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The Power of Information Age Concepts and Technologies

Applying Executable Architectures to Support Dynamic Analysis of C2 Systems

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Agenda

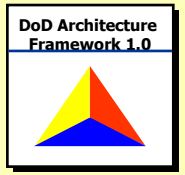
- Start With Integrated Architecture Descriptions
- Transition To “Dynamic” Executable Models
- Dynamic network and communication
- Federation of Simulations
  - Executable operational architecture
  - Executable communications architecture
  - Combat Simulation
- Measures of Merit
- An Example of Execution Results

Definition: Executable Architectures

- **Static Architecture Models only show that Activities "*must be capable of*" producing and consuming Information**
  - **No details on event sequencing**
  - **No details on how or what conditions information is produced/ consumed**
  - **No details on producers/ consumers themselves or other resources used**
- **Dynamic (over time) Executable Architecture Models go beyond "*must be capable of*"**
  - ✓ **Defines precise sequential/ concurrent event model**
  - ✓ **Defines precisely under what conditions Information is produced/ consumed**
  - ✓ **Defines details on producers/ consumers (number and process ordering) and other resources (when [not] available)**

Dynamic model of Activities and their event sequencing performed at Operational Nodes by Roles (within Organizations) using Resources (Systems) to produce and consume Information

Start With Integrated Architecture Descriptions

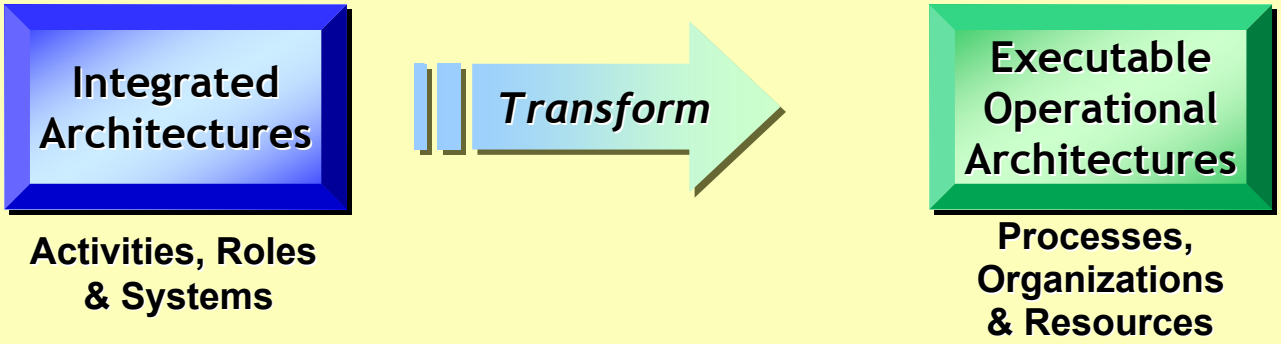


DoD Architecture Framework v1.0 DODAF

- Before you can use architecture descriptions for any analysis purposes **you must first have an architecture** that is
  - **Integrated, unambiguous, and consistent**
- What's an Integrated Architecture (IA)?
  - (1) DOD Architecture Framework (DoDAF): AV-1, AV-2, OV-2, OV-3, OV-5, SV-1, and TV-1 (*+ OV-4 the forgotten product, key to DOTLMPF*)
  - (2) Integrated Operational and System views *within* a single architecture and among *multiple* architectures
- Most architectures are ***static*** representations of activities, roles, systems, nodes, …
- Must supplement static representations with **Dynamic** models of time-dependent behavior models of processes, organizations, and resources
  - Enables a more expanded and comprehensive analysis
  - Support funding decisions, acquisitions, system engineering

Approach To Dynamic Architectures

1. Develop fully **integrated, unambiguous, and consistent** DODAF views within single architectures and among multiple architectures
    - Enable both "**As-Is**" (now) and "**To-Be**" (future) architecture development, gap-analysis, and assessment
    - **Data centric** approach for architecture element and product rendering and cross-product relationships based on core set of architecture elements
    - Capture sufficient representations of architectures to build "dynamic" executable process models
2. Transform integrated "**static**" representations to "**dynamic**" time-dependent behavior models in an executable M&S tool



Transition To "Dynamic" Executable Models

"Static-Land"

Time / Cost Properties

"Dynamic-Land"

Leaf Operational Activity +

Processing time and its statistical time distribution + average wait time before processing + continuation strategy + **cost$** + Input conditions + Output conditions

→ Process

Activity, Task

Information Exchanges →

\+ Transport time and its statistical time distribution + quantity + **cost$**

→ **Connections between Processes**

Sends Info

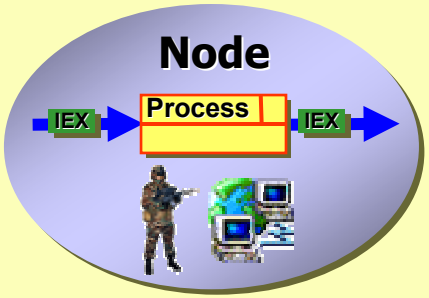
\+ Hourly and fixed **cost$** + single/periodic unavailability times + set up time + capacity (quantity) + processing strategy (FIFO, etc.)

→

Roles, Systems

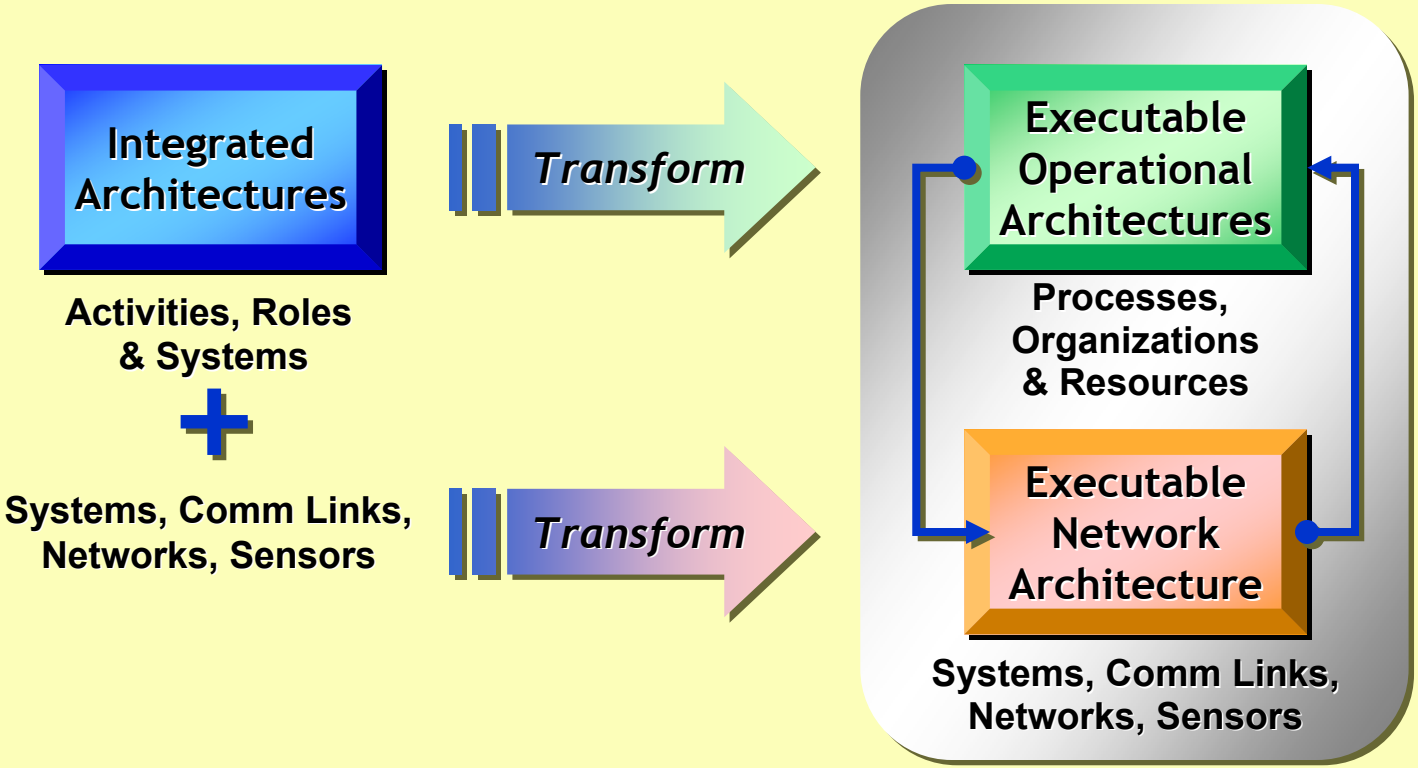
Resources

Resources, Job Titles

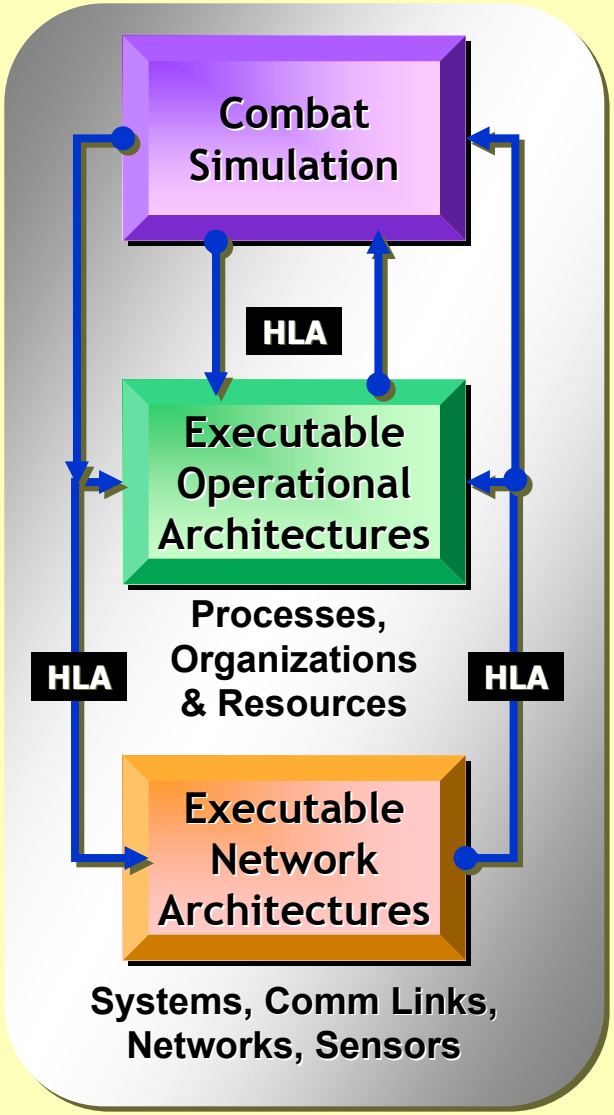


However, Dynamic Process Models Are Incomplete

- Must consider related **dynamic communications network** exchanges of informational elements over networks from producer to consumer
- Enables dynamic analysis of process flow, organizational structure supporting processes, information flow and use of resources



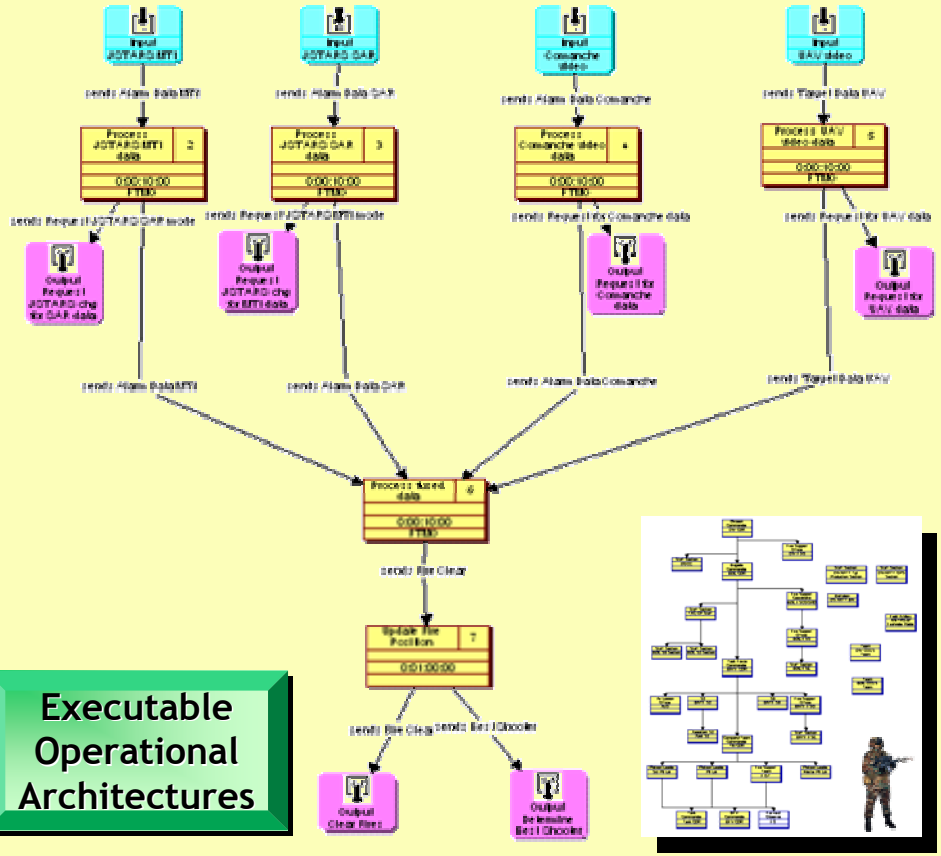
Federation of Simulations



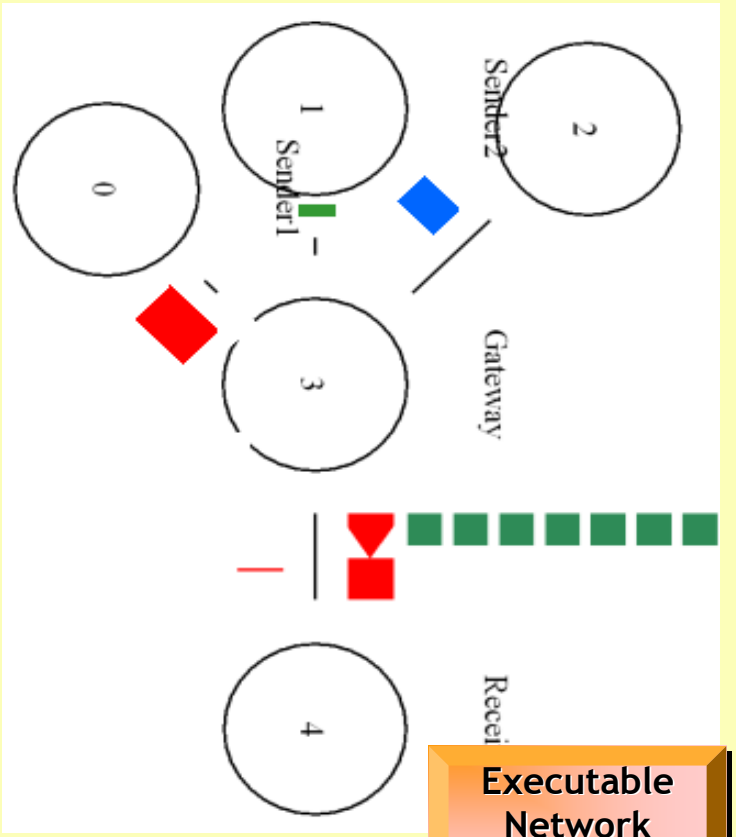
- Extend integrated operational/ communication executable architecture to link to combat simulation
  - Represents mission scenario generator
  - Provides different mission "stimuli (triggers)" to drive operational/ comm architecture.
  - Supports analysis and examination of how forces behave under different mission parameters and conditions
- Develop federation of simulations that represent mission threads (business processes), communications networks, and operational environment
  - Measure and assess Performance (MOP) & Effectiveness (MOE) as well as Force Effectiveness (MOFE)

Executable Architecture Models

Combat Simulation



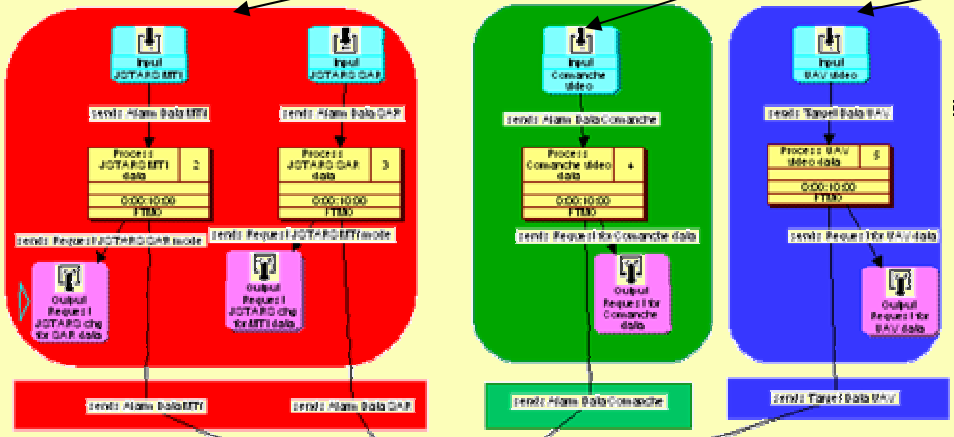
Executable Operational Architectures

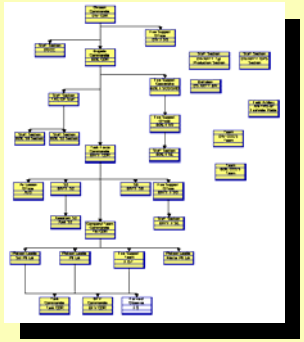


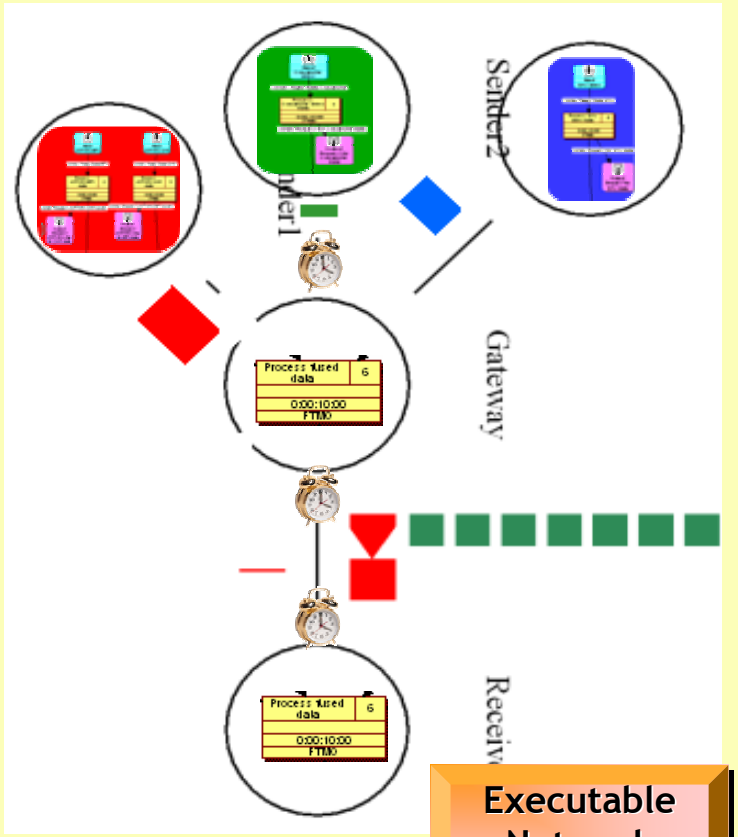
Executable Network Architecture

Mapping Executable Architecture Models

Combat Simulation







Executable Operational Architecture

Executable Network Architecture

HLA

Time-Related Measures of Merit

- Time to complete a task or group of tasks
  - Delay due to bottlenecks – (human or mechanical) resource not available
  - Consider:
    - Increasing number of resources (permanent or temporary increase)
    - Having resources available more often
- Time to send information
  - Delay due to inability of comms network to transmit/receive information
  - Delay due to interdependence of tasks within a process
  - Consider:
    - Alternate ways of communicating information among resources
    - Automation of manual tasks

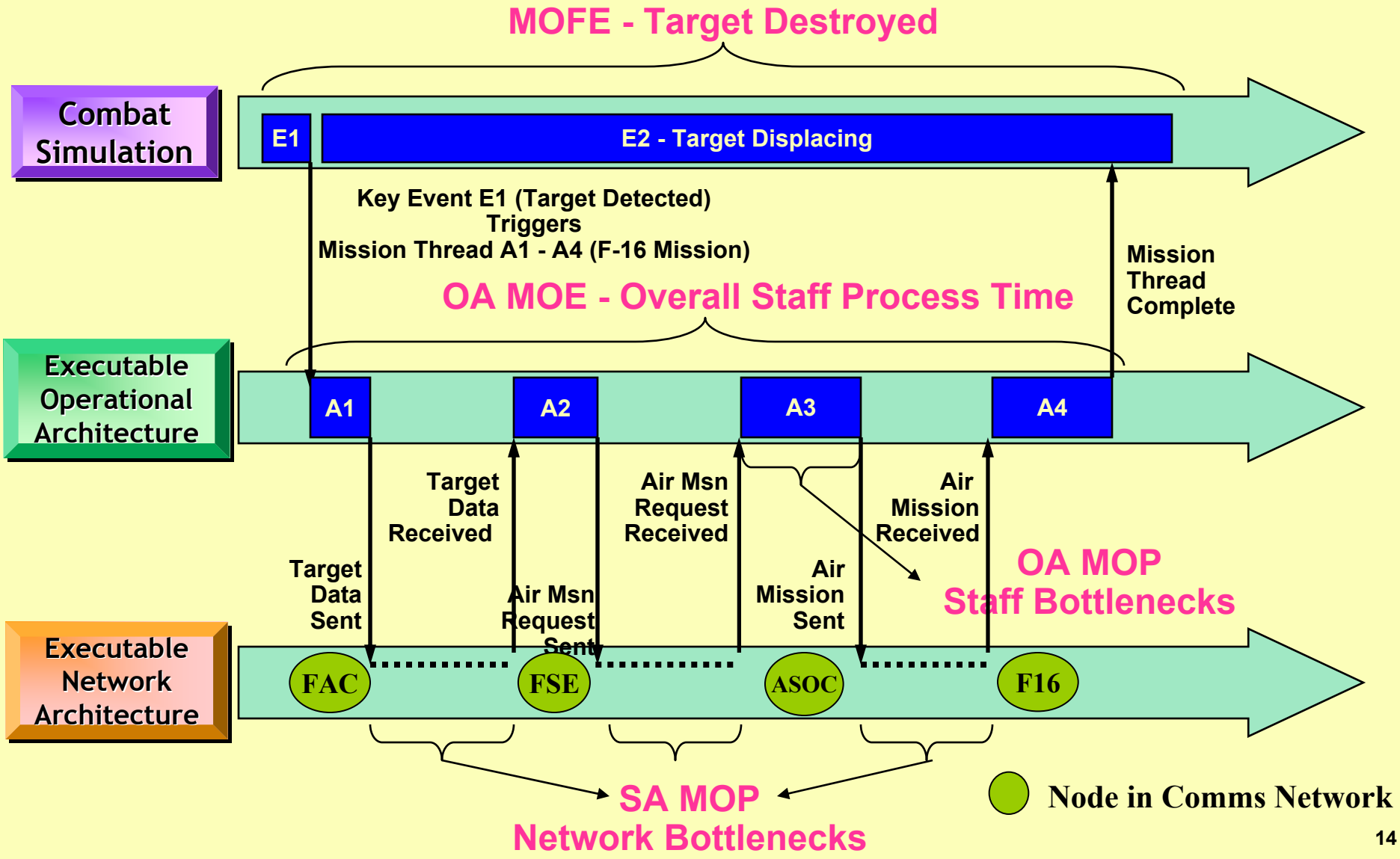
Resource-Related Measures of Merit

- Utilization of Resources (Human or Mechanical)
  - Bottleneck (Overutilized)
  - Idle (Underutilized)
- Cost of Resources
  - Static (Pricetag)
  - Dynamic (Operating Cost)
- Marginal Utility of Additional Resource
  - Benefit gained by adding additional resource
  - Cost of additional resource

Reliability-Related Measures of Merit

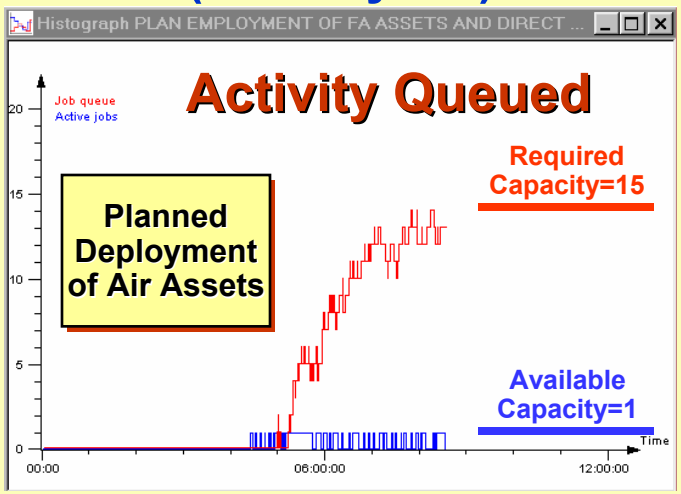
- Health of the Operation
  - Impact of single point of failure
    - Mission Failure
    - Loss of Life
    - Task Failure
    - Minimal Impact
  - Availability of alternate/back-up resources when they're needed
- Recoverability
  - Time to recover from a failure
  - Adaptability to changes in environment
    - Time
    - Quality
    - Mission Success
    - Losses
  - Graceful degradation
    - Mission tasks completed prior to shutdown
    - Mission accomplished prior to status changed to combat ineffective

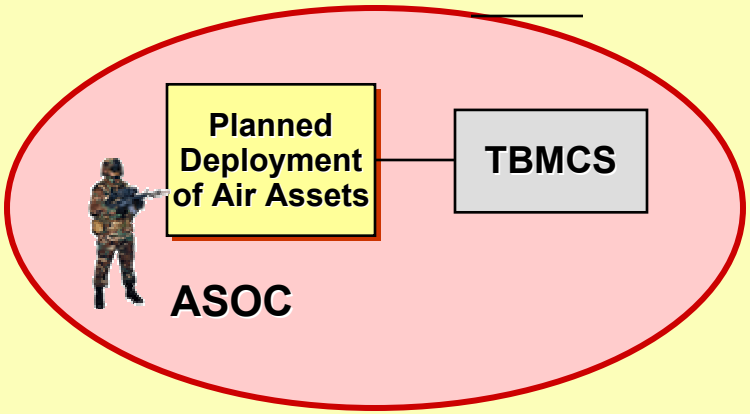
Model Interactions & Sample Measures of Merit



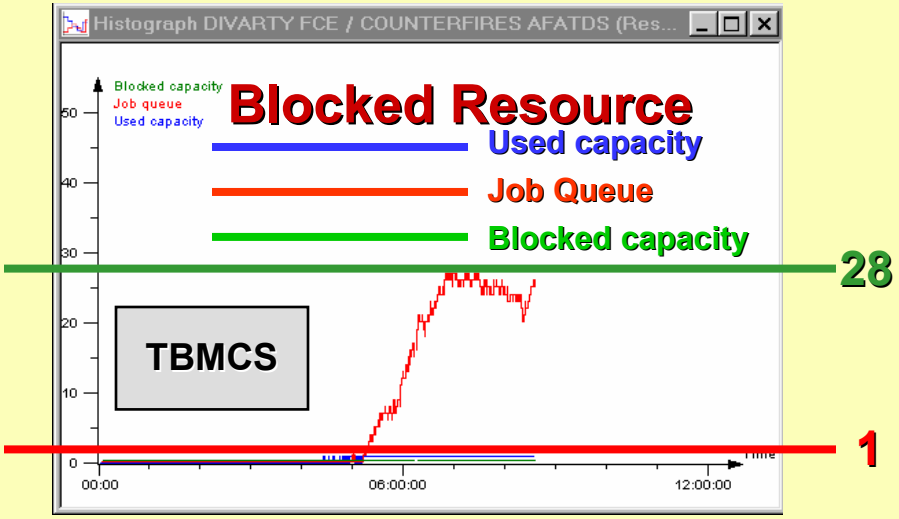
Execution Results: For Staff Size of 1
Exceeds Capacity - Everything Blocked

Planned Deployment of Air Assets (Activity A3)

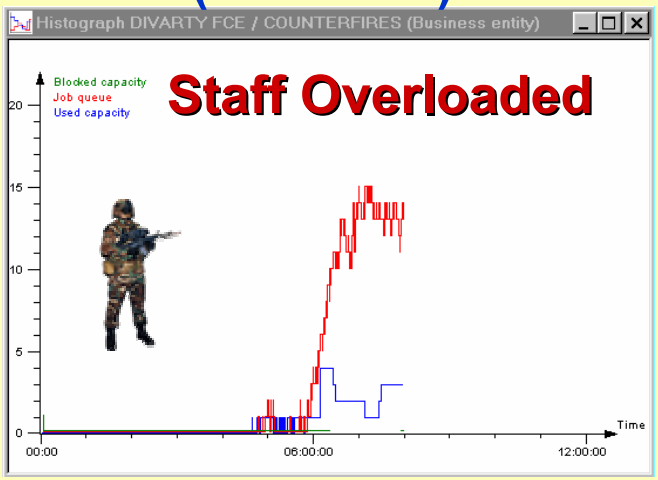




TBMCS (# of Resources = 1)

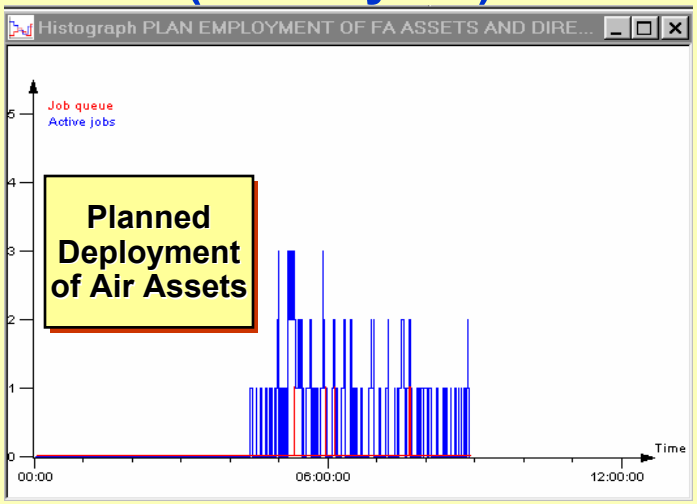


ASOC (Staff of 1)

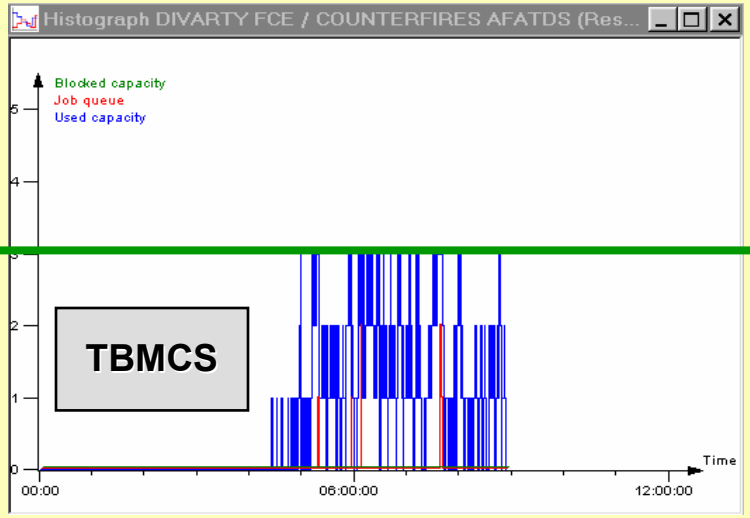


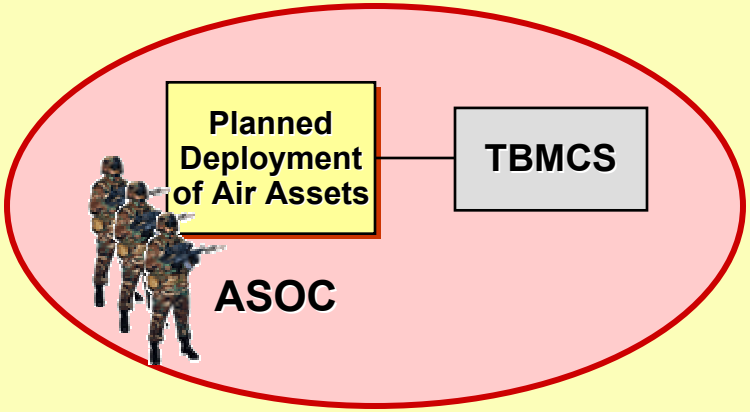
Execution Results: For Staff Size of 3
Everything Within Capacity

Planned Deployment of Air Assets (Activity A3)

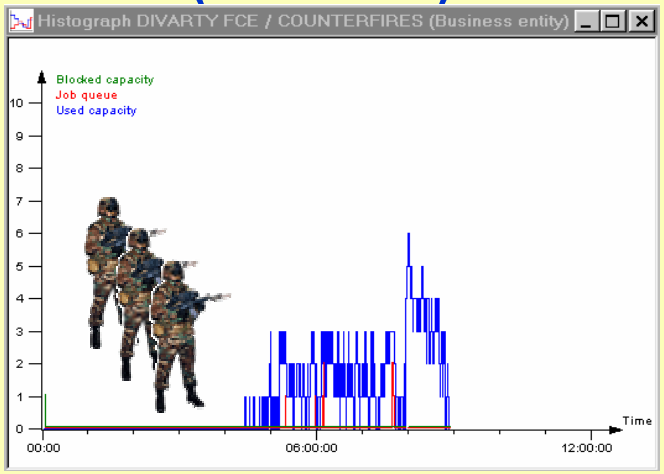


TBMCS (# of Resources = 3)





ASOC (Staff of 3)



Emerging Technical Issues

- Stale information in the business process model
- Major changes to process flow (e.g., staff cell or sensor destroyed, or system fails)
- Applying contextual updates among combat simulation, business process model and network communications model
  - Combat simulation updates node locations in comms model
  - Combat simulation updates node status (destroyed, non-operational) in process model and comms model
  - Process model sends orders to specific unit in combat simulation
- Allocating activities in mission thread to the appropriate simulation
  - Some activities represent physical actions – more appropriate for the combat simulation to execute
  - Some activities represent information processing actions – more appropriate to stay in the business process model
- Incorporating dynamic cost analysis to address operational costs of a system

Summary

- Current architecture framework products support only static analysis
- Objects and relationships in static architecture products must be mapped to dynamic models to create executable architectures
- Executable architectures offers means to conduct dynamic analysis of systems or capabilities described thru an Integrated Architecture
- Challenges are:
  - Capturing sufficient representation of system and operational environment in executable architectures
  - Collecting appropriate data to populate activities in executable architectures
  - Identifying and capturing MOE and MOP to support dynamic analysis

Backup

Benefits of Architecture Analysis

Static/ Graphical

Static Analysis

- Locate, identify, resolve definitions, properties, facts, constraints, inferences, and issues both within and across models
  - Redundant, conflicting, missing and/or obsolete
- Identify, reconcile and clean inconsistent "dirty" architecture data
  - Different names mean same thing
  - Same name means different things
- Mine architecture data
  - Reveal and discover hidden rules, practices, gaps, relationships, requirements, and patterns on how enterprise conducts its business
- Determine effect and impact of change
  - "what if" something is redefined, redeployed, deleted, moved, delayed, accelerated, defunded

Dynamic/ Behavioral

Dynamic Analysis

- Understand complex, time-dependent operational processes, their resources, costs, and relationships
  - Simplify, measure and optimize for performance, and effectiveness
- Measure System Performance (MOP) & Effectiveness (MOE) and Force Effectiveness (MOFE)
  - Assess system's ability to function in its operational environment and determine a unit's overall success in accomplishing its mission
- Provide time and costs analysis using executable architectures a 1st step in an architecture-based investment strategy
  - Align architectures to funding decisions
  - Ensure investment decisions are directly linked to DoD mission objectives and their outcomes