Maritime Threat Response

Systems Engineering and Analysis-9

AY2006 Integrated Project

Final Presentation

24 May 2006

Opening Remarks

Dr. Frank Shoup

Director

Meyer Institute for Systems Engineering

Introduction

LCDR Andrew "Chunder" Kessler, USN

Student Project Leader

Morning Agenda

◆ Project executive overview	0905-0930
◆ Systems engineering process	0930-0955
◆ Break	0955-1005
◆ SoS architecture and C4ISR	1005-1020
◆ Counter WMD mission	1020-1040
◆ Counter SAW mission	1040-1100
◆ Break	1100-1110
◆ Counter SBA mission	1110-1130
◆ SoS sustainment overview	1130-1200
◆ Summary and conclusions	1200-1220

Afternoon Agenda

◆ Lunch break	1220-1320
◆ Classified brief (Glasgow STBL)	1330-1410
◆ Walk to Bullard Hall	1410-1420
◆ Breakout sessions	1420-1600
• Radiation detector demos	(Bullard 100C)
• Counter WMD model demo	(Bullard 100A)
• Counter SAW model demo	(Bullard 100A)
• Counter SBA model demo	(Bullard 100A)
• Sustain model demo	(Bullard 100A)

Presentation Rules of Engagement

- Morning briefs are synopses of detailed project work
  - Information conveyed in summary form
- Afternoon break-out sessions are available for in-depth discussions of project work
- Please hold questions until the end of the individual brief
  - Each briefer will open up the floor for questions at the end of his presentation
- Hand-outs provide amplifying information

Project Description

- Tasking evolved from Office of the Assistant Secretary of Defense for Homeland Defense (OASD HD) through Meyer Institute for Systems Engineering
- Develop a conceptual, near term system of systems (SoS) to respond to terrorist threats to the United States emanating from the Maritime Domain by
  - Generating alternatives using existing systems and Concepts of Operations, Programs of Record, and commercial off the shelf (COTS) technologies
  - Recommending a cost effective SoS that must minimize impact on commerce
- Deliver project results in a final brief (5/24) and technical report

MTR Project Interfaces

ON NPS CAMPUS

SEA-9 FACULTY ADVISOR

DR. TOM HUYNH

SEA-9 MTR PROJECT TEAM LEAD

LCDR ANDY KESSLER

NPS FACULTY CONSULTANTS

FACULTY ADVISORS

PROF CRAIG SMITH (SENSORS)

PROF GAMANI KARUNASIRI (COMMS, SENSORS)

PROF DICK HARKINS (COMMS, SENSORS)

LCDR DAVID MEYER (OPS ANAL, MOVES)

PROF KAREN BURKE (INFO OPS, ASSURANCE)

PROF CHRIS BROPHY (WEPS, TAC MISSILE)

LTCOL ANDY HERNANDEZ (WAR-GAMING)

SEA-9 MTR PROJECT <u>FUNCTIONAL LEADS</u>

MS. JENNIFER DAVIS

MAJ MIKE SHEWFELT

LT BRIAN CONNETT

LT JOE ORAVEC

LT CHIU-ROURMAN

ENS SHAUNNAH WARK

TDSI

TSSE

OFF CAMPUS

<u>OP REQ / STAKEHOLDERS</u>

OASD(HD)

DHS

NORTHCOM

OPNAV N51

COAST GUARD (DIST 11)

