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# Challenges in Vertical Collaboration Among Warfighters for Missile Defense C2

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# Challenge: Evolving Missile Defense Plans for Net-Centric Operations

- In 2004, USSTRATCOM will Oversee the Deployment of the Initial Defensive Operation (IDO) for Missile Defense
  - Architecture Has Been in Development for Over Twenty Years
  - Comprised of Land, Air, Sea and Space Elements Developed by the Army, Navy, Air Force and the Marines
  - NCW Concepts Such As Networked Sensors Will Be Employed, Although Not Originally Envisioned
  
- The Corresponding Integrated Missile Defense Plan Must Consider the Complex, Distributed Sensors and Weapons From Around the Globe
  - The Plan Includes Tens of Systems Frequently Engaged in Multiple Missions for Different Commanders Against Multiple Threat Types
  - Individual System Planners Already Exist or Are in Development
  - Question is What the Role These Individual Planners Should Have in Integrated Plan for an NCW Architecture



# Missile Defense 101

Enemy Missiles Have the Range to Be Launched in One Theater Area of Responsibility (AOR), Fly Over Another AOR and Impact in Yet Another AOR. With These Ranges, Missile Defense Has Become a Global Issue in Theater Conflicts.



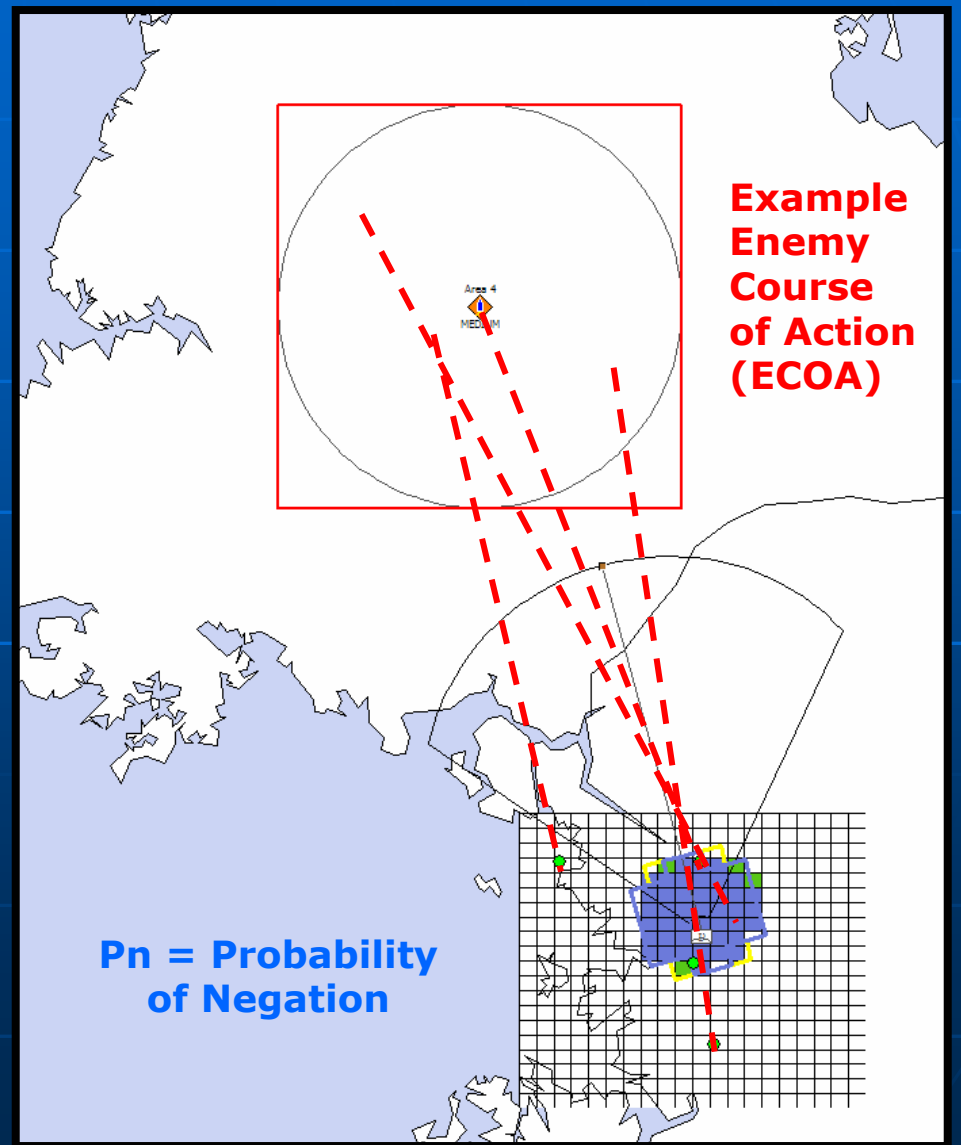
*Sensors are Networked. The AEGIS Ship may be supporting engagements in Korea, Japan and the U.S. simultaneously.*



# Steps in Developing A Missile Defense Plan

## Guidance

1. Gather Mission Guidance (current situation and plan objectives)
2. Analyze Defense Capability
  - Feasible Enemy Trajectories
  - Feasible Friendly Detections and Intercepts
3. Evaluate Enemy/ and Friendly Courses of Action
  - Most Likely Events
  - Includes Timing and Raid Size

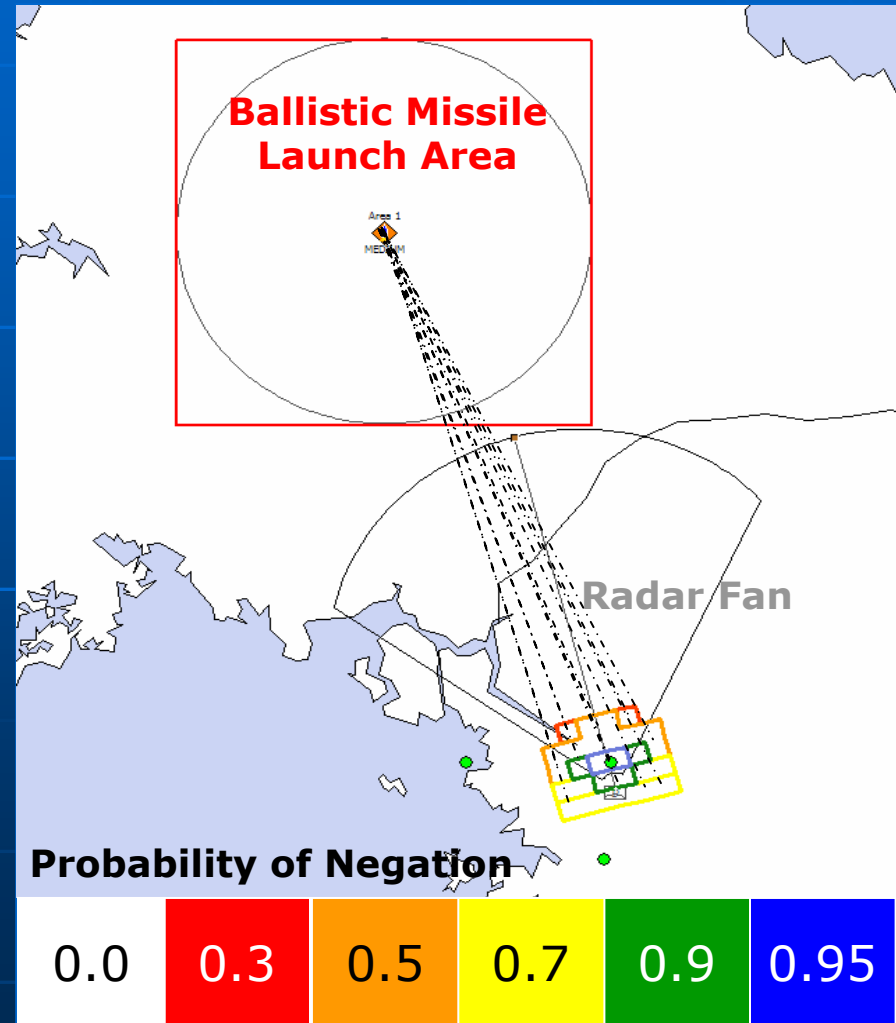




# Analyzing Complex Defense Capability

Increasing Complexity

- Single System, Single Threat (shown here)
- Single System, Multiple Threat Types, Single Mission (BMD)
- Single System, Single Threat, Multiple Chains of Command (AORs)
- Single System, Multiple Missions
- Multiple Systems, Interacting Systems, Single Threat
- Multiple Systems, Interacting Systems, Multiple Threats
- Multiple Systems, Multiple Threats, Multiple Chains of Command





# Plan Development (Pre-Network Centric Warfare (NCW))

## Planning Focus

## Products

### Strategic

- Monitor Situational Awareness of Air Defense Plan

### Top Level Operational Planner

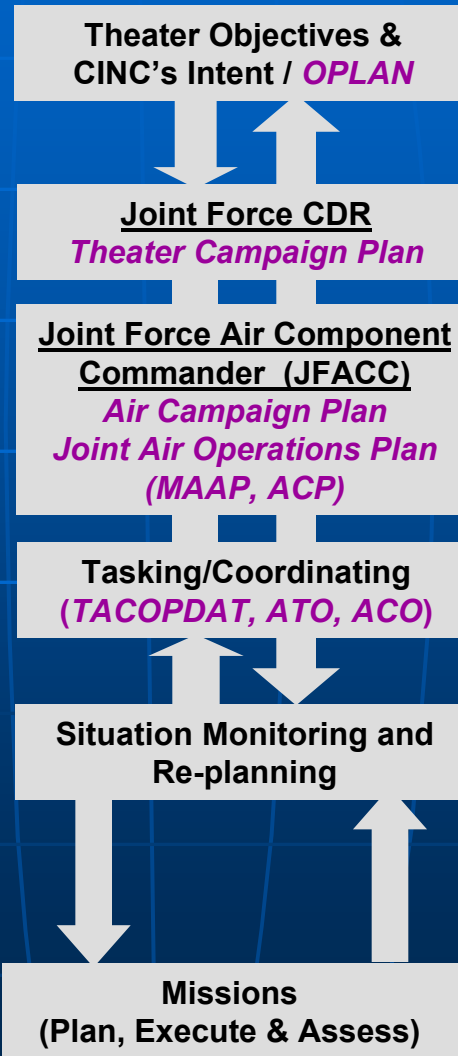
### Operational

- Develop A Prioritized Defended Asset List (Guidance)
- Develop Intelligence Preparation of the Battlespace (IPB)
- Evaluate Tactical Plans and Merge into An Operational Plan

### Detailed Tactical Planners

### Tactical

- Develop Plan Based on System Capabilities, Constraints for Optimal Locations



## Tactical Plans

ABL



AEGIS BMD



PATRIOT

THAAD



GMD





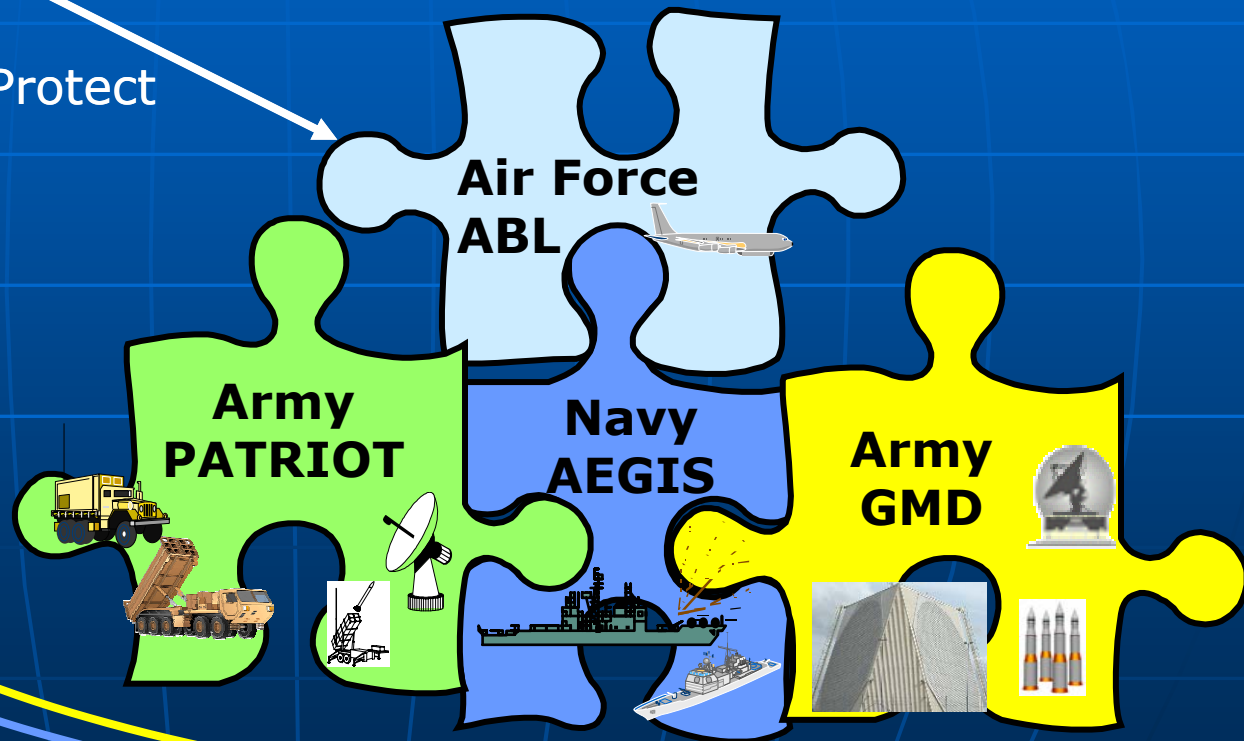


# Building the Pre-NCW Operational Plan

**Guidance**

Threats,  
Assets to Protect

**“Integrated”  
Missile Defense  
Plan**



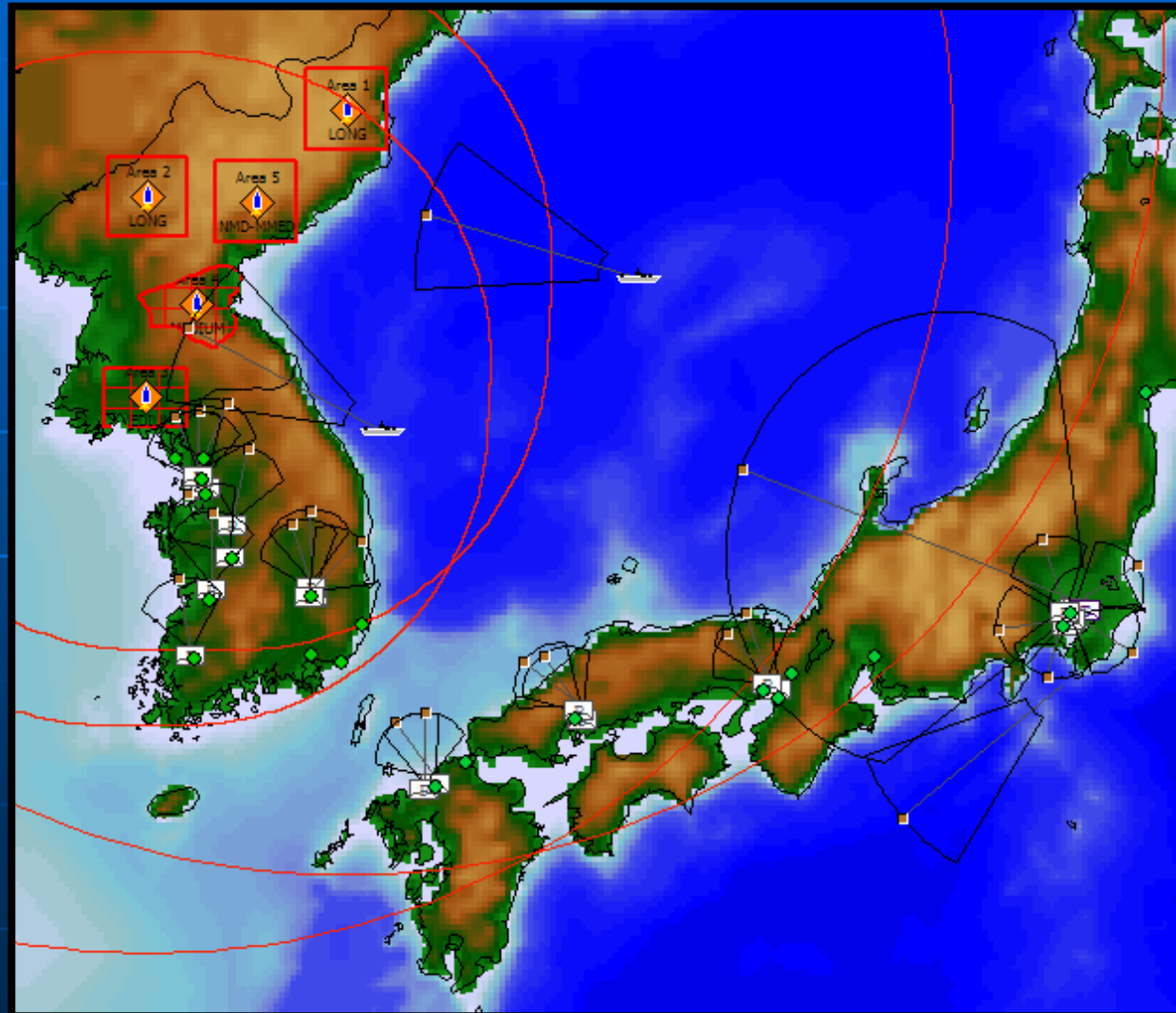
**Plans**

Not Really Integrated, But  
with Autonomous Systems,  
It Would Be Close



# More Steps in Developing A Missile Defense Plan (Complexity) – A Tough Problem

- **Multiple Systems With Intereactions** (AEGIS SPY RADAR, AEGIS SM-3, PATRIOT RADAR, PATRIOT PAC-2/GEM/PAC-3, GBI, UWR, COBRA DANE...), **Multiple Threats** (SCUD-B, SCUD-C, NO-DONG...), **Multiple Chains of Command** (USFK, USFJ, NORTHCOM)
- **Multiple Missions** (BMD, AAW...)
- **Environment** (Terrain, Water, Supportability, Electro-Magnetic Effects)







# Planning Levels for Net-Centric Operations in Missile Defense

AOR 1 (e.g., PACOM)

AOR 2 (e.g., NORTHCOM)

## Strategic

- Monitor Situational Awareness of Air Defense Plan

## Operational Planner

- Develop Plan With Sufficient Detail to Recommend Options for Sensors/ Weapons
  - Includes C2 Such As Net-Centric Operations

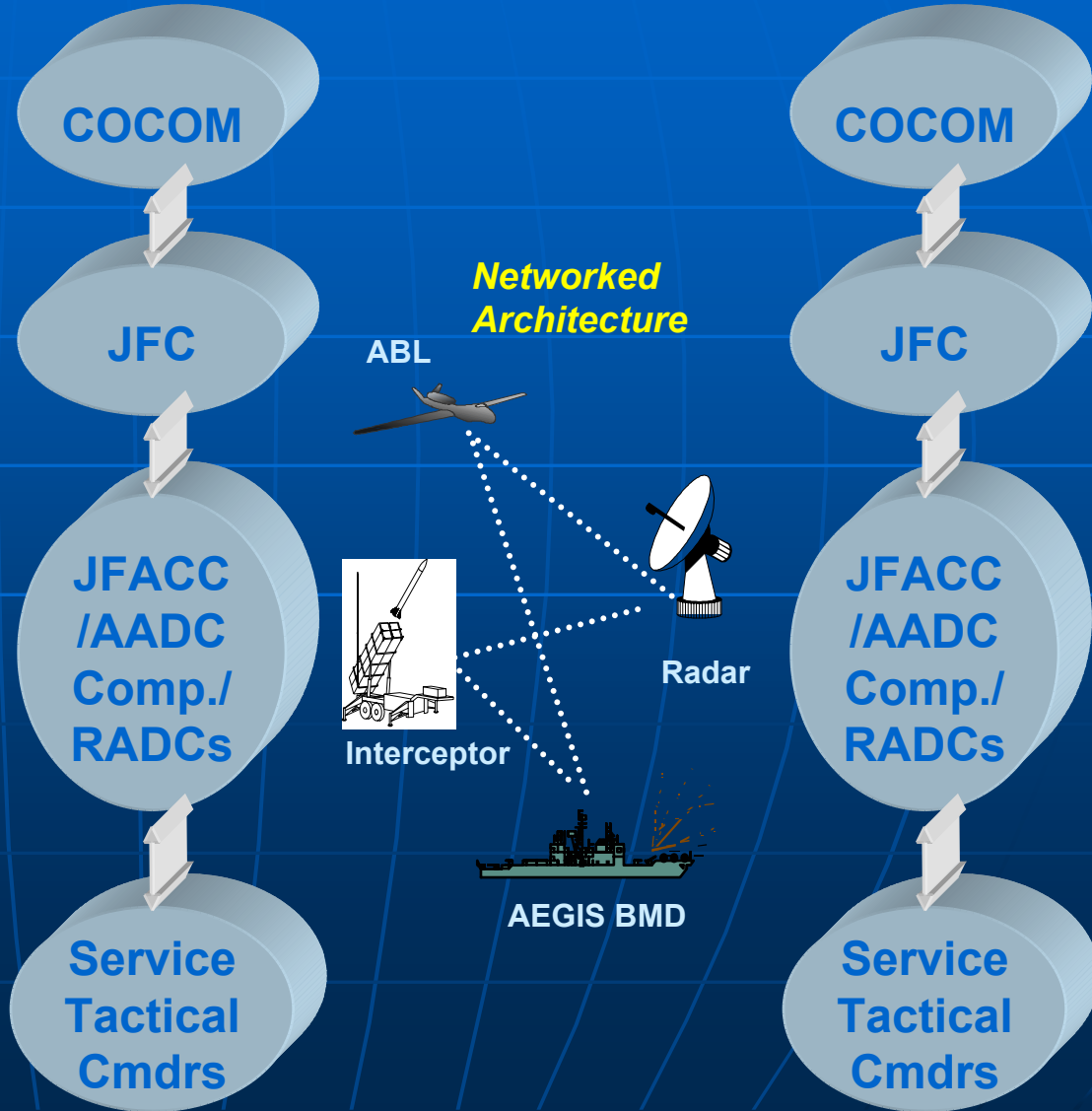
## Operational

- Evaluate Performance of Options to Illustrate Capabilities and Limitations to Decision Makers
  - Transmit to Lower Echelon Units for Refinement/Validation

## Tactical Planners

- Evaluate Tasking Based on Given Threat, Asset and Architecture
- Balance with Multi-Mission, Supportability, and Environmental Impacts

## Tactical

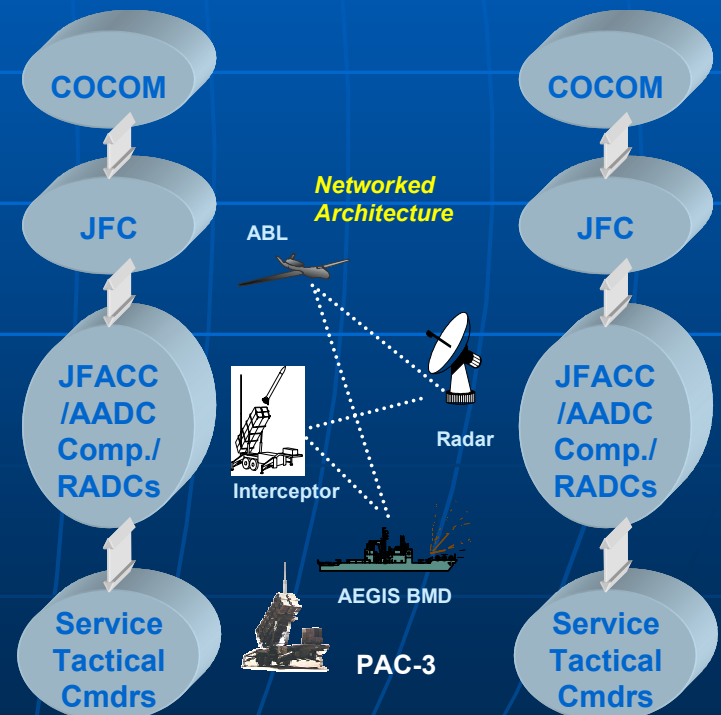




# NCW: Now What?

1. **SINGLE PLANNER.** Build a Detailed Mission Planner (i.e., "One-Sim") for both Operational and Tactical Planning Levels
2. **FEDERATED PLANNERS.** Develop Medium Level Fidelity Planner for Operational Level and Collaborate with Detailed Tactical Planners
3. **NET-CENTRIC PLANNER.** Develop a Detailed Mission Planning Framework Comprised of Planning Services Performing Synchronized Development and Mission Validation

## *Options for Evolving Mission Planning for Net-Centric Operations*





# Option 1. Single Planner

## Depth and Breadth

- Contains All Threats, Sensors, Weapon and C2BMC Models
  - Current Tactical Models Include Detailed Physics Algorithms (e.g., Detection, Clutter, Multi-path, Atmospheric Drag, Lethality, Weather)
- Considers Multi-Mission Aspects
  - Littoral Warfare
  - Air Defense (Aircraft, Cruise Missiles)
- Addresses Supportability, Reliability and Environmental Impacts
  - Road Networks, Water Depth & Channels, Terrain, Local Weather/Seas

**Possible:**      **yes**

**Likely:**        **No**

**Why Not?** Magnitude of the Problem (Breadth and Depth is Staggering), Engineering Details Are Evolving on all the Systems Simultaneously, Effort Crosses Service Boundaries with Acquisition Implications.



# “One-Sim” Planner Example

*Operational*

Threat Model		Satellites		Platform	
C2BMC		Radar Model		Laser	
A/C	Interceptor		Terrain		IR
Launchers		Anti-Air Warfare			EMI
Littoral Warfare			Supportability		

*Tactical*





## Option 2. Federated Planners

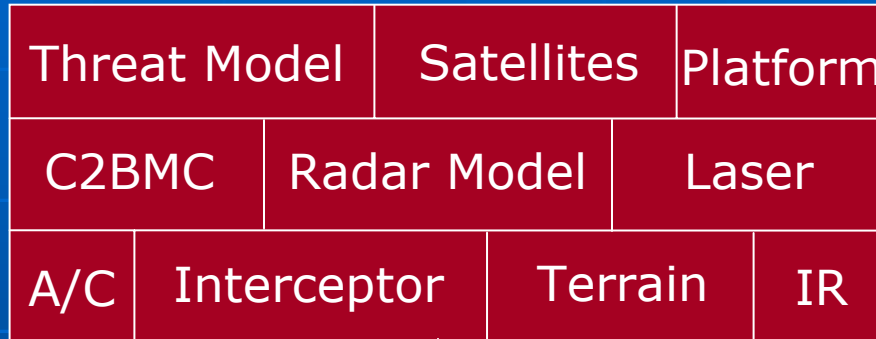
- Essentially, the Current Situation
- Top Level Operational Planner Evaluates Threats, Assets and System Elements for Defense Capability
  - Creates Tasking (threat + asset + defense triplets)
  - Evaluates Architecture Performance
  - Requests Refinement by Tactical Level Planners
    - Tactical Planner Submits Task Validation, Suggests New Location/Orientation and Additional Assets for Protection
  - Submits Final Plan
- Registered XML Schema for Threat Input and Missile Defense Design (Plan) Assists In Collaboration
- Refinement by Tactical or Service Planners Can Be Difficult, Unless Each Planner Can Model the Other Sensors or Weapons They Interact With (e.g., Navy AEGIS Models Army Ground-Based Interceptor)



