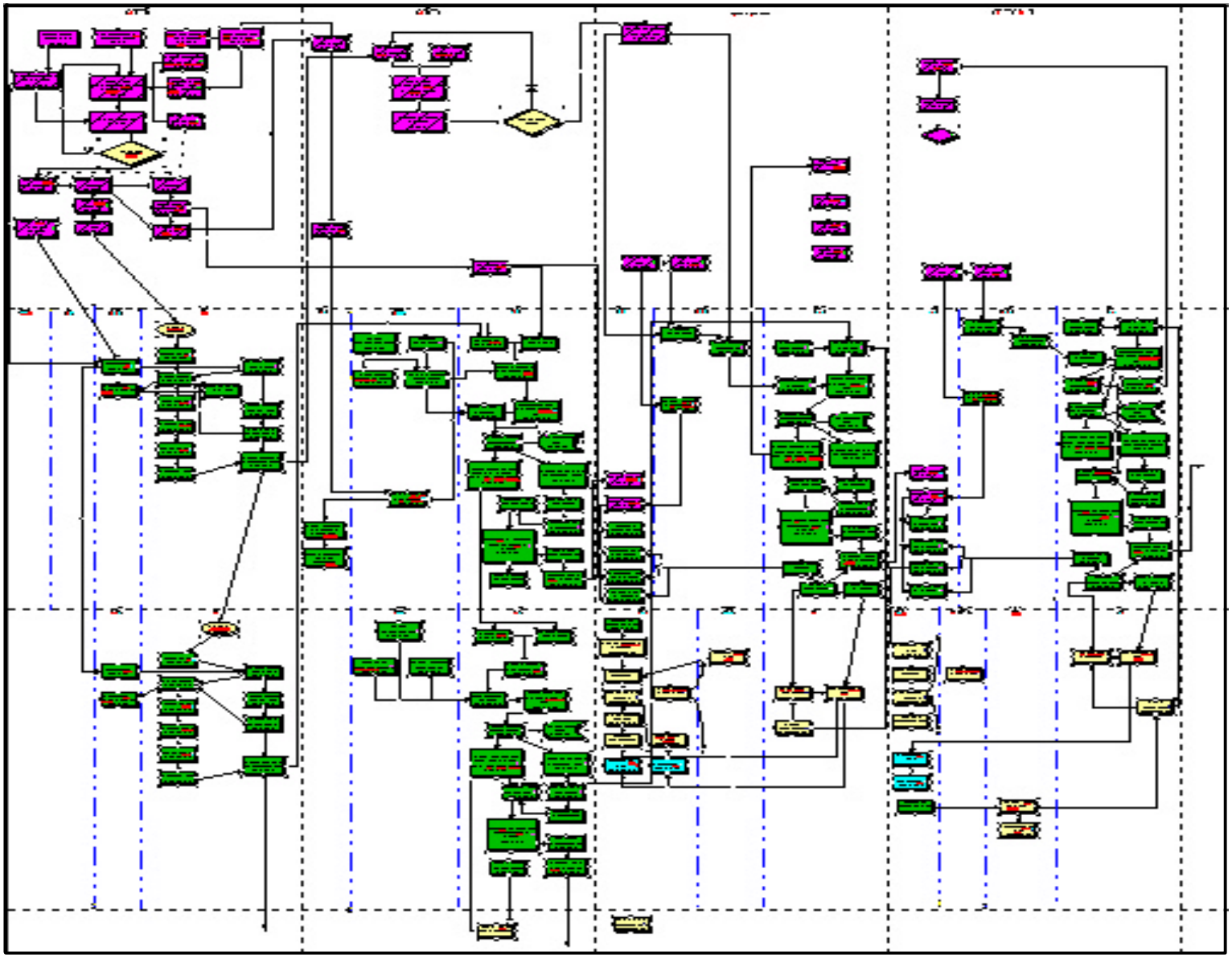
Mission

- CJFLCC intends to prevent Hostile Country from reaching Capital of Country of Interest by blocking access to the main north/south road into Capital. He anticipates need to delay movement of Hostile Country forces north long enough for the Heavy Division to occupy defensive positions astride main north/south road.

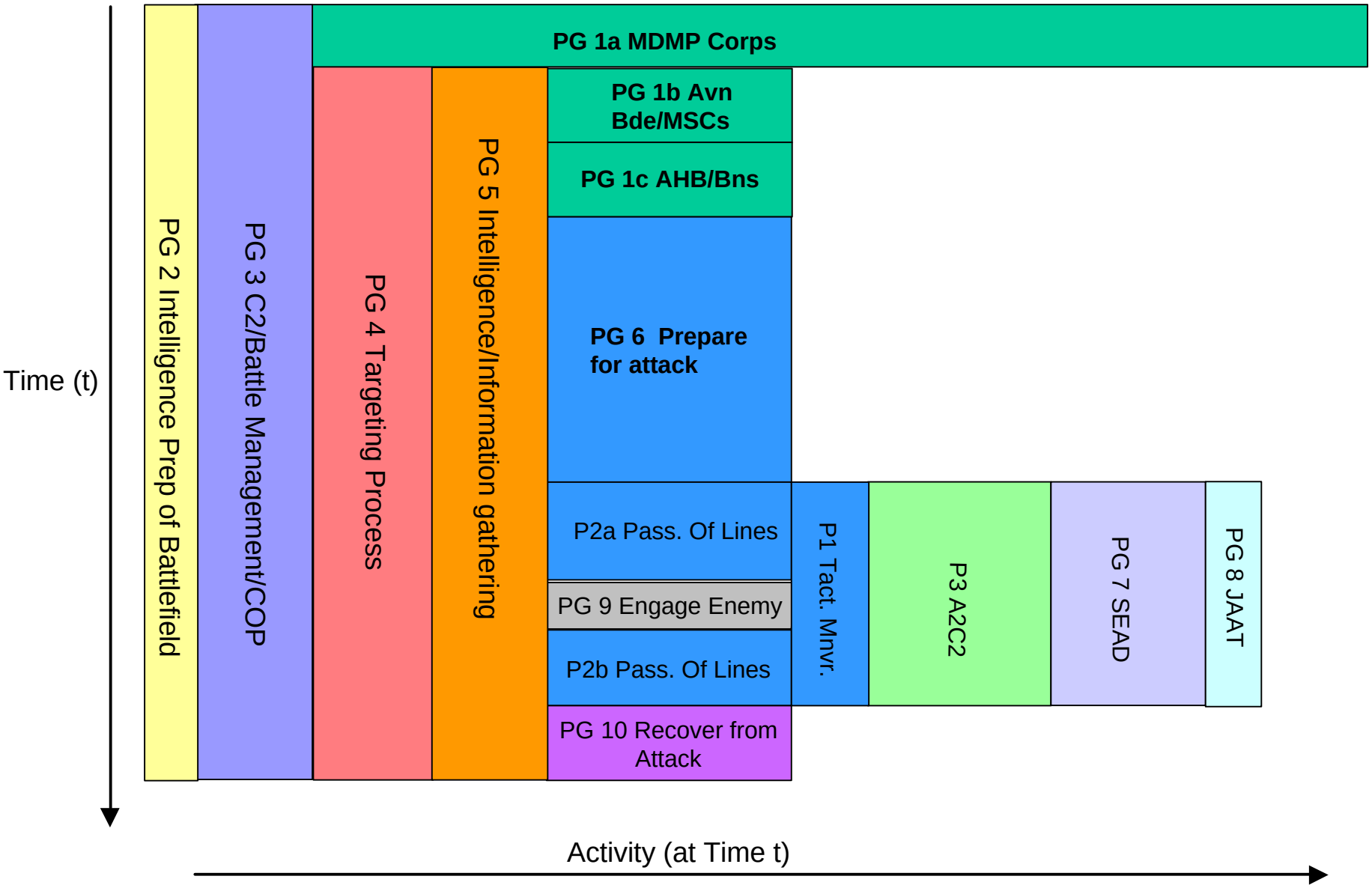
Framework Illustration



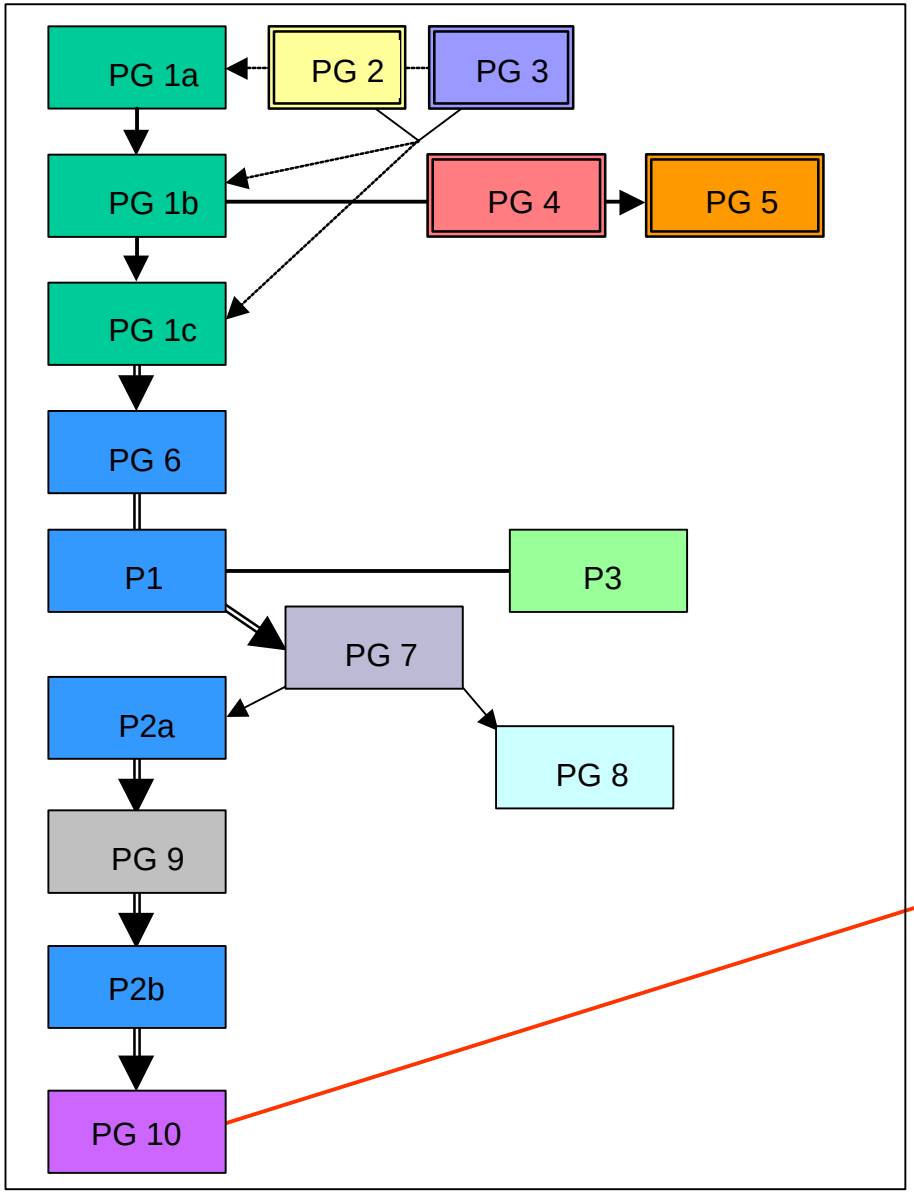
Task Explosion



Deep Attack Process Group



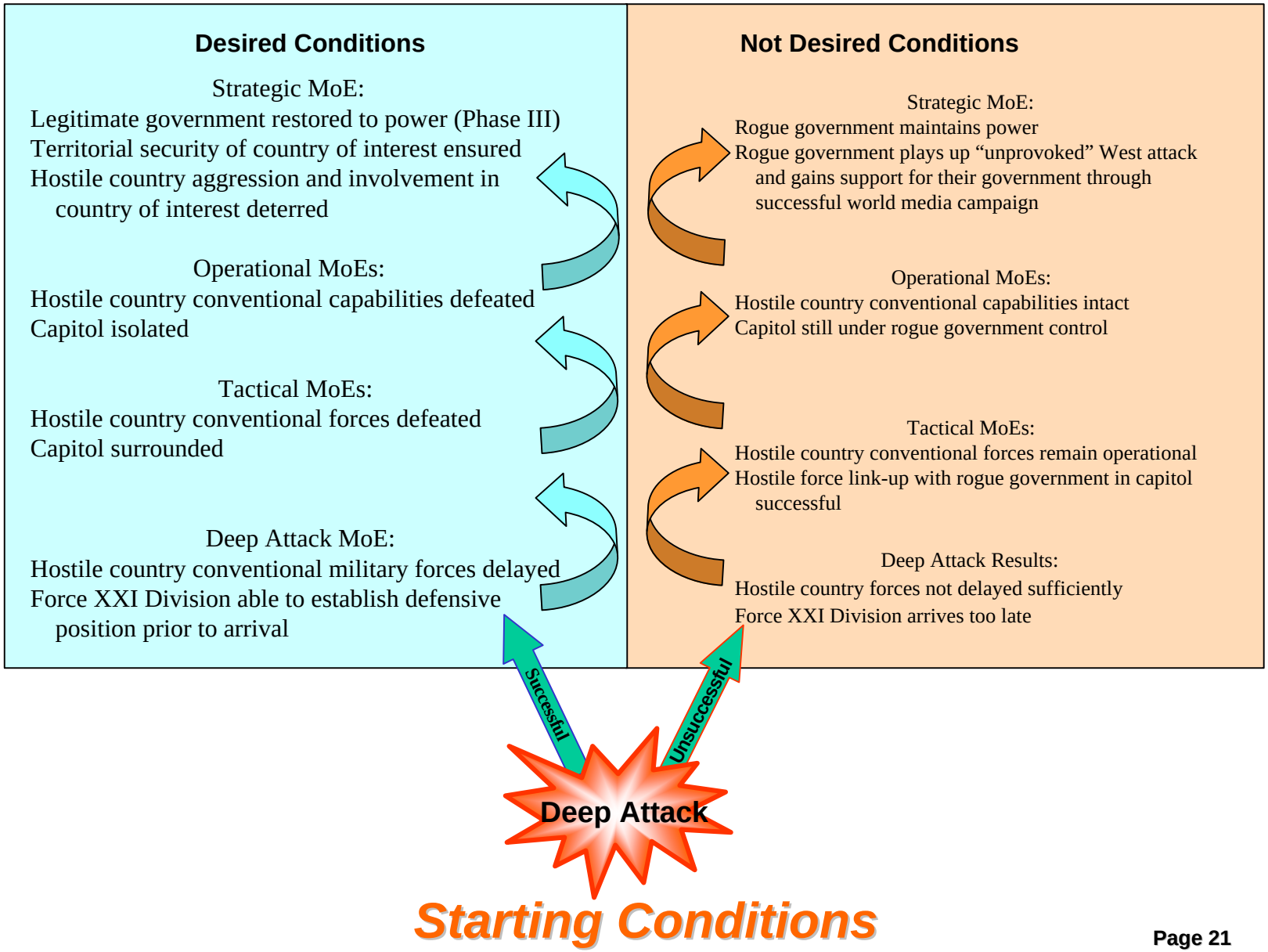
Deep Attack Process Group



- Start Process Group 1a first.
- PG 2 and PG 3 are continuous and feed into PG 1a, b, and c
- PG1b, 4 and 5 begin during PG 1a.
- PG's 4, and 5 are continuous. PG 1c begins during PG 1b.
- PG 6 follows PG 1c.
- P1 and P3 begin when PG6 ends and end when PG 10 begins.
- PG 7 begins after P1 begins and before P2a begins and ends when P2b ends.
- P2a and PG 8 begin during PG7.
- PG 9 begins after P2a.
- P2b begins after PG 9.
- PG 10 begins after P2b
- Deep Attack Process Group ends when PG 10 is complete

MoE: Country of Interest conventional military forces delayed long enough for Heavy Division to establish defensive position blocking progress north to Capital.

Relating Mops to MoEs



Stating the Problem "the same old Physical Capabilities way"

Mission:
- **Main Battle Tank closes with and destroys enemy**

Key Performance Parameter:
- **90% probability of kill at 5000 meters.**

Will inevitably constrain the range of solutions to " the same old… "
Monolithic Single-Platform, Mechanically-Integrated Physical Hunter-Killer

Stating the Problem "the emerging Mission Capabilities way"

Mission:
- **FCS halts OPFOR advance by drawing the enemy into the open for destruction by an affordable combination of direct and indirect fires.**

Key Performance Parameter:
- **Prevent OPFOR firing platform closure to lethal firing positions on manned FCS platforms using awareness, stealth, mobility, and fire.**

Will open the range of solutions to consider " the emerging… "
Distributed Multi-Platform, Digitally-Integrated Virtual Hunter-Killer"

Backup Slides

Definition of Measure

- **Measures distinguish among varying levels of task performance. More than one measure may be specified for any single task.**

Task:

- **OP 2.2.1 Collect Information on Operational Situation**

Measures:

SCALE	MEASURE
Time	To retask collection asset
Time	Since most current intel. info. was collected
Percent	Of collection requirements filled
Percent	Of collection reqmts filled by multiple sources
Percent	Of targets accurately located
Percent	Of targets accurately identified

MISSION-BASED TASK STANDARDS

Standards express the degree to which (how well) a military organization or force must perform a task* under a specified set of conditions.

A criterion defines acceptable levels of performance for a measure and is often expressed as a minimum acceptable level of performance.

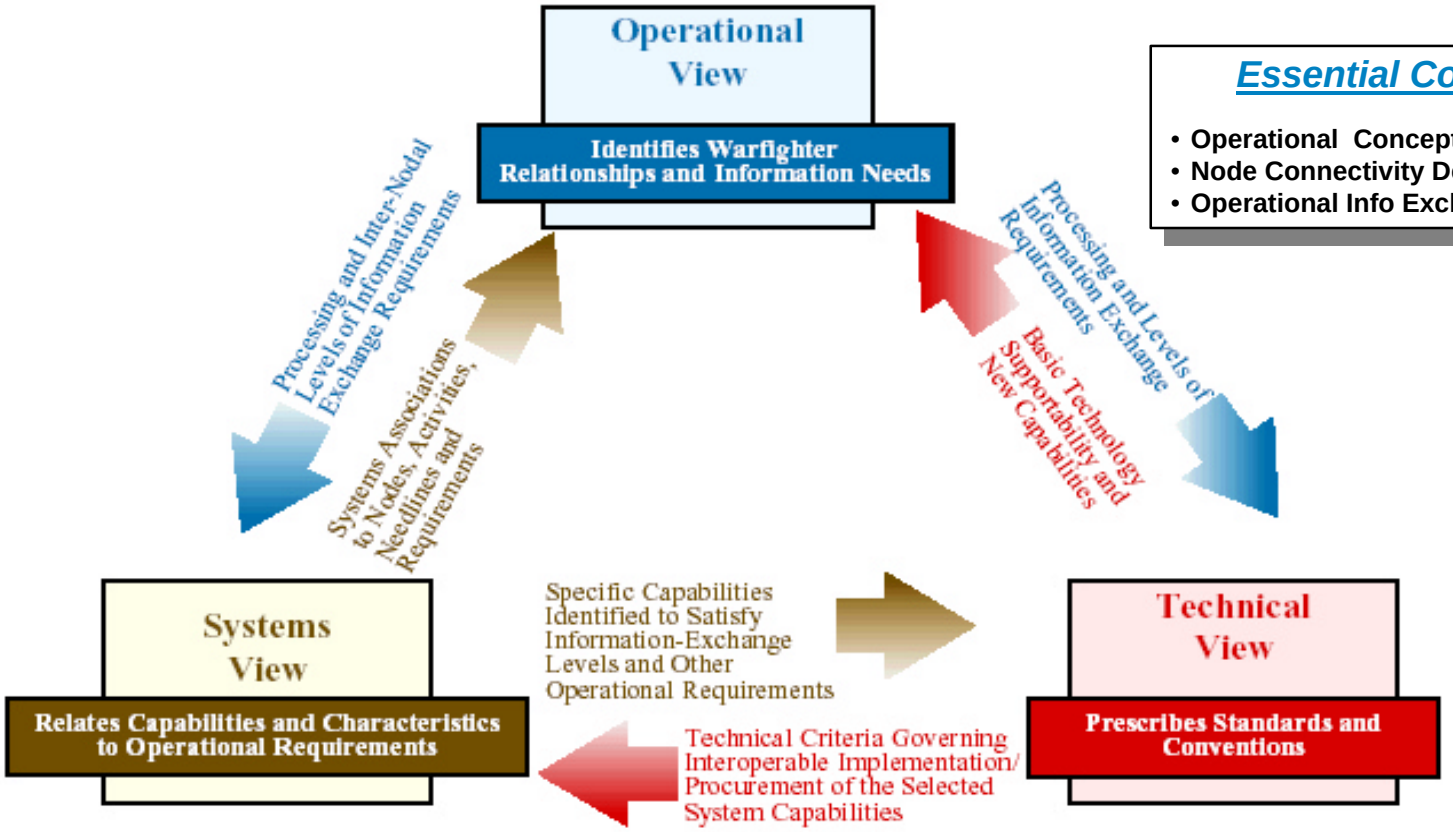
Standard:

Criterion	Scale	Measure
100	km x km	sector search area
5	minute	sector search time
90	percent	probability of detecting threat
1	percent	false alarm rate

***e.g.;** **Collect Information on Operational Situation (OP2.2.1)**

C4ISR Architecture Framework:

Operational Architecture captures mission requirements



Essential Content

- **Operational Concept Graphic**
- **Node Connectivity Description**
- **Operational Info Exchange Matrix**

The operational architecture view is a **description of the tasks and activities, operational elements, and information flows required to accomplish or support a military operation**.

Source: C4ISR Architecture Framework, Version 2.0, 18 Dec '97