3RD FLEET

<u>TECH REQ / ADVISORS</u>

LLNL / LANL / PNNL

DNDO / NNSA

SWDG / NWDC

Operation SEA HAWK

NAVSPECWARCOM

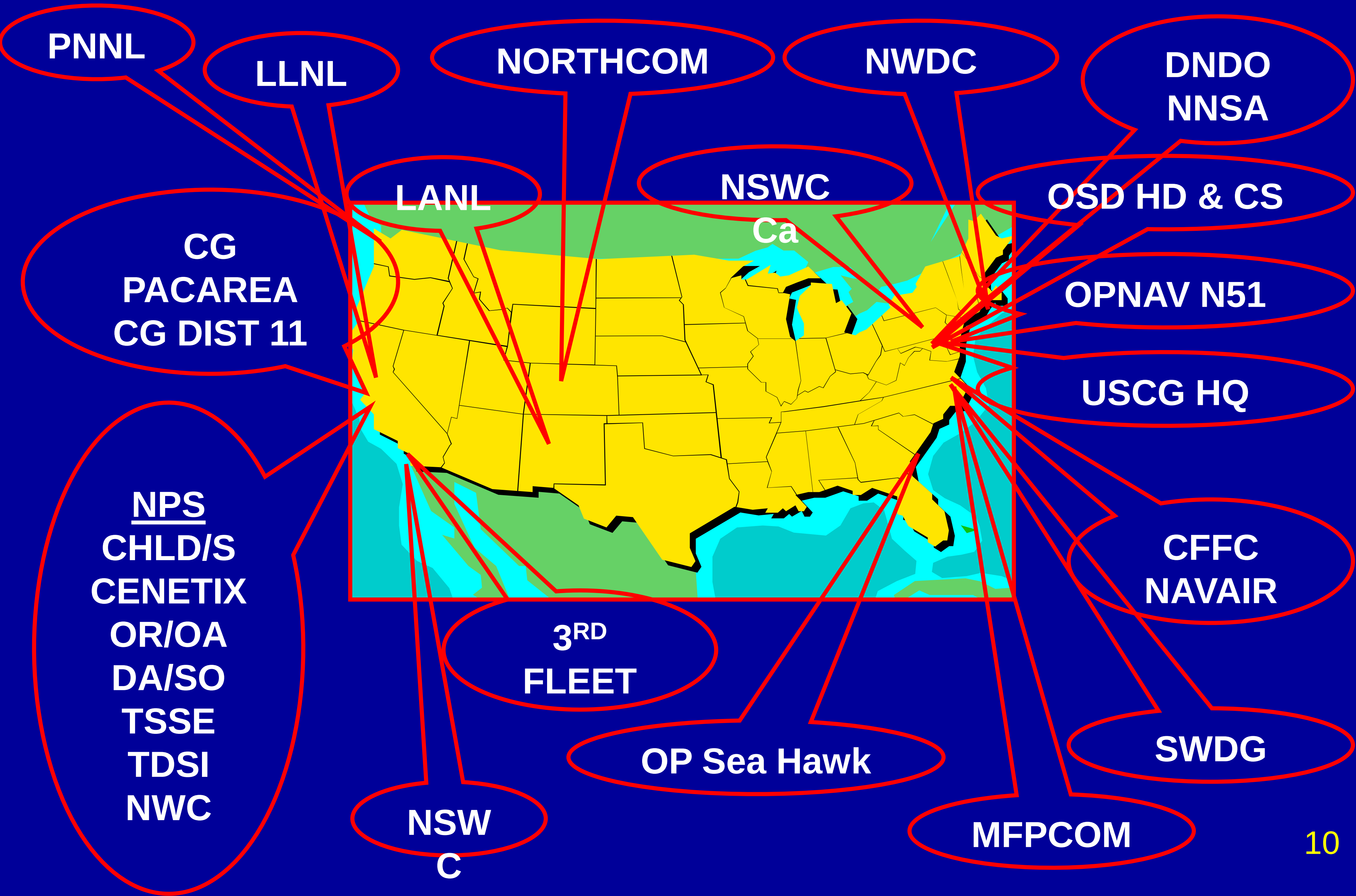
NSWC Carderock

NAVAIRSYSCOM

Project Focus, Constraints and Assumptions

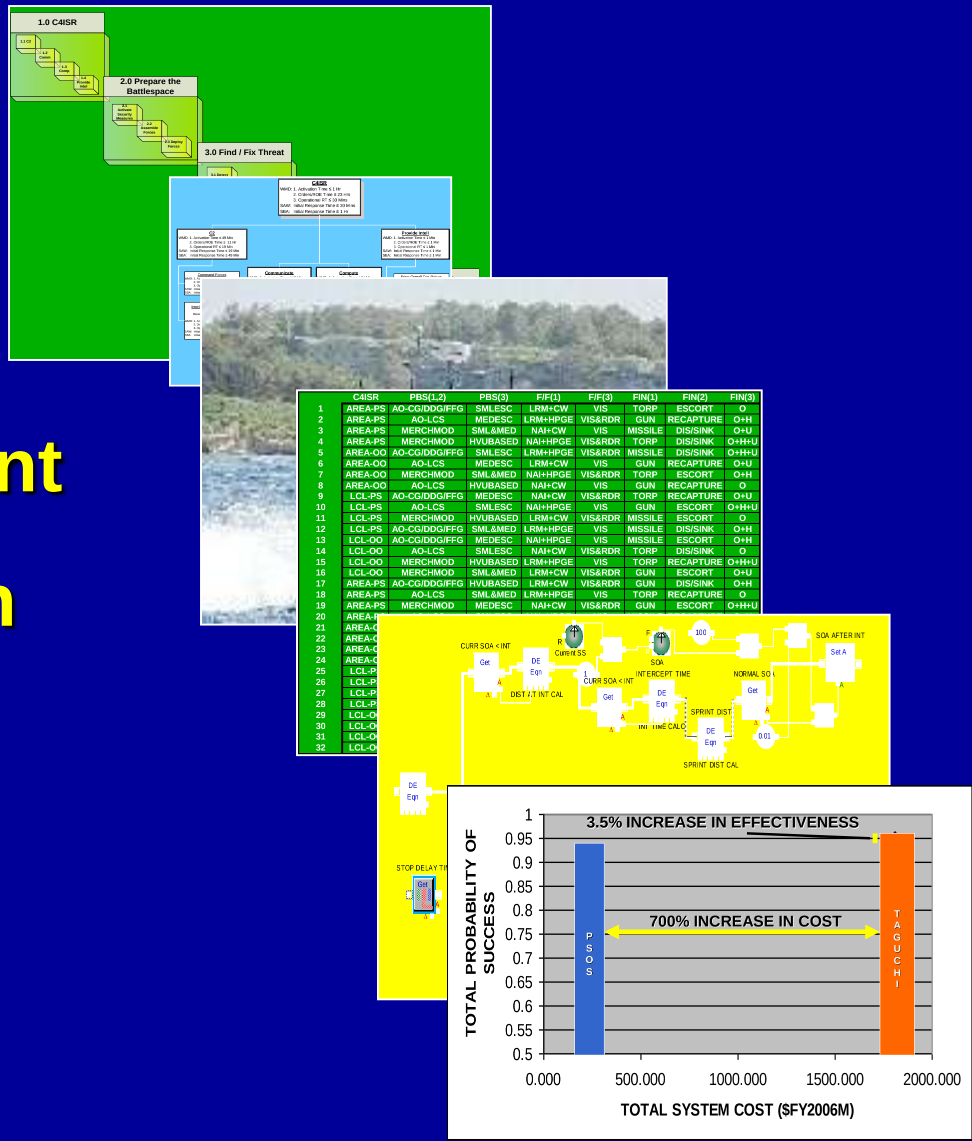
- **SoS architectural focus**
  - Existing systems, new CONOPS
  - Joint and inter-agency solutions
  - Near term technological solutions to fill gaps
- **Constraints**
  - Design project schedule (SoS design complete by CDR)
  - Conceptual design (no hardware fabrication)
  - Architecture assessment by modeling and simulation
  - New systems IOC within five years
- **Assumptions**
  - Intelligence via MDA system as an external interface
  - SoS solution to be independent of political and jurisdictional issues