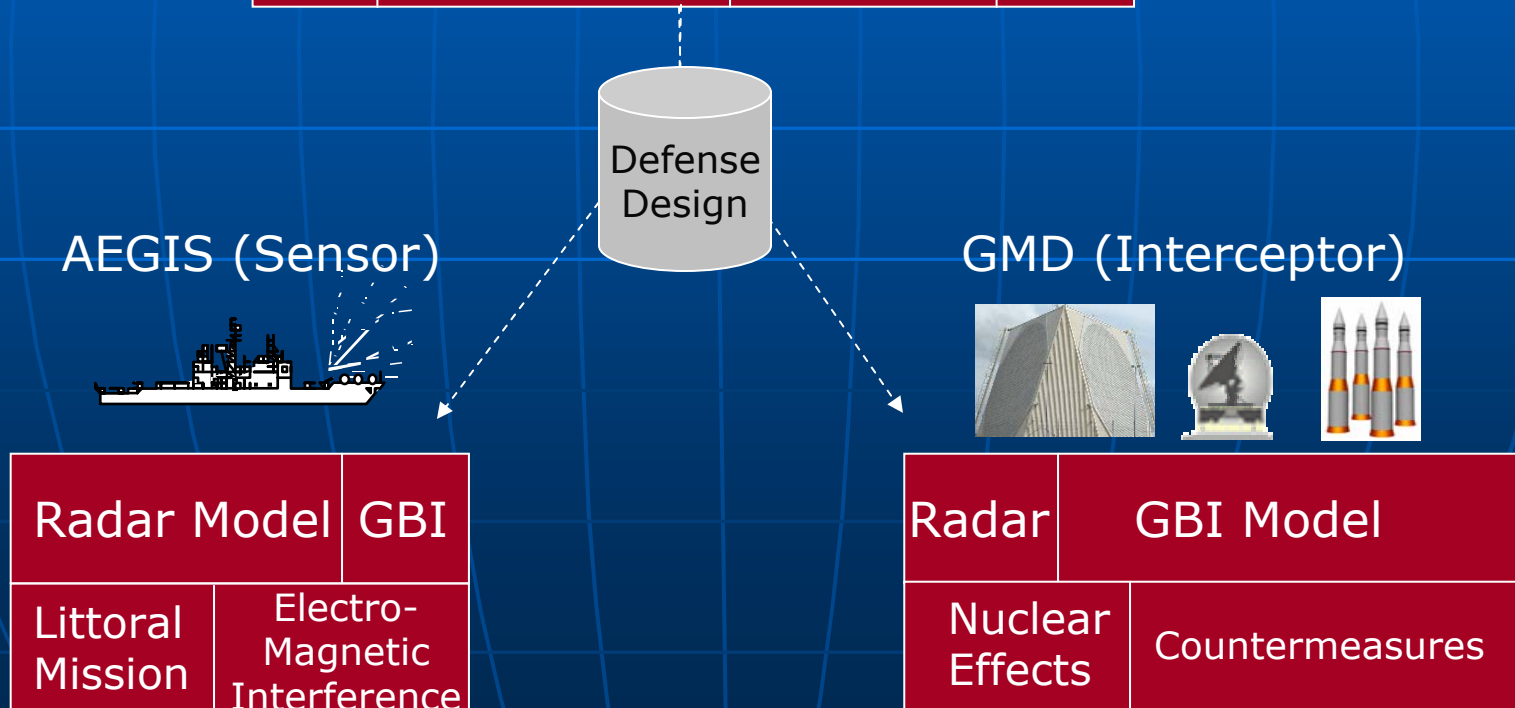


# Federated Planner Example

**Operational**



**Tactical**





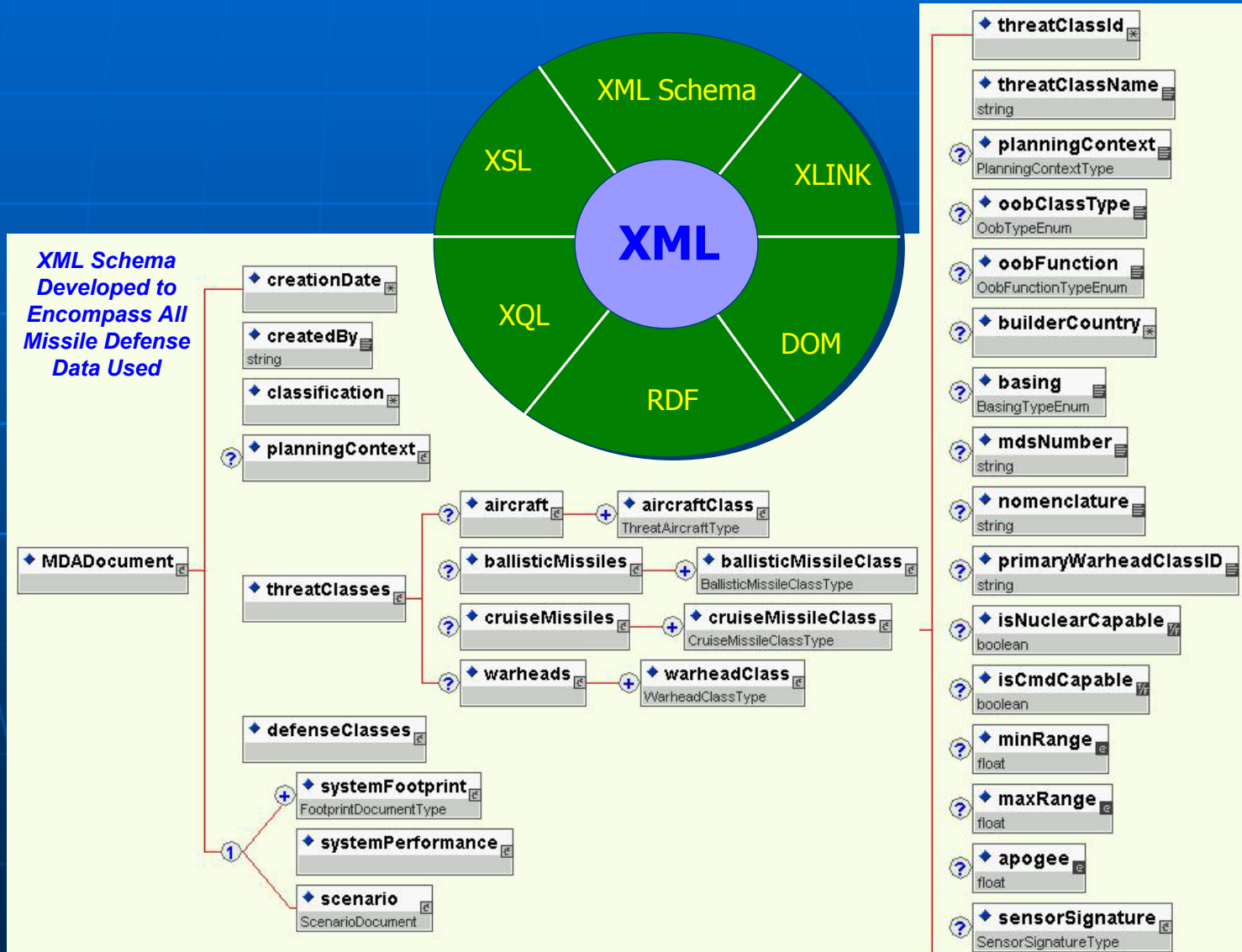
# Technology Advances Supporting the Collaboration Among Planners

- eXtensible Markup Language (**XML**)

- Missile Defense Agency (MDA) Developed an XML Schema for the Missile Defense Planning Data
- Defense Intelligence Agency (DIA) Developed an XML Schema for Ballistic Missile Threat Data

- MDA's Operational Level Planner Employed the **Java Messaging Services (JMS)** to Exchange Plans

- MDA and the Army Are Developing A **Web Service** Interface To Validate Tasks Among Their Planners





# Web Service Standards Used To Support Net-Centric Planning

- eXtensible Markup Language (XML)/ XML Schema Definition (XSD)
  - Syntax for Messages and Data Types
- Hyper Text Transfer Protocol (HTTP)/ Simple Object Access Protocol (SOAP)
  - Transport and Syntax for Synchronous/ Asynchronous Messaging
- Web Services Description Language (WSDL)
  - XML Format for Describing Network Services
- Universal Description, Discovery and Integration (UDDI)
  - Registry model supporting 'publish, find, bind, execute'
- Web Services: WS-Security, WS-Transaction, WS-Coordination
  - Syntax for reliable messaging, encrypted payloads



# Option 3. Net-Centric Planner

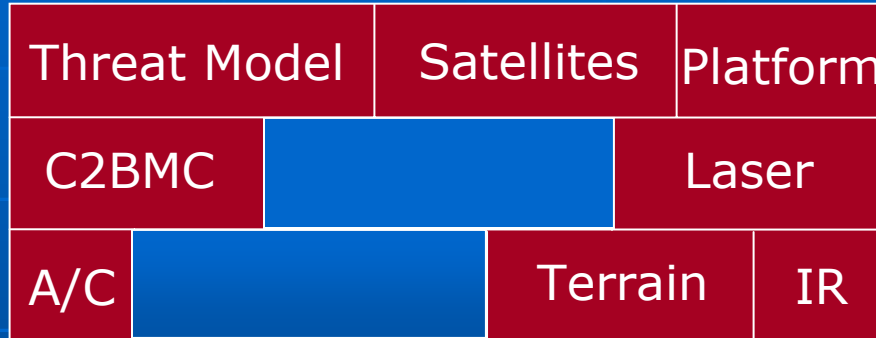
- Operational Level Architecture Planner Evaluates Threats, Assets and System Elements for Defense Capability
  - Creates Tasking (threat, asset, defense triplets)
  - Evaluates Architecture Performance Using Web Services for Element Capability
  - Publishes Initial Plan
  
- Each System Element (sensor or weapon) Subscribes to Missile Defense Plans
  - Evaluates Tasking
    - Identifies Any Issues with their Element Locations
      - Multi-Mission Impacts, Water Depth, Terrain, Electro-Magnetic Interference
    - Calculates Element Performance for Each Threat-Asset Pair
      - Sensor Elements Produce Detection/Track History or Signal-to-Noise Ration (SNR) plots
      - Weapon Elements Produce Probability of Negation Contours for Their Weapon using the Sensor Network
    - Validates Tasking for Original Location/Orientation or Suggests Revised Location/Orientation Showing Original and Revised Validation Matrices for Approval (which starts cycle of iteration)

**What Happens When One Element Suggests a Revised Location/Orientation....The Plan Development Must Be Iterative.**



# Net-Centric Planner Example

**Operational**



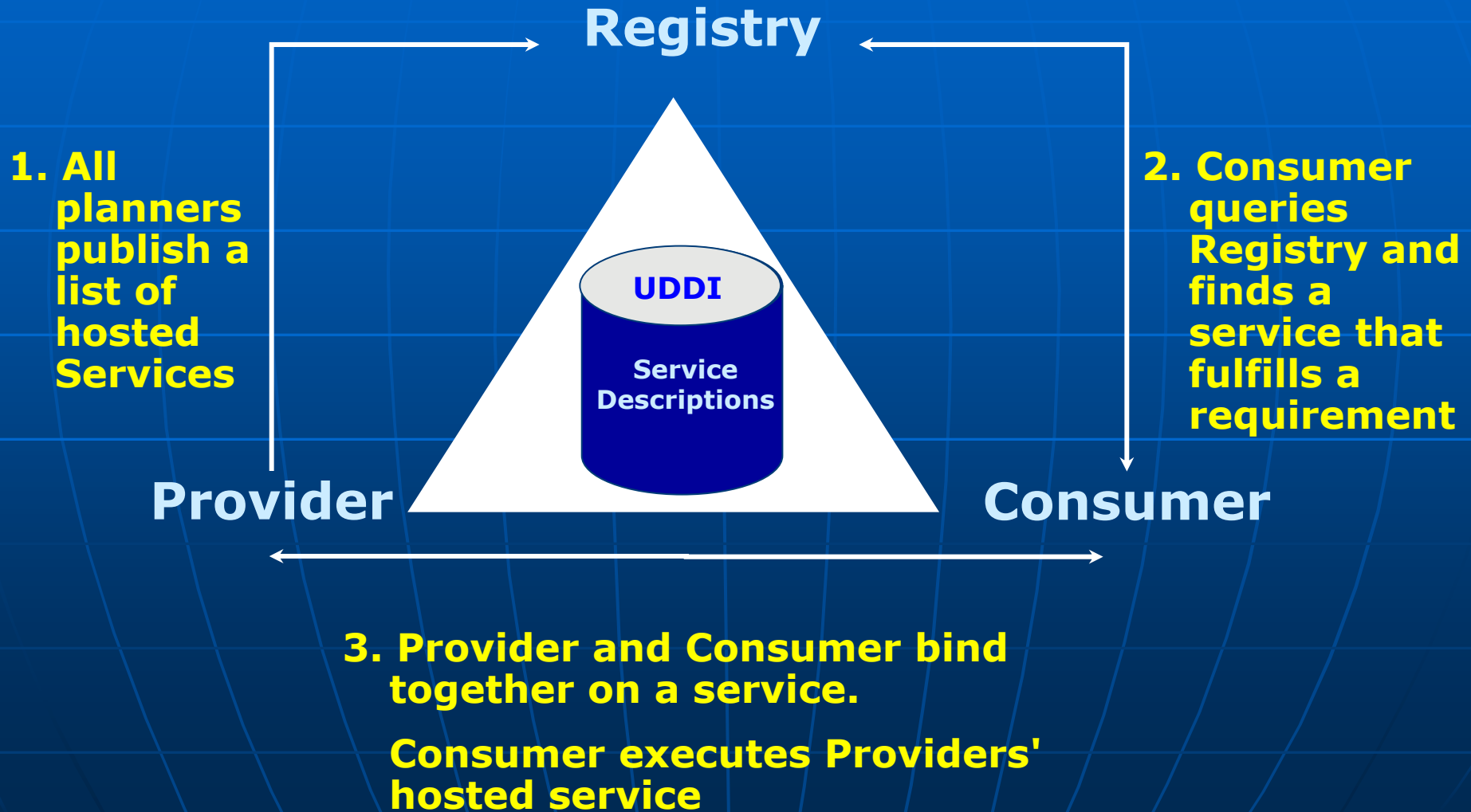
**Tactical**







# Web Services Context Diagram





# Net-Centric Planner Example

**AEGIS (Sensor)**



**Planner #1  
Radar Model**

**GMD (Interceptor)**



**Planner #2  
Interceptor**

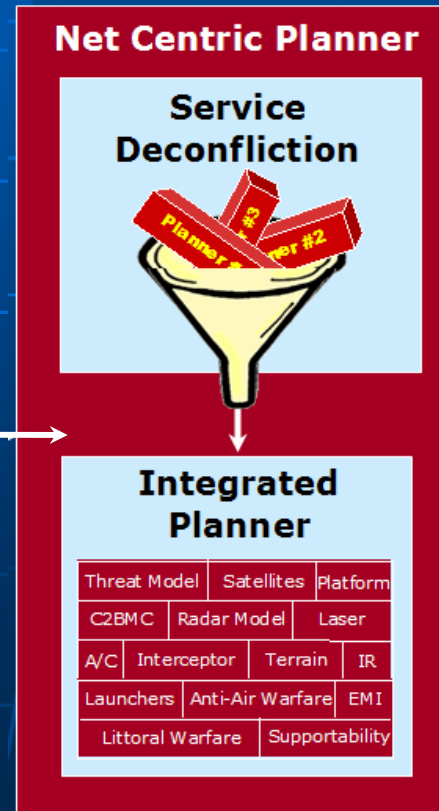
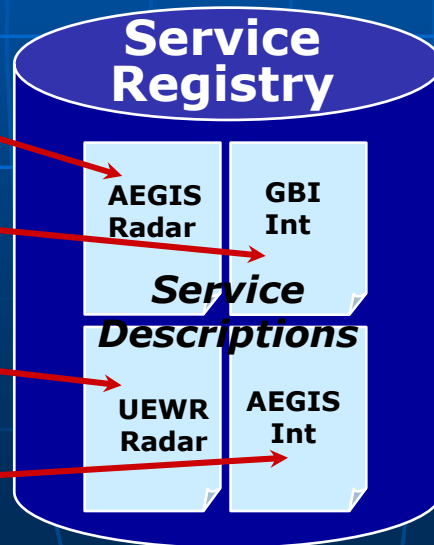
Web Services

**Planner #1**

**Planner #2**

**Planner #3**

**Planner #4**



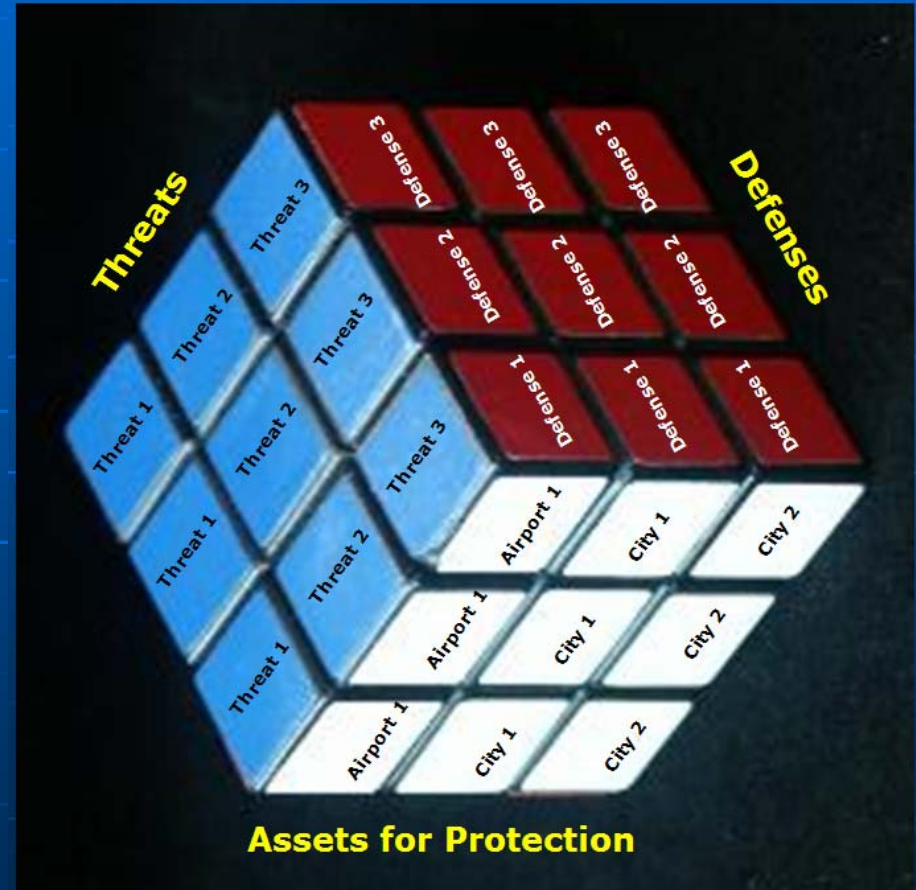
**Integrated Plan**





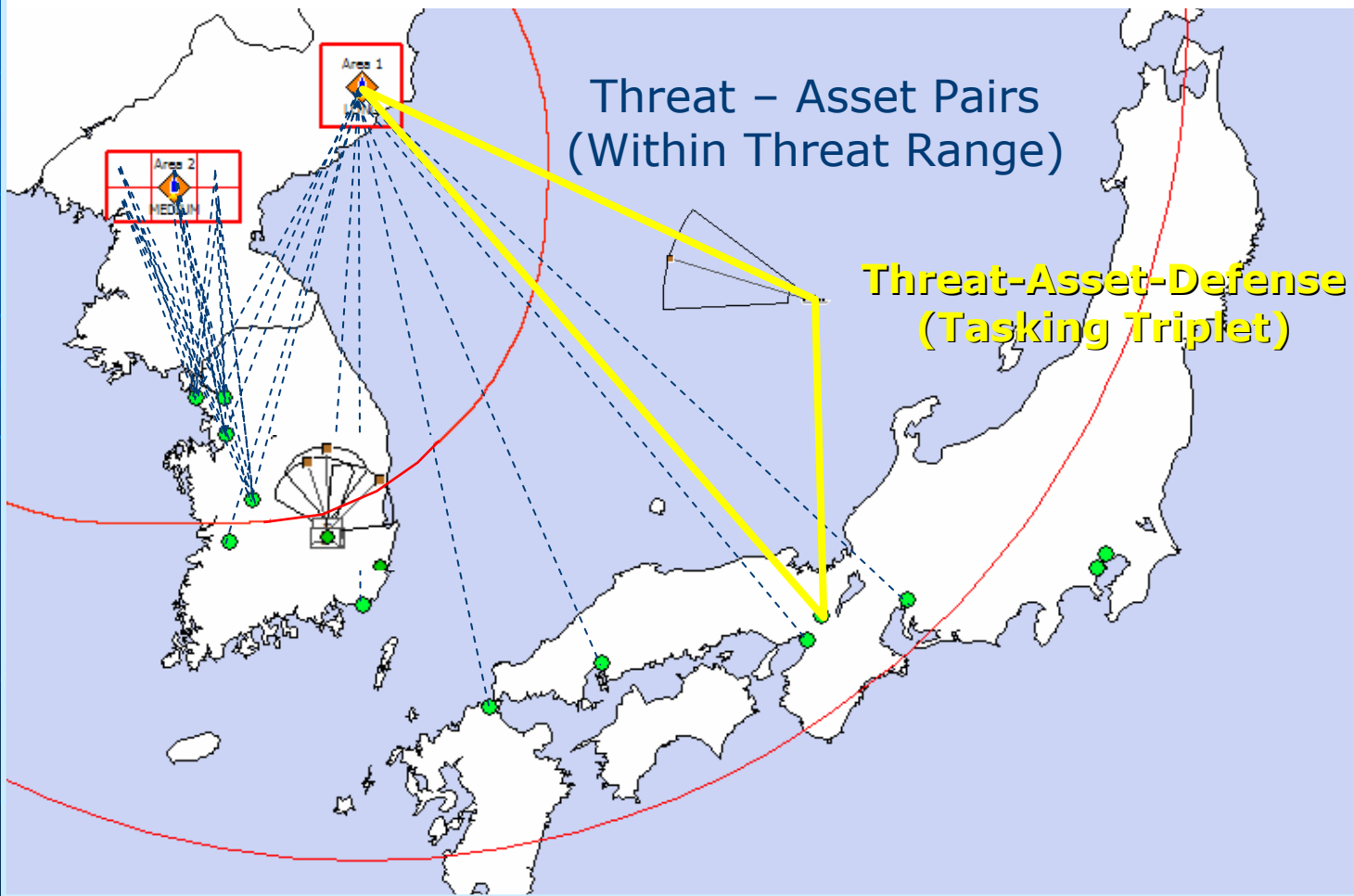
# The Plan “Glue”: A Results Cube

- Operational Planner Constructs a Threat – Asset-Defense (Tasking) Results Cube
  - Task (Cube) Can Contain Original Performance, Validation Attribute and Validated Performance
    - Tactical Planners Can Validate Each Task (Initial Plan with Improving Confidence)
- Results Can Be Translated into Probability of Negation Contours – Color Coded for Intuitive Reading



# Tasking Triplets

Missile Defense Task = **Threat** (location, type) + **Asset** (point/area to defend) + **Defense** Tasked to Defend Asset Against Threat

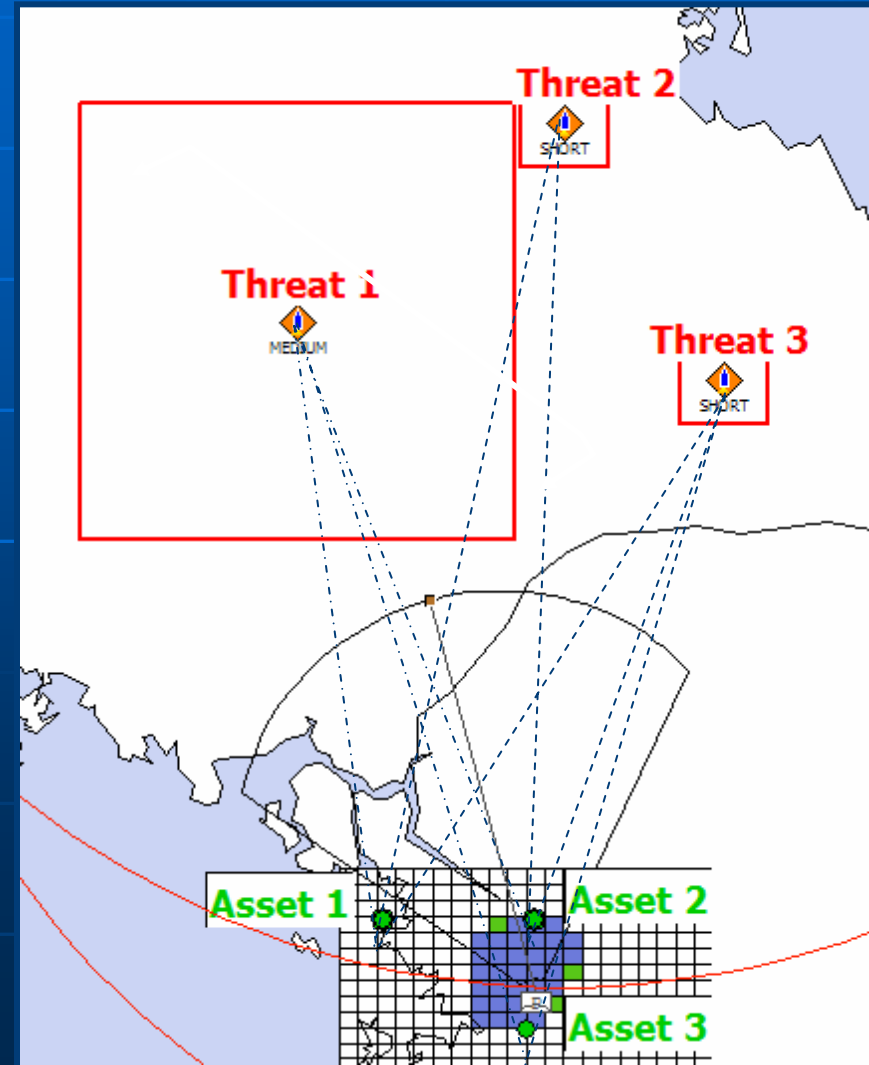




# Tasking Details for One Defense Element

- Each Element Calculates its Sensor or Weapon Performance for Each Threat-Asset Pair

Threat 1 Asset 1 <b>No</b>	Threat 2 Asset 1 <b>No</b>	Threat 3 Asset 1 <b>Yes</b>
Threat 1 Asset 2 <b>Yes</b>	Threat 2 Asset 2 <b>Yes</b>	Threat 3 Asset 2 <b>Yes</b>
Threat 1 Asset 3 <b>No</b>	Threat 2 Asset 3 <b>Yes</b>	Threat 3 Asset 3 <b>Yes</b>



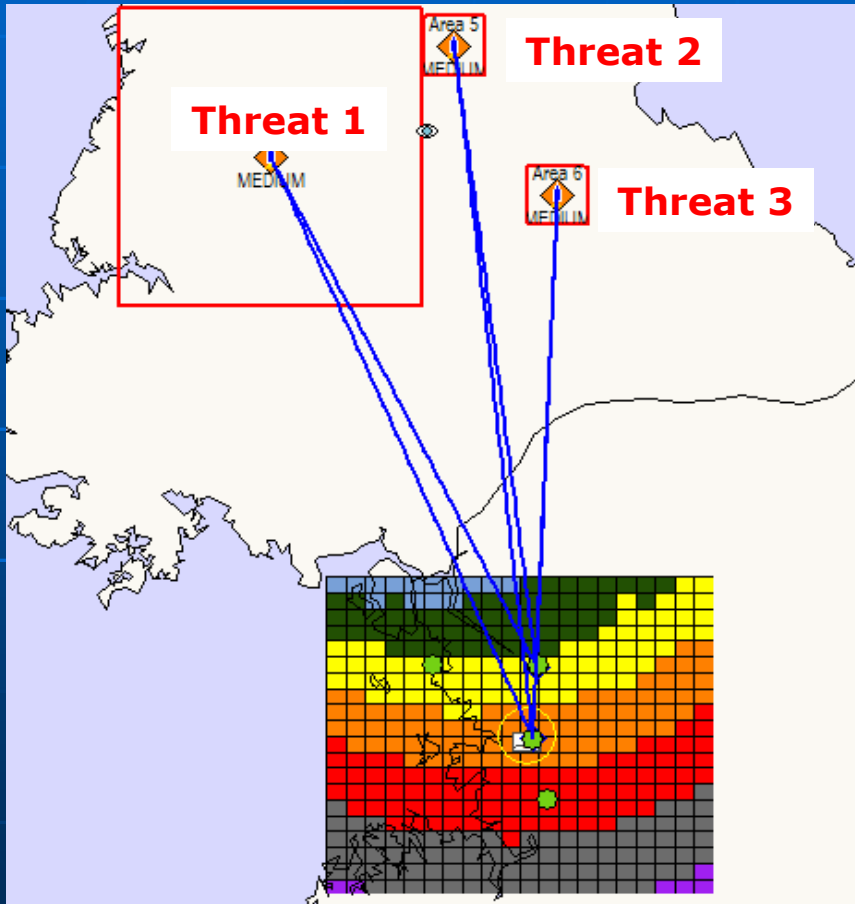




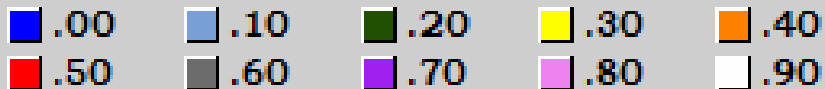
# Example Results for Sensors and Weapons



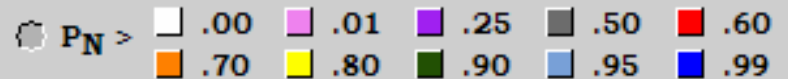
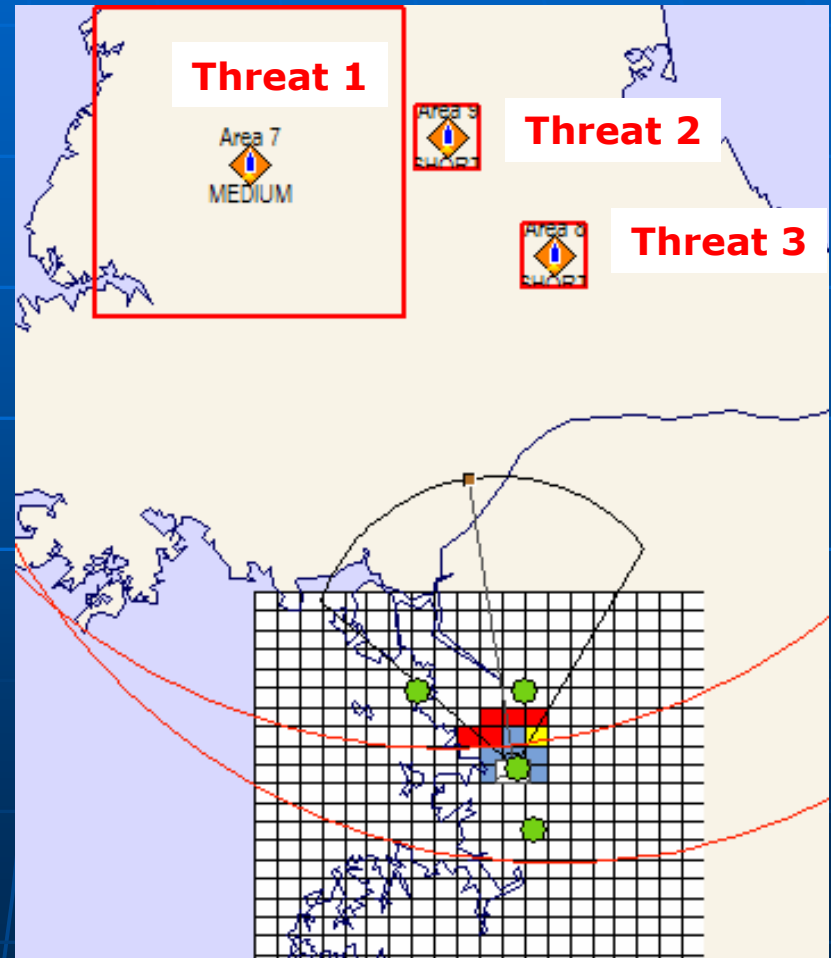
**Sensor: Ave. Earliest Detection Time**



(as a percentage of total threat flight time)



**Weapon: Probability of Negation**





# Next Steps for Net-Centric Planning

- **Develop Web Services Approach Across Missile Defense Planners**
  - Determine What Physics-Based Questions Can Be Provided?
  - Evaluate Modeling Approaches Across Planners (e.g., common terrain, terminology, measures of performance)
- **Determine CONOPS for Information Flow**
  - Is Network Ubiquitous or Should Operational Level Planner Retain Duplicate Models to Gracefully Degrade?
- **Finalize Missile Defense Planning and Intelligence XML Schemas to Accommodate Net-Centric Planner Needs**
  - Evaluate Current XML Schemas Against Required Breadth and Depth



# Summary

- Missile Defense Planning Incorporating NCW Concepts Is Complex
- Several Options Exist to Develop and Validate the Plan
  - Single "One-Sim" Planner
  - Federated Planner
  - Net-Centric Planner
- Choosing a Net-Centric Planner Solution Provides the Best Path To Evolving the Current Missile Defense Planning Process