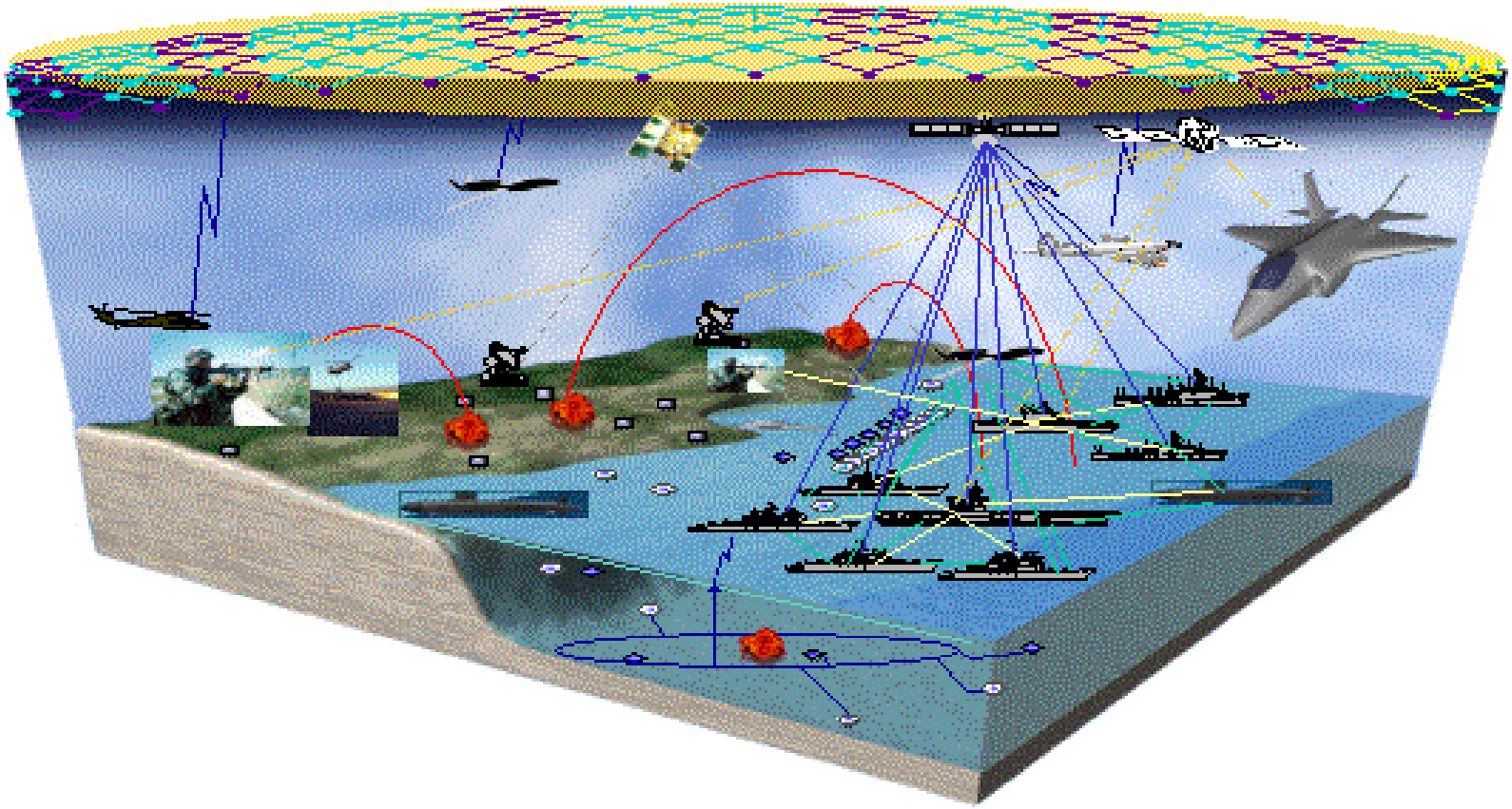
AY 2004 Spring Integrated Project

Maritime Dominance in the Littorals



Wayne E. Meyer Institute of Systems Engineering
Naval Postgraduate School, Monterey, CA

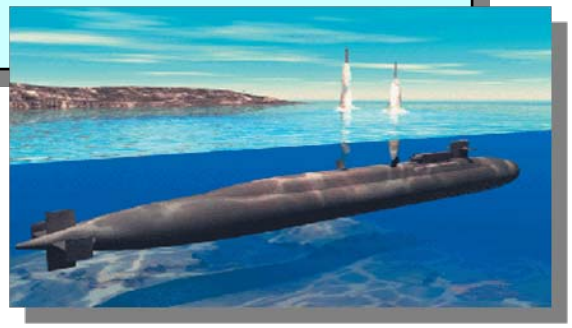
Project Description

- Execute Tasking from Deputy Chief of Naval Operations (CNO) for Warfare Requirements (OPNAV 7)
- Develop a Conceptual System of Systems (SoS) for Maritime Dominance that Enables SEA BASING and SEA STRIKE in the Littorals
  - Generate Alternatives Using Existing Systems, Current Programs of Record, and Future Systems
  - Recommend Cost Effective Conceptual SoS That Minimizes Risk To Allied Personnel While Accomplishing Objectives
- Deliver Results in a Final Briefing and Technical Report

SoS Focus and Constraints

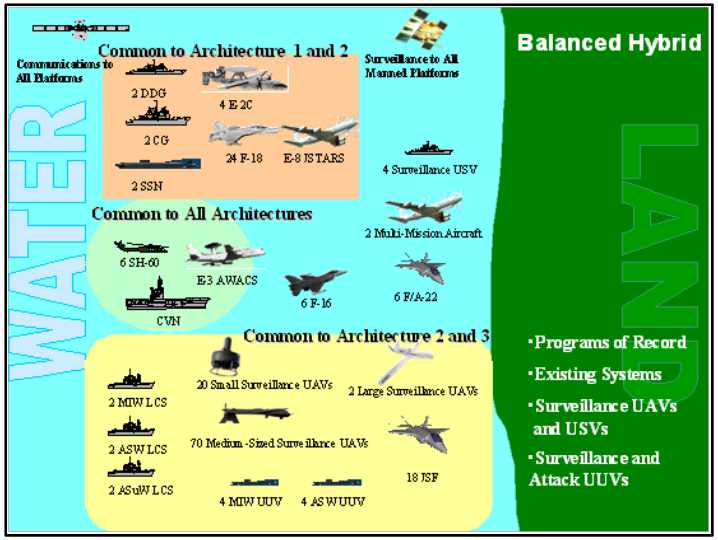
- **SoS Architectural Focus**
  - Combination of both Manned and Unmanned Systems
  - Surface, Subsurface, Air and Space Systems
  - Employment of Forces From All Services

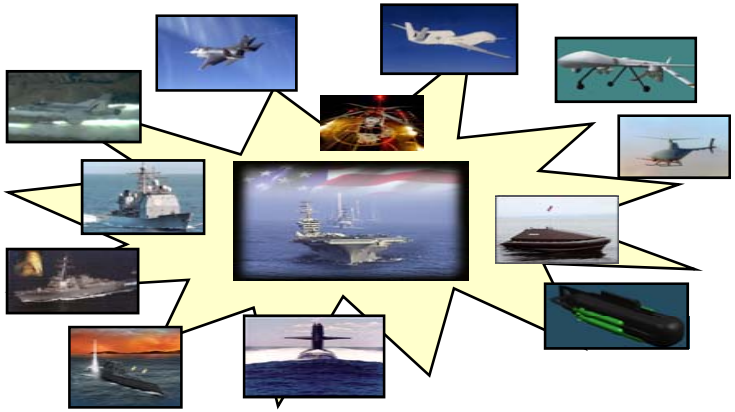
- **Constraints**
  - Scenario Constraints
    - Land Forces Deployed up to 200 nm Inland
    - Striking/Supporting Maritime Forces Deployed up to 200 nm Offshore
  - Timeframe Constraint
    - Concepts of Operations Applicable within 2020 Timeframe
  - Cost Being a Necessary Selection Variable



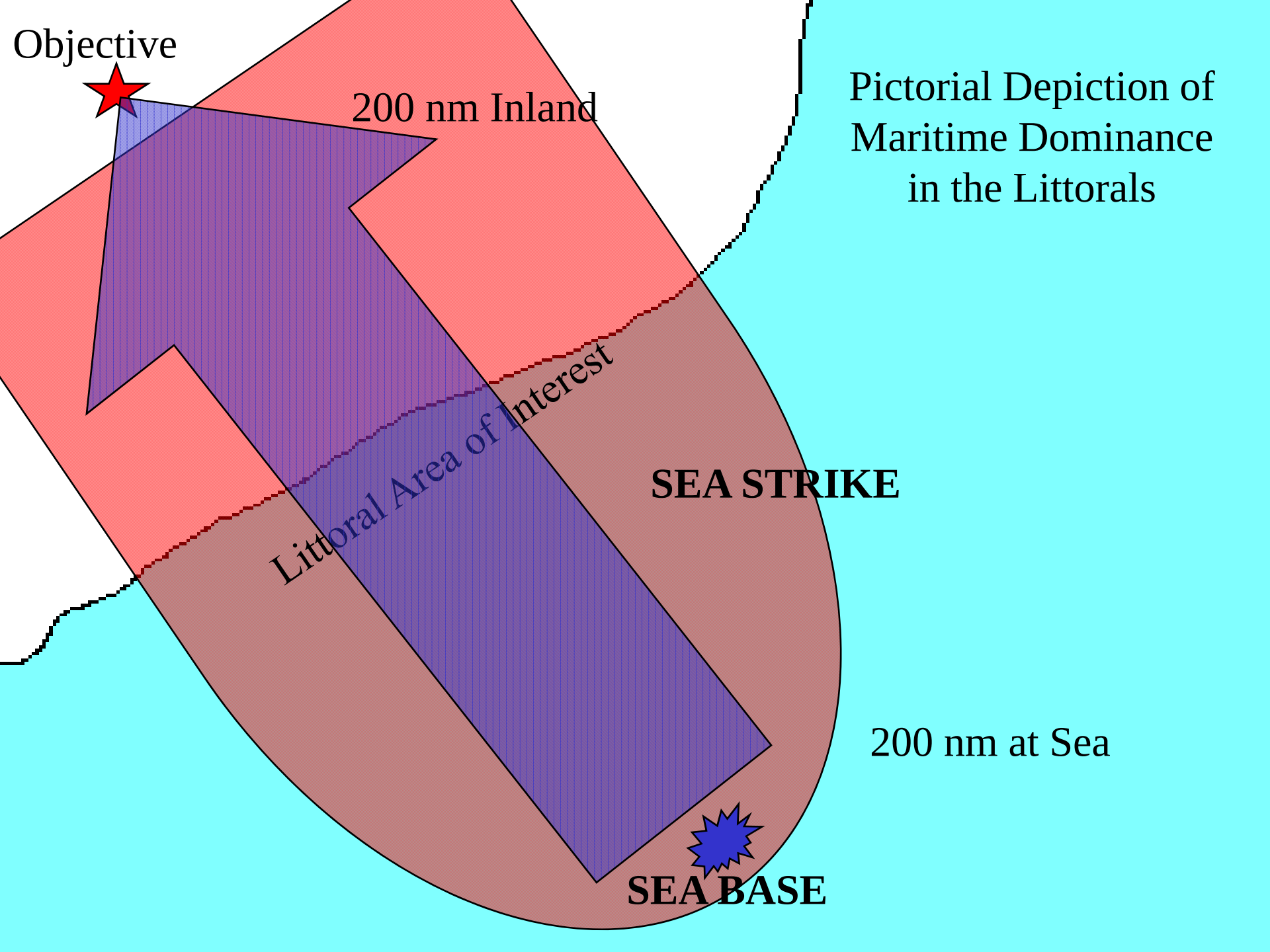
Recommended System of Systems for Maritime Dominance in Littorals

- **Unmanned Vehicles Complement But Cannot Replace Manned Platforms**
- **Recommended System of Systems Enabling SEA BASING and SEA STRIKE in 200 nm by 200 nm Littoral Operation Area in 2020 Timeframe**
  - **Consists of Unmanned/Manned Vehicle Ratio of Approximately 1.5 to 1**
  - **Utilizes Distributed Communications with 100nm Physical Platform Distribution**
  - **Employs Decentralized Command & Control Structure**
  - **Is Cost Effective Relative to Other Alternatives**





- **Distributed Communications**
  - Faster Dissemination of Information
  - Minimum Impact on Throughput with Node Failures
- **Decentralized Command and Control**
  - Shorter Reaction Times
  - Less Network Demand
  - Single C2 Node Failure Avoidance
- **100 nm Platform Distribution**
  - Superior Overall Performance


Pictorial Depiction of Maritime Dominance in the Littorals
Objective
200 nm Inland
Littoral Area of Interest
SEA STRIKE
200 nm at Sea
SEA BASE

2004 Integrated Project Interface

NPS Community

Faculty Advisors

Prof. W. Solitario-Overall Project Coord
Dr. T. Huynh-Proj. Mgmt, Sys. Design & Analysis
Dr. R. Cristi-Communications
Dr. D. Kapolka-Sensors
Dr. G. Karunasiri-Sensors
Dr. I. Kaminer-Land Systems
Dr. F. Papoulias-Land Systems
LCDR R. Gottfried-Operations Research
Prof. K. Burke-Information Systems

Temasek Defense Systems Institute Technical Teams

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Study Direction, SEA5 Technical Inputs Contributing Analysis

Performance Analyses

Industry
Boeing
Lockheed Martin
Northrop Grumman
Raytheon

Technology Resource

SEA5

Integrated Project Lead

LCDR Q. Tran

SEA5 Team

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ENS B. Peterson, USA
ENS S. Poitevent, USA
ENS R. Smith, USA
ENS M. Tsikalas, USA
ENS C. Tubbs, USA

Initial Study Plan
Periodic Updates

Input and Feedback

Legend
Primary Coordinators
Internal Structure
External Stakeholders

Operational Requirements

CNO N7
Fleet Commanders
(CAPT Kline, Dr. Olwell)

Technical Requirements

NAVSEA
FNMOC
NCAA
AFCAA

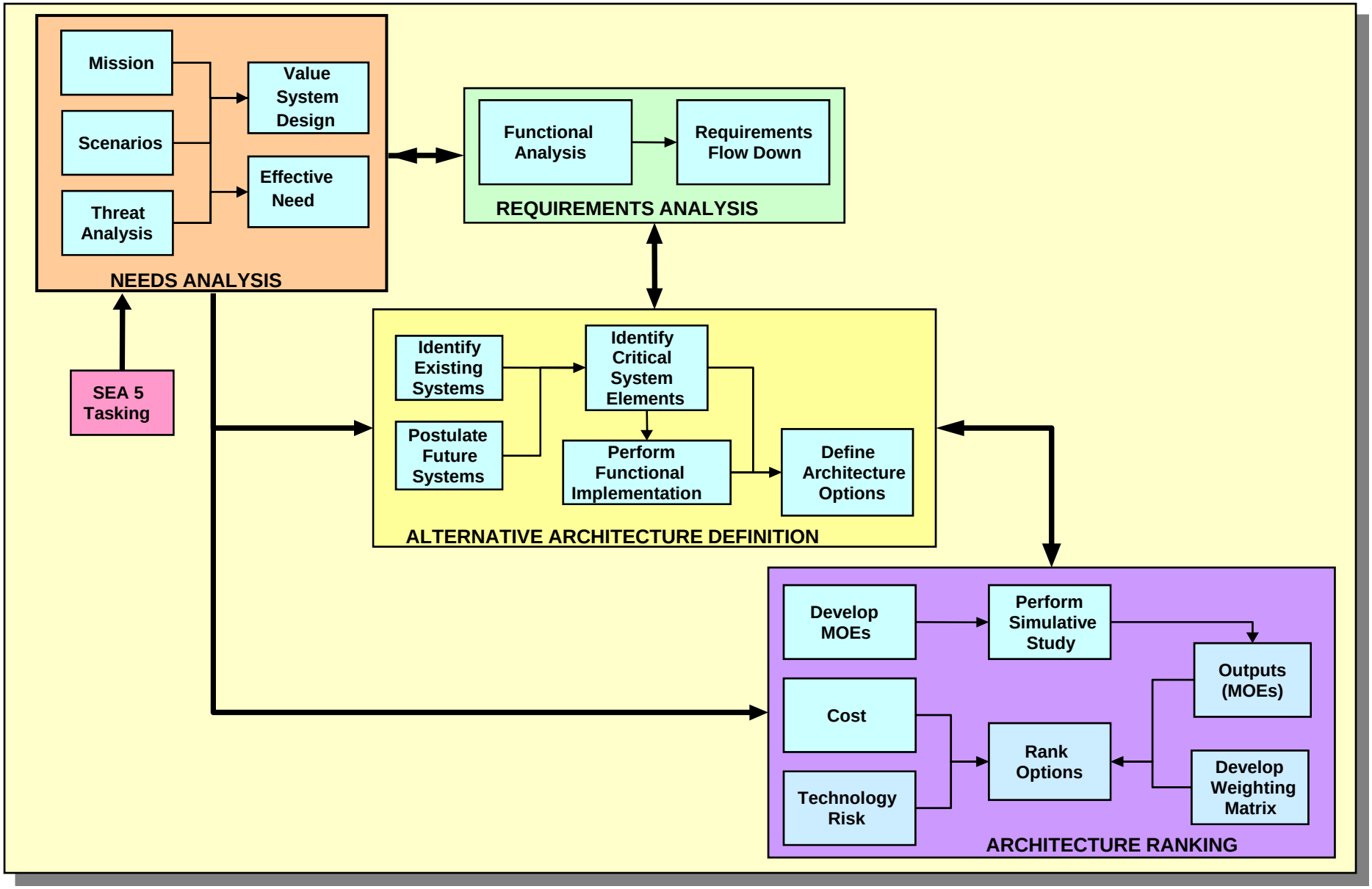
End User Requirements

Joint Military Community
Air Warfare
Amphibious Warfare
Land Warfare
PYSOPS/INTEL
Special Operations
Subsurface Warfare
Surface Warfare

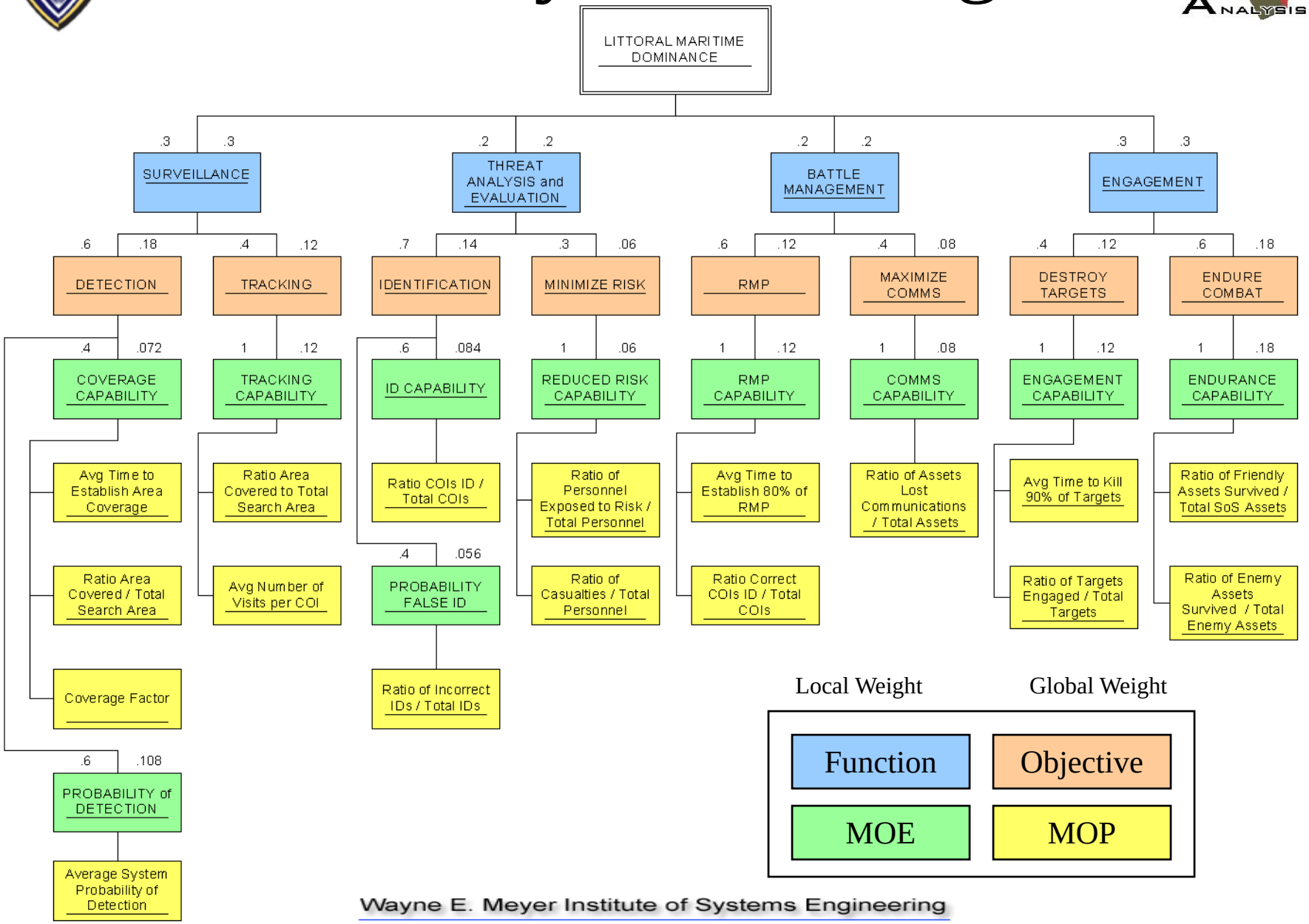
Effective Need

Develop a SoS Solution to Enable SEA BASING and SEA STRIKE by Providing Maritime Dominance in the Littoral Environment Through Cooperative Surveillance, Threat Analysis and Evaluation, Battle Management, and Engagement

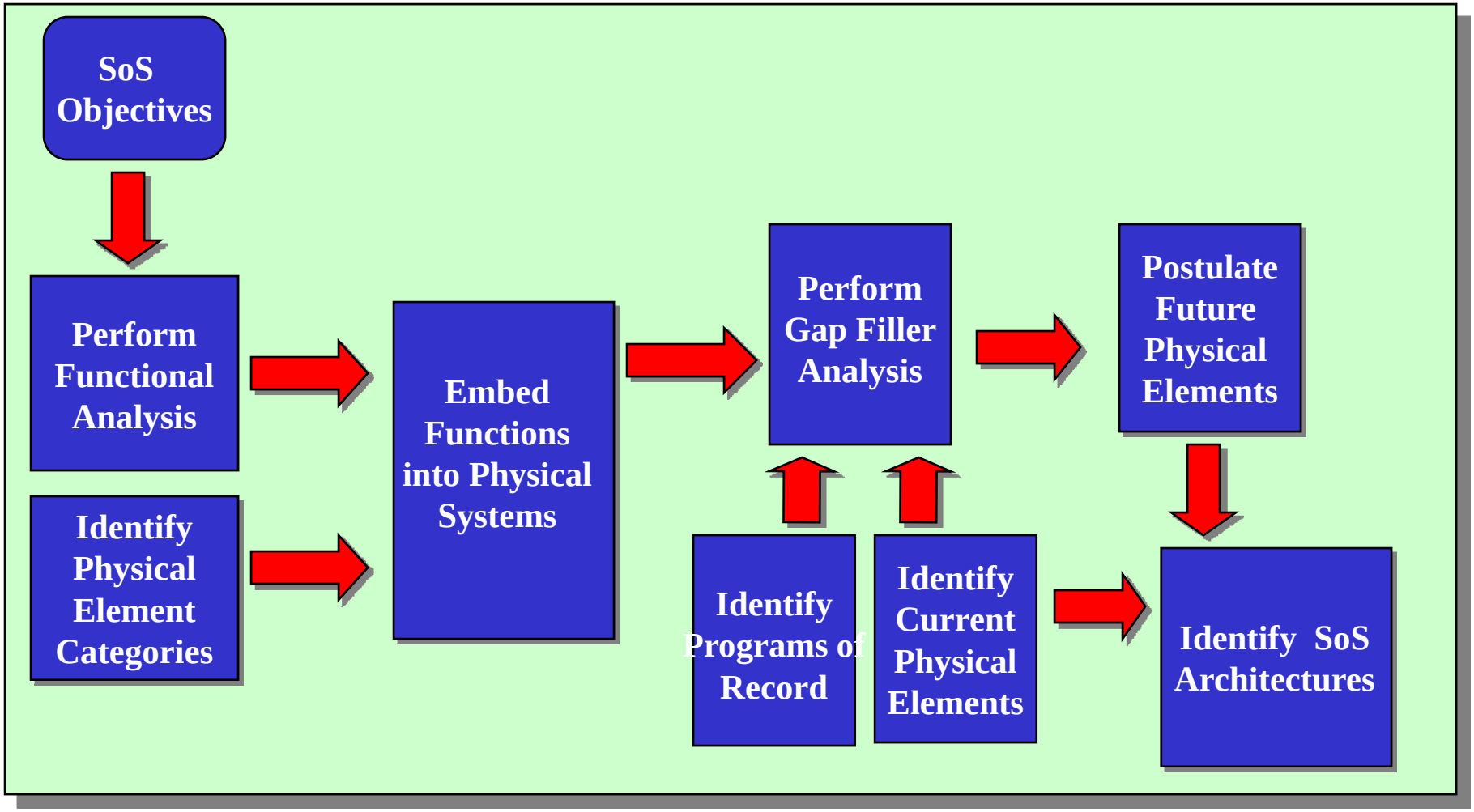
SoS Development Process



Value Systems Design



SoS Architectures Definition Process



Manned Only

WATER

NAVAL

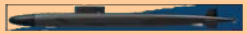
Common to Architecture 1 and 2

2 DDG

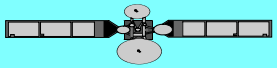
4 E-2C

2 CG

36 F-18 E-8 JSTARS



2 SSN

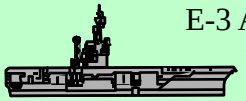


Communications to All Surface Platforms

Common to All Architectures

10 SH-60

E-3 AWACS



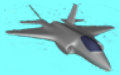
CVN

6 MH 53

5 CH 53

10 AH-1

5 E/A 6B



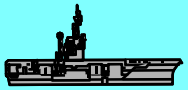
14 F-14

2 P-3

8 S-3

2 DDG

2 FFG



LHA

MHC

MCM

2 F-117

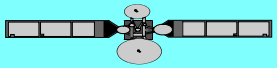
1 B-2

- Current Systems
- Carrier Air Wing
- Based Off Carrier Battle Group

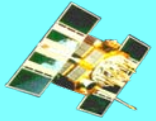
Balanced Hybrid

WATER

NAVAL



Communications to All Platforms



Surveillance to All Manned Platforms

Common to Architecture 1 and 2

2 DDG

4 E-2C

2 CG

24 F-18 E-8 JSTARS

2 SSN

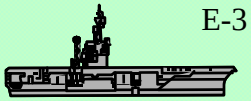
4 Surveillance USV

2 Multi-Mission Aircraft

Common to All Architectures

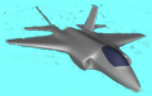
6 SH-60

E-3 AWACS



CVN

6 F-16



6 F/A-22

Common to Architecture 2 and 3

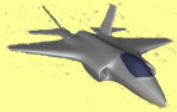
2 MIW LCS

20 Small Surveillance UAVs

2 Large Surveillance UAVs

2 ASW LCS

70 Medium-Sized Surveillance UAVs



18 JSF

2 ASuW LCS

4 MIW UUV

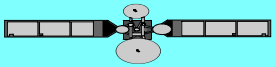
4 ASW UUV

- **Programs of Record**
- **Existing Systems**
- **Surveillance UAVs and USVs**
- **Surveillance and Attack UUVs**

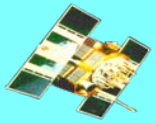
Primarily Unmanned

WATER

NAVAL



Communications to All Platforms



Surveillance to All Manned Platforms

2 CGX

2 DDX

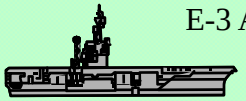
30 Medium Sized Strike UAVs

50 Medium Multi-Mission UAVs

Common to All Architectures

6 SH-60

E-3 AWACS



CVN

TDSI Insertion UUV

4 Multi-Mission USVs

Common to Architecture 2 and 3

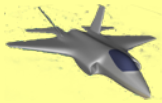
2 MIW LCS

20 Small Surveillance UAVs

8 Large Surveillance UAVs

2 ASuW LCS

30 Medium-Sized Surveillance UAVs



14 JSF

2 ASW LCS

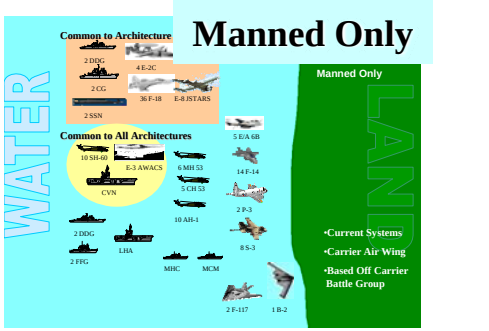
10 ASW UUV

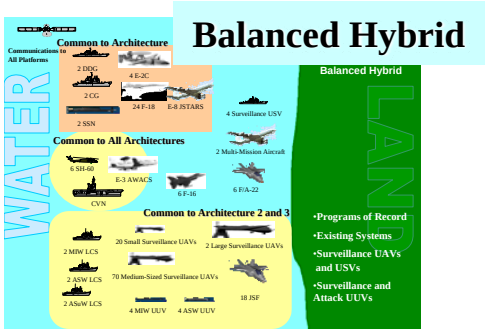
4 MIW UUV

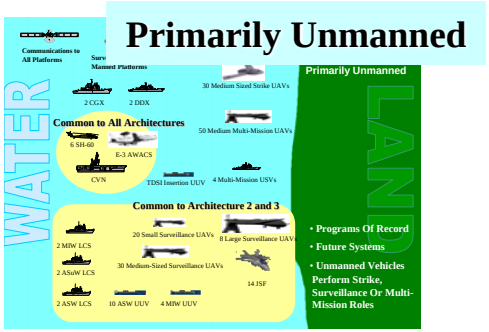
- **Programs Of Record**
- **Future Systems**
- **Unmanned Vehicles Perform Strike, Surveillance Or Multi-Mission Roles**

Architecture Summary

- Three Architectures With Progressing Reliance on UVs
  - Manned Only
  - Balanced Hybrid
  - Primarily Unmanned
- Architecture Effectiveness Modeled in Simulative Study Against Test Scenarios







South China Sea Scenario

- PRC Warship Strafed by Philippines Fighter
- PRC Naval Blockade of Puerta Princessa
  - Historical Rights and Economic Requirements
  - Need to Establish Safety Perimeter Around South China Sea
- PRC Reinforcement of Presence in the Spratly Islands
  - Paved Runways
  - Pier and Maintenance Facilities
  - ADA Batteries and Ballistic Missile Sites.
- PRC Invasion of Kepulauan Natuna (Indonesia)
- PRC Invasion of Palawan After a 30-day Blockade
  - Land, Air, Sea, and Missile Forces Moved to Island

Scenario Criteria

PRC Invasion Force

Aircraft 735

Surface 79

3 SOVREMMENY DDG
1 CV + 30 SU-30
55 DDG, FFG, & PGM

Subsurface 21

5 Type 091/093 SSN
15 Diesel SS (4 Kilo)

MARDIV 1

ARTDIV 1

INFDIV 7*

*3 Additional Reserve (Guangzhou)

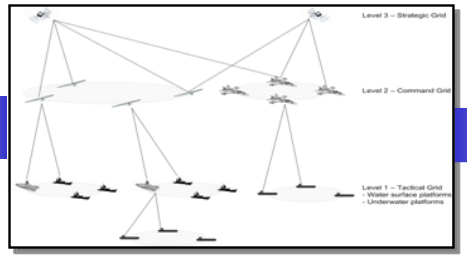
No Heavy Armor Division
Light Armor Units With MANPADS

- **Tactical Littoral Environments**
- **Scenario Definition Guided By Complexity**
  - Mission
  - Enemy Force Structure
  - Level of Hostility

Scenario	Enemy	Conflict	Escalation
Benign	Neutral	Unlikely	Unlikely
Nominal	Aggressive	Medium	Low
Stressing	Hostile	High	Medium

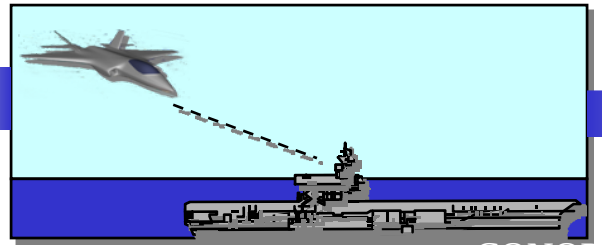
Campus Wide Integrated Project

COMMUNICATIONS
Conceptual Communications Network



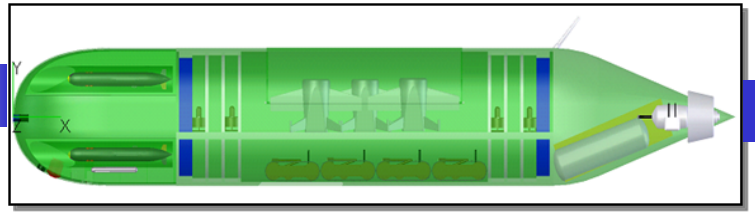
Extend™
Link Capacity 24 Mbps
Max. Comm. Range 60 km

INFORMATION ASSURANCE
Technology Exploitation Study and Limitation Parameters



Littoral Deployment CONOPS

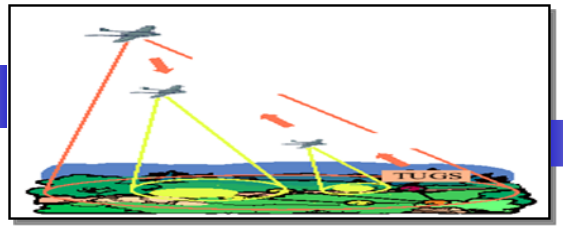
LAND SYSTEMS
Submersible UV
Craft Carrier



Littoral Deployment CONOPS

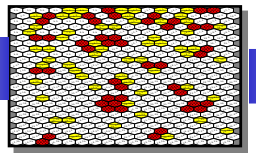
ALWSE-MC
- **5 Golden Eye UAVs**
- **20 iSTAR UAVs**
- **4 REMUS UUVs**
- **6 TALON Robot UGV**

SENSORS
In Depth Sensor Study for Operation in Littorals



Excel
- **Center Frequency 440 MHz**
- **BW 19.38 MHz**
- **Peak Power 1000 W**
- **Average Power 19 W**
- **Azimuth 3dB Beam Width 19°**
- **Elevation 3dB Beam Width 38°**
- **Nominal Gain 14 dB**

OR
Analytical Support Conceptual Modeling



Littoral Deployment CONOPS

Cost Estimation Results

	Cost in FY04$B		
Architecture	**Purchase Cost**	**O&S***	**TOC****
Manned Only	0	1.53	23
Balanced Hybrid	4.7	1.34	24.3
Primarily Unmanned	10.4	1.13	25.8

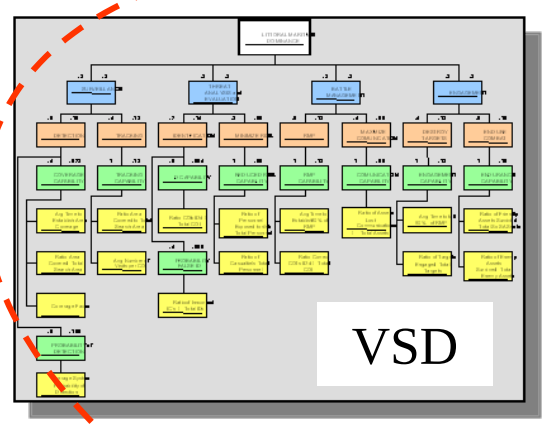
*** Per 1-year Basis**

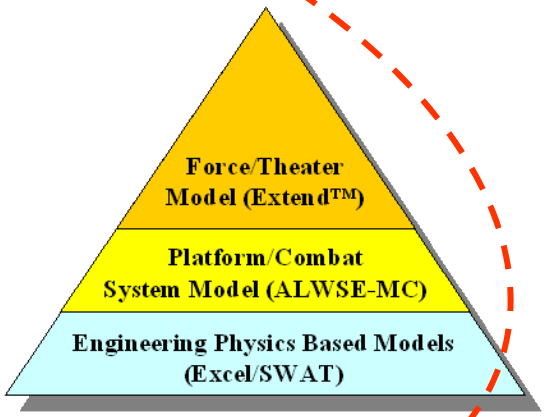
**** Per 10-year Basis Including Inflation**

Cost Estimation Methodology

- All O&S Costs in FY2003 From VAMOSC, AFTOC and OSMIS Databases
- Costs for Future Systems (i.e., UVs and (X) Ships) Estimated Using Analogy Technique
- Derivation of Proposed Future System Unit Cost Using Cost Factors
  - Complexity
  - Miniaturization
  - Productivity Improvement

Simulative Study Overview





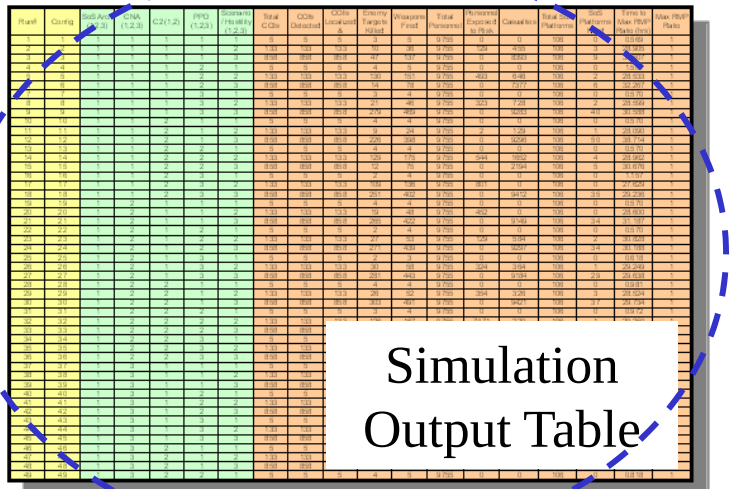
Modeling Framework

Result

- Quantitative Data Provided to Answer Important Questions

Method

- Important Questions and Sensitive Design Variables Identified
- Comprehensive Modeling Framework Developed to Answer the Important Questions



Run#	Config	SoS Arch (1,2,3)	CNA (1,2,3)	C2 (1,2)	PPO (1,2,3)	Scenario Fidelity (1,2,3)	Total C2Is	C2Is Detected	C2Is Localized &	Enemy Targets Killed	Weapons Fired	Total Personnel	Personnel Exposed to Risk	Casualties	Total Platforms	SoS Platforms	Time to Max RWP Rate (hrs)	Max RWP Rate
1	1	1	1	1	1	1	8	8	8	8	9	9 750	0	0	108	0	19.69	1
2	2	1	1	1	1	2	133	133	133	10	36	9 750	528	4295	108	3	32.859	1
3	3	1	1	1	1	3	858	858	858	47	137	9 750	0	8363	108	9	32.267	1
4	4	1	1	1	2	1	8	8	8	4	5	9 750	0	0	108	0	19.69	1
5	5	1	1	1	2	2	133	133	133	130	151	9 750	463	6148	108	2	28.633	1
6	6	1	1	1	2	3	858	858	858	54	78	9 750	0	7377	108	8	32.267	1
7	7	1	1	1	3	1	8	8	8	3	4	9 750	0	0	108	0	19.70	1
8	8	1	1	1	3	2	133	133	133	27	46	9 750	323	728	108	2	28.662	1
9	9	1	1	1	3	3	858	858	858	209	484	9 750	0	8083	108	48	41.599	1
10	10	1	1	2	1	1	8	8	8	4	4	9 750	0	0	108	0	19.70	1
11	11	1	1	2	1	2	133	133	133	9	24	9 750	2	129	108	3	28.662	1
12	12	1	1	2	1	3	858	858	858	226	848	9 750	0	8258	108	68	38.774	1
13	13	1	1	2	2	1	8	8	8	4	4	9 750	0	0	108	0	19.70	1
14	14	1	1	2	2	2	133	133	133	129	175	9 750	344	1652	108	4	28.952	1
15	15	1	1	2	2	3	858	858	858	12	75	9 750	0	2194	108	8	30.876	1
16	16	1	1	2	3	1	8	8	8	2	4	9 750	0	0	108	0	19.71	1
17	17	1	1	2	3	2	133	133	133	169	198	9 750	801	0	108	0	27.629	1
18	18	1	1	2	3	3	858	858	858	261	402	9 750	0	5412	108	35	29.236	1
19	19	1	2	1	1	1	8	8	8	4	4	9 750	0	0	108	0	19.70	1
20	20	1	2	1	1	2	133	133	133	19	48	9 750	452	0	108	0	28.633	1
21	21	1	2	1	1	3	858	858	858	269	422	9 750	0	5149	108	34	41.167	1
22	22	1	2	1	2	1	8	8	8	4	4	9 750	0	0	108	0	19.70	1
23	23	1	2	1	2	2	133	133	133	27	53	9 750	504	594	108	2	28.662	1
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25	25	1	2	1	3	1	8	8	8	4	4	9 750	0	0	108	0	19.70	1
26	26	1	2	1	3	2	133	133	133	30	58	9 750	324	394	108	1	28.248	1
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33	33	1	2	2	2	3	858	858	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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42	42	1	3	1	2	3	858	858	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	43	1	3	1	3	1	8	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
44	44	1	3	1	3	2	133	133	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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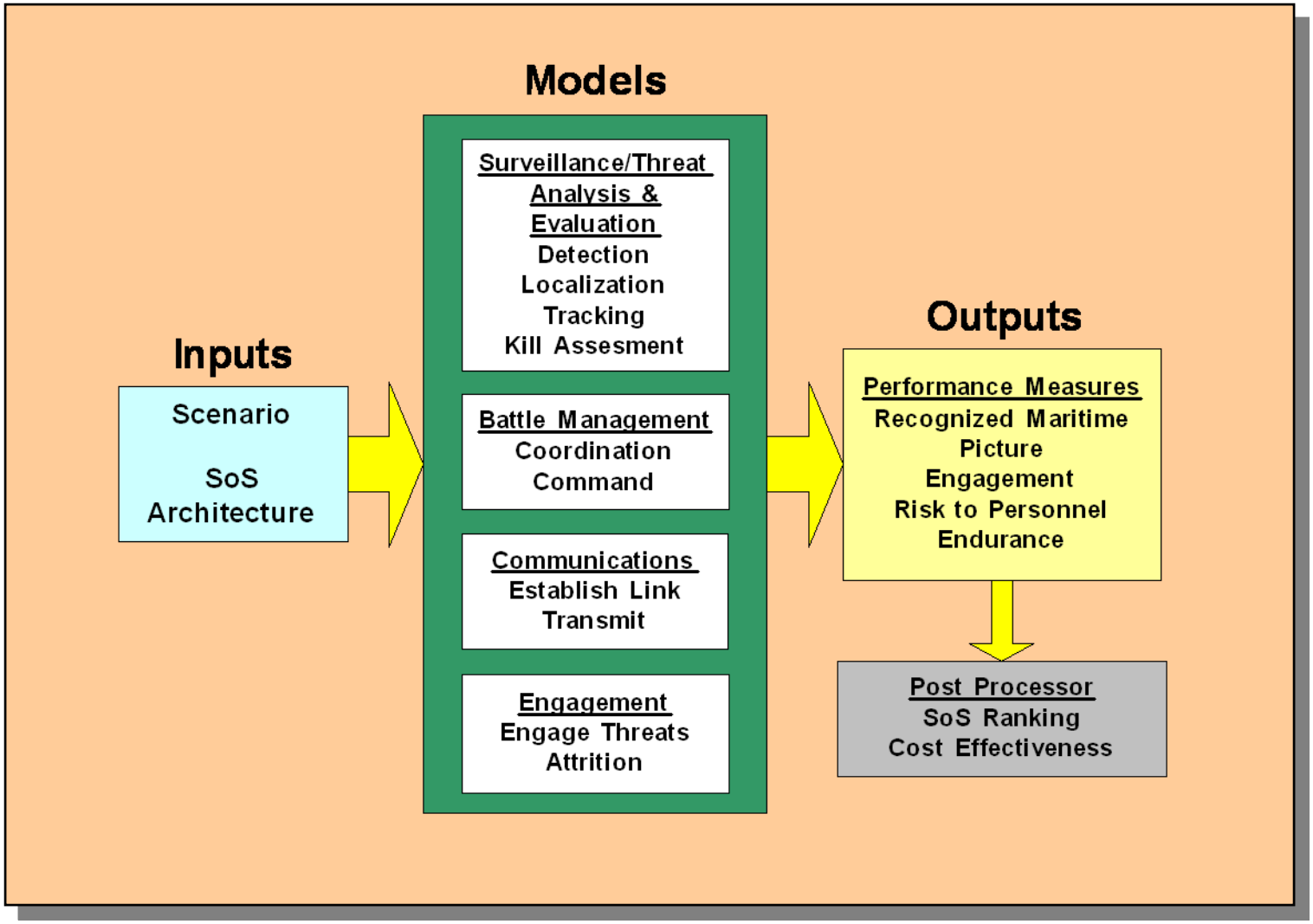
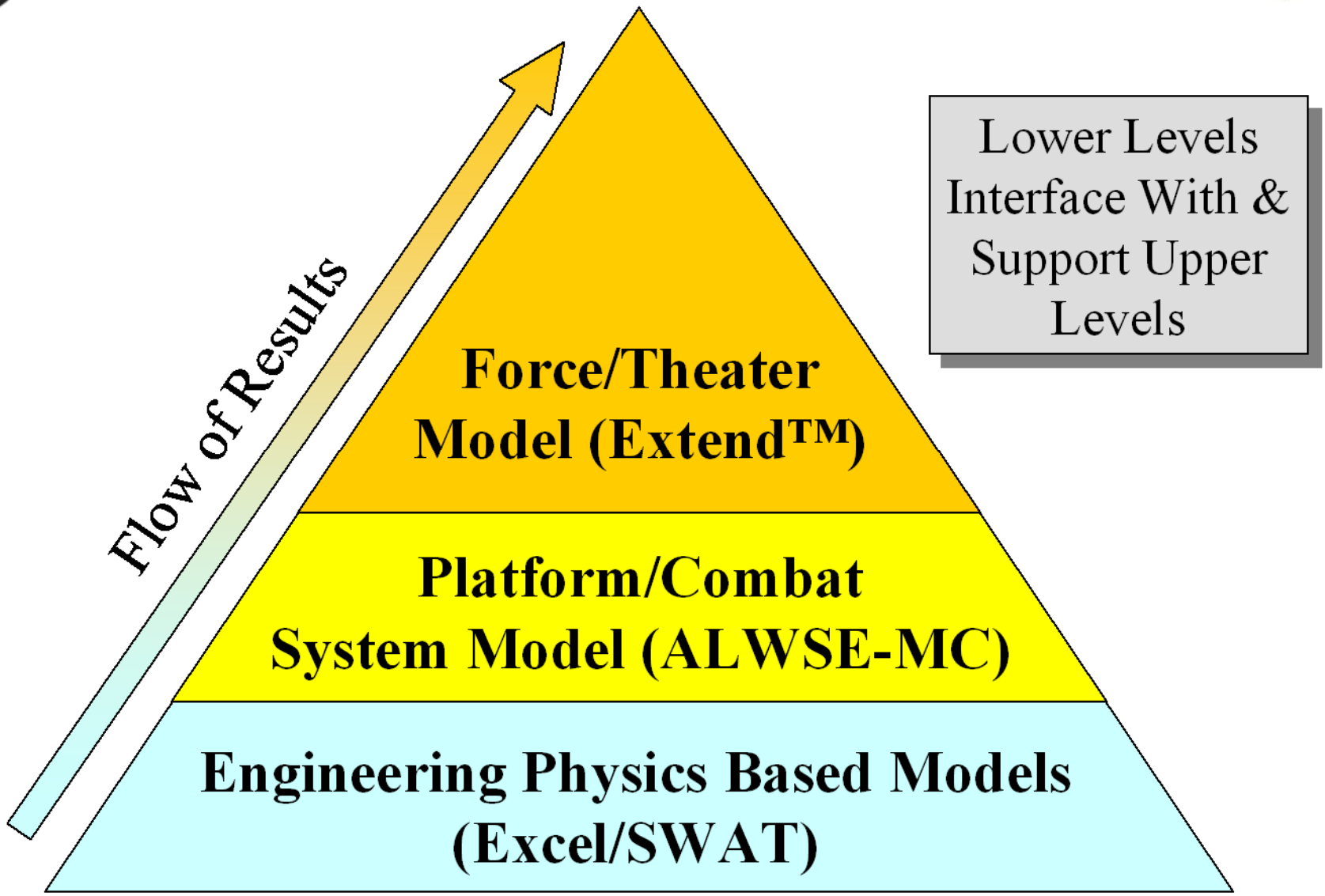
46	46	1	3	2	1	1	8	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47	47	1	3	2	1	2	133	133	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
48	48	1	3	2	1	3	858	858	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49	49	1	3	2	2	1	8	8	8	4	5	9 750	0	0	108	0	19.78	1

Simulation Output Table

Simulative Study Design

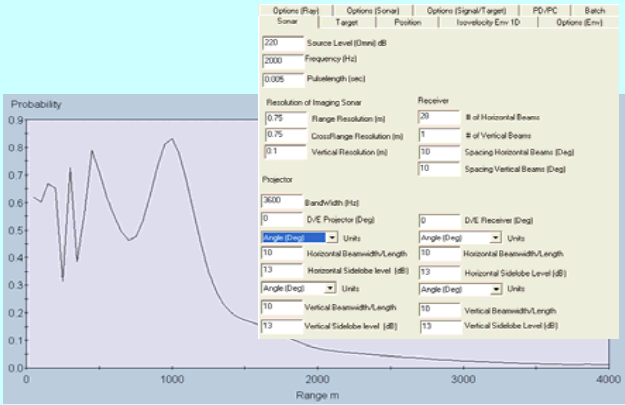


Modeling Framework



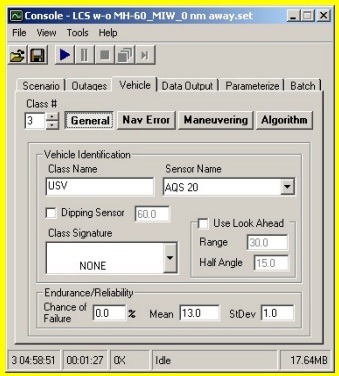
Modeling Tools Interface

Excel/SWAT



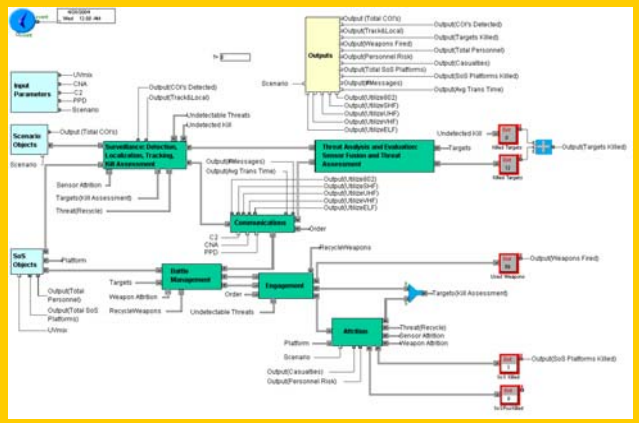
Lateral Range Detection Curves

ALWSE-MC



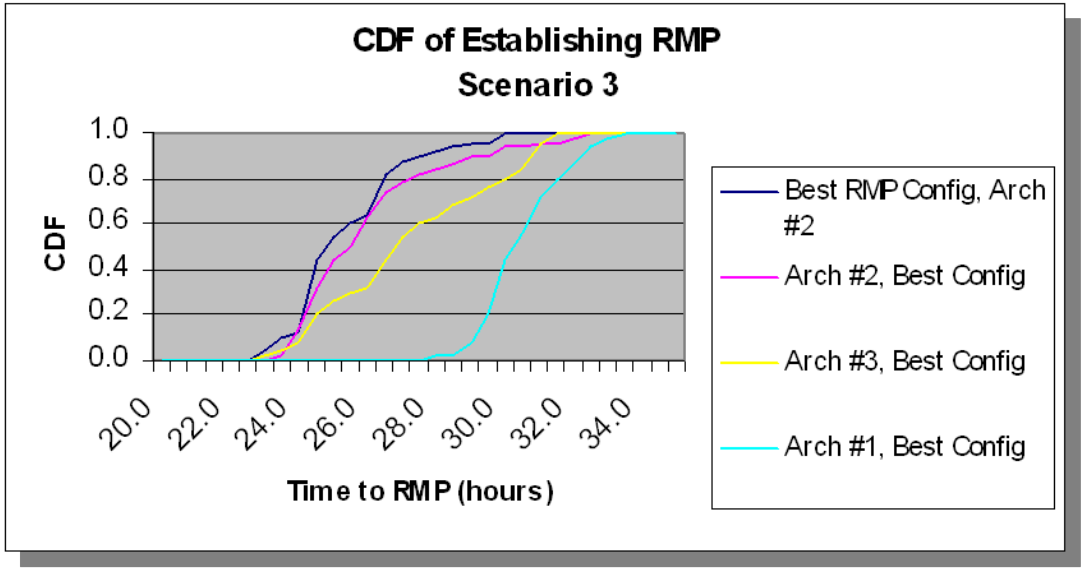
Database Tables

Extend™

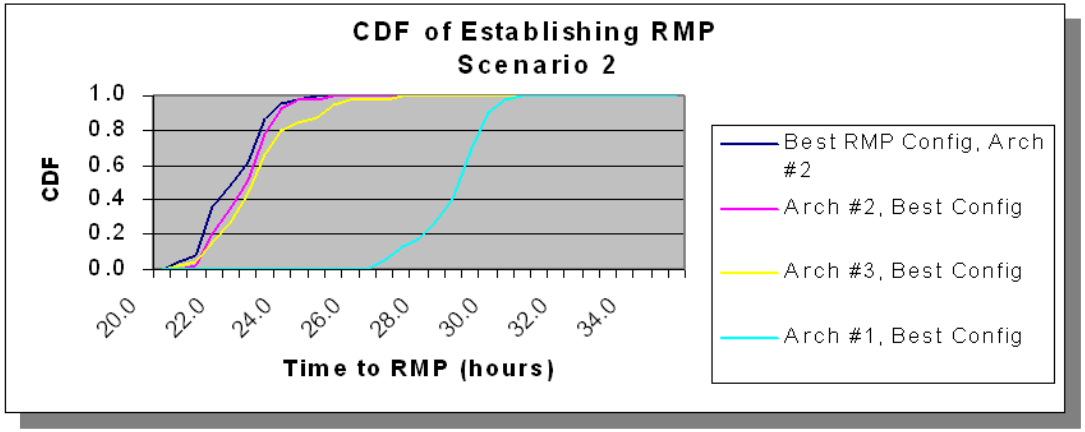


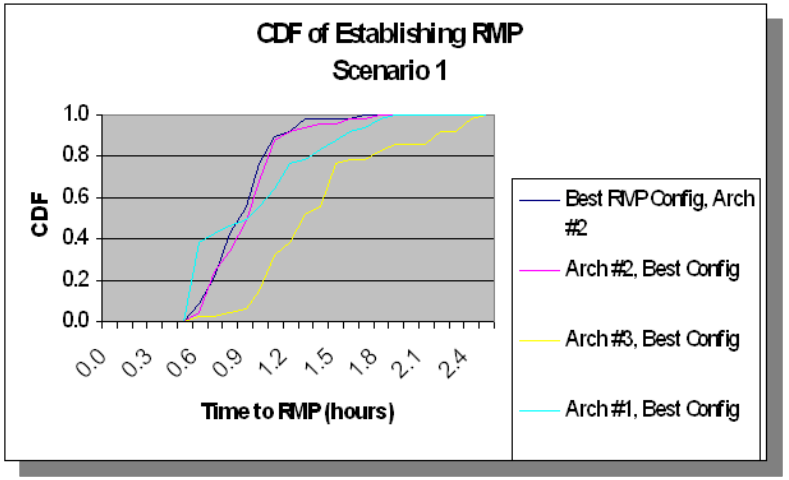
Time To Detection Data

Selected Configuration Validation



- Comparison of CDF for Time-to-RMP for Best Configuration from 162 Configurations to CDFs for Selected Configurations
- Excellent Agreement between Best-Configuration CDF and CDF for Selected Architecture 2-Best Configuration Thus Validating Chosen Configuration
- Comparison of CDFs for Other MOEs Also Validating Chosen Configuration





CDF: Cumulative Distribution Function

Arch 1 – Manned Only

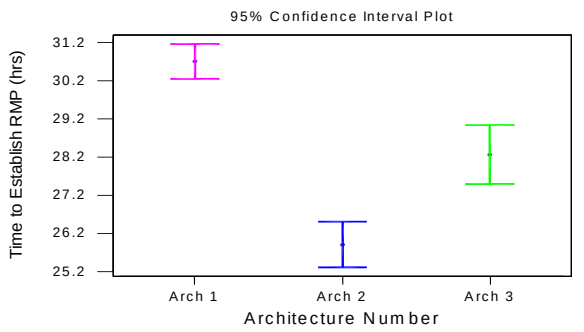
Arch 2 – Balanced Hybrid

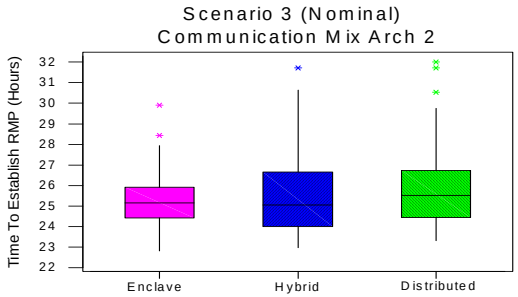
Arch 3 – Primarily Unmanned

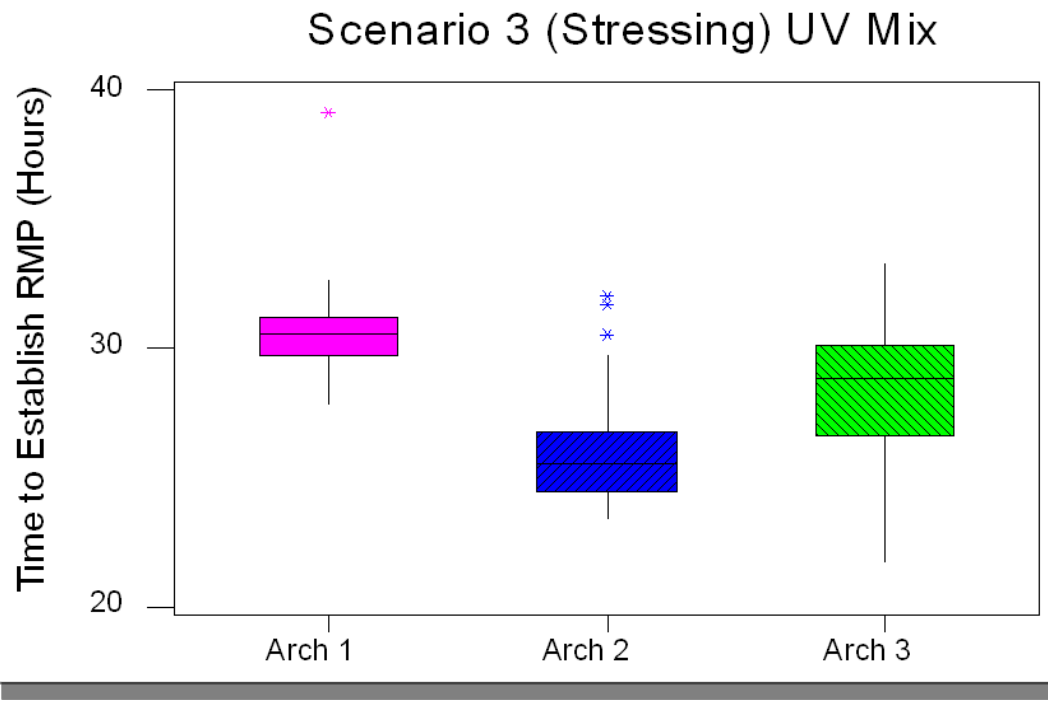
Effects of Configuration Attributes On RMP

Arch 1 – Manned Only
Arch 2 – Balanced Hybrid
Arch 3 – Primarily Unmanned

- Significant Effects of Unmanned/Manned Ratio on Time-to-RMP
- Insignificant Effects of Command and Control Structure & Communication Network Architecture







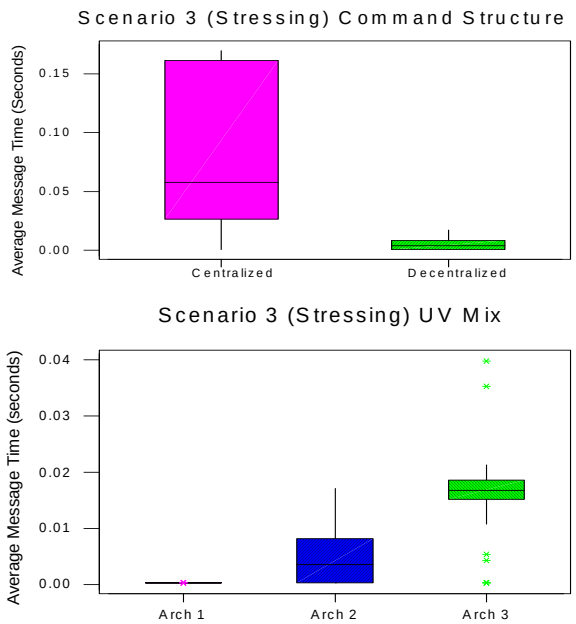
Effects of Configuration Attributes On Communications Performance

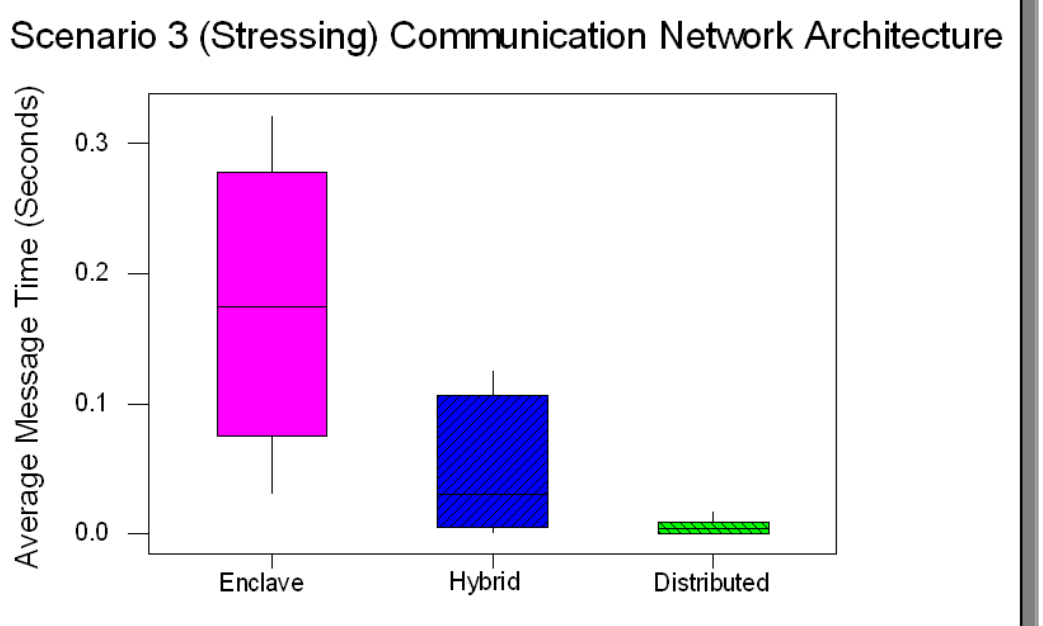
Arch 1 – Manned Only

Arch 2 – Balanced Hybrid

Arch 3 – Primarily Unmanned

- Significant Effects of Unmanned/Manned Ratio, Command & Control and Communication Network Architecture on Communication Performance (Message Delay)

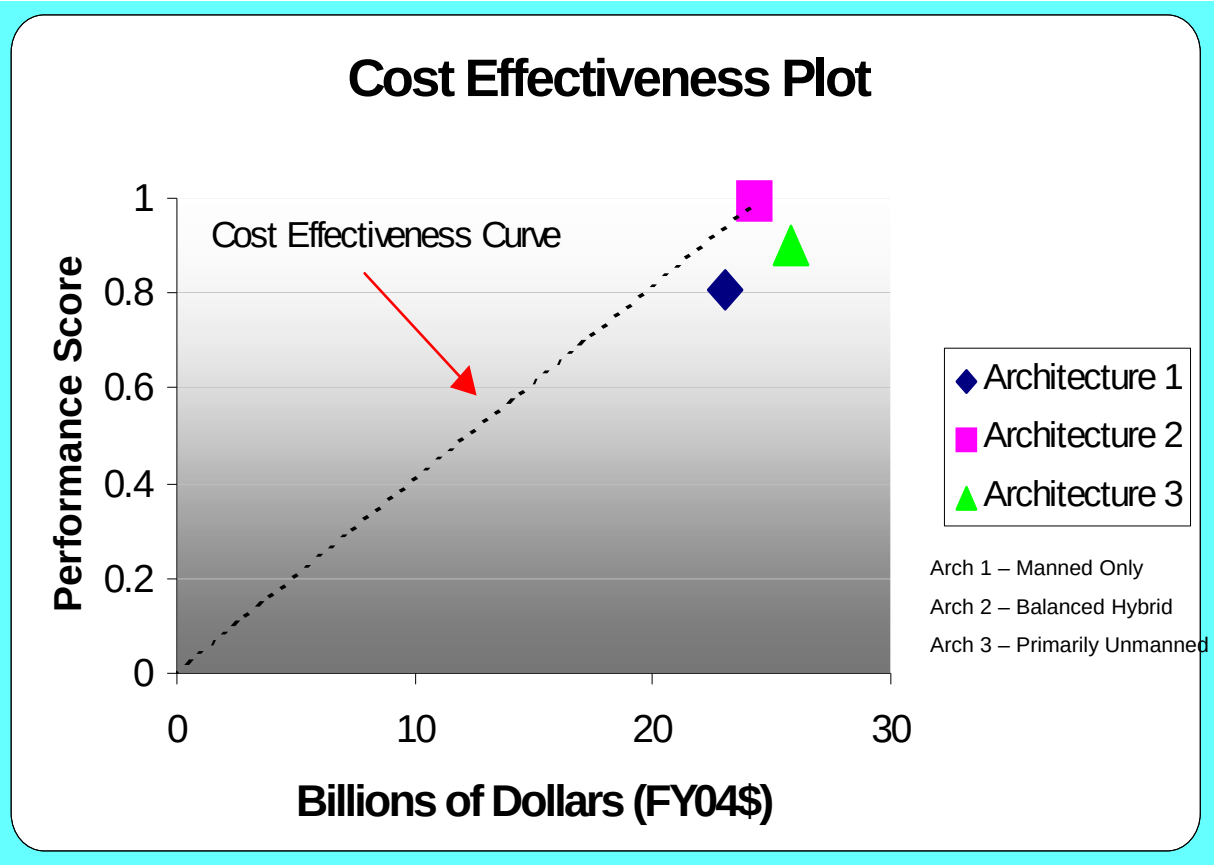




Cost Effectiveness Curve

for Architecture Recommendation

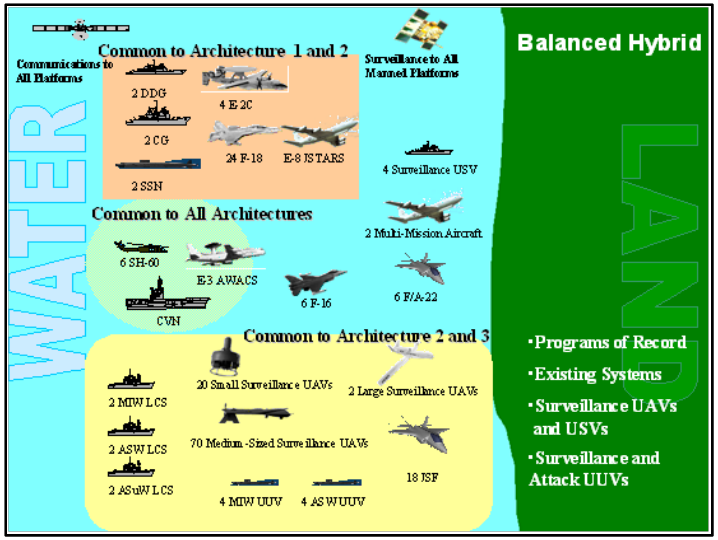
- Balanced Hybrid Cost Effective & Cost Efficient
- Manned Only Cost Effective Not Cost Efficient
- Primarily Unmanned Dominated (Neither Effective or Efficient)

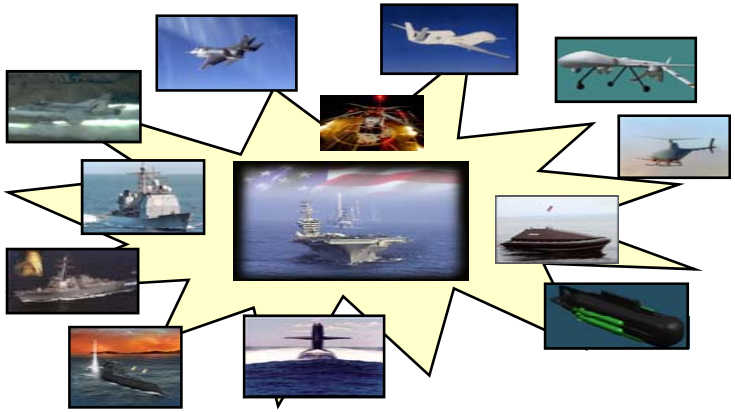


Balanced Hybrid Recommended Based on Cost & Performance

Recommended System of Systems for Maritime Dominance in Littorals

- **Unmanned Vehicles Complement But Cannot Replace Manned Platforms**
- **Recommended System of Systems Enabling SEA BASING and SEA STRIKE in 200 nm by 200 nm Littoral Operation Area in 2020 Timeframe**
  - **Consists of Unmanned/Manned Vehicle Ratio of Approximately 1.5 to 1**
  - **Utilizes Distributed Communications with 100nm Physical Platform Distribution**
  - **Employs Decentralized Command & Control Structure**
  - **Is Cost Effective Relative to Other Alternatives**





- **Distributed Communications**
  - Faster Dissemination of Information
  - Minimum Impact on Throughput with Node Failures
- **Decentralized Command and Control**
  - Shorter Reaction Times
  - Less Network Demand
  - Single C2 Node Failure Avoidance
- **100 nm Platform Distribution**
  - Superior Overall Performance