Project Stakeholders and Advisors



Project Phase Overview

- Needs analysis
- Requirements analysis
- Functional analysis
- Architecture development
- Modeling and simulation
- Cost analysis
- Effectiveness analysis
- Architecture recommendation



SoS Problem Statement

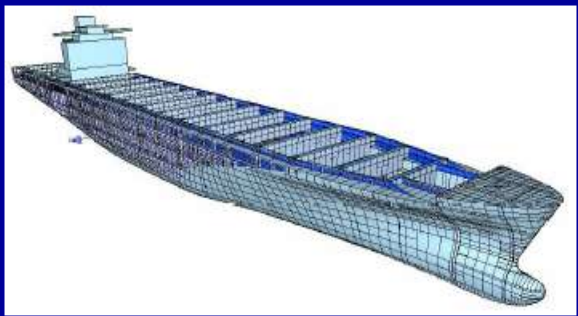
- "Define and select a cost-effective system-of-systems (SoS) architecture and its concept of operations that will enable responses to national security threats to the United States homeland that emanate from the maritime domain. Consider, at a minimum, the threat being a WMD device smuggled on board a ship and the threat being a vessel employed as a weapon itself. The responses could be validation of a suspected threat and/or the negation of an identified threat. Intelligence regarding a threat to the homeland is assumed to be available to the appropriate agencies for use by the system of systems. The SoS will consist of systems that are currently in service, in development, or could be developed within the next five years."

Mission Need Statement

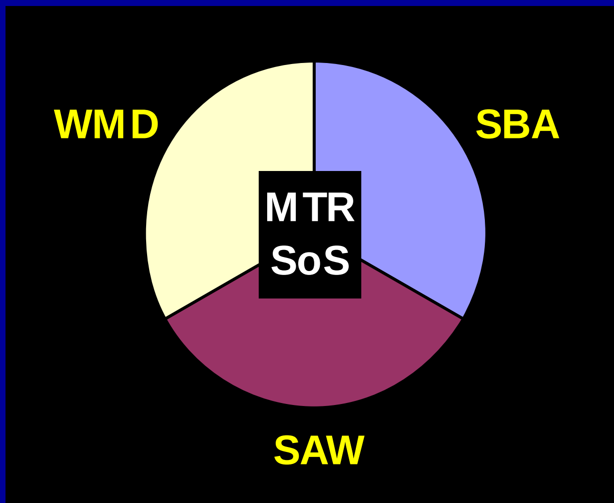
During all environmental conditions, the Maritime Threat Response (MTR) system must stop the terrorist attack outside of the range of lethal effects and do so with minimal impact on commerce and economic cost.

Representative Maritime Terrorist Threats





Weapon of Mass Destruction (WMD) on container ship

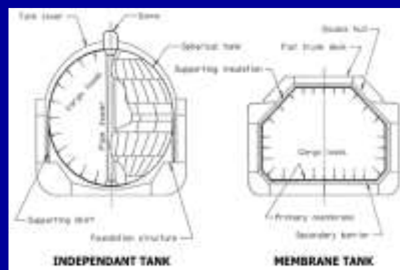





Ship targeted by small boat attack (SBA)


OIL TANKERS


LNG/ LPG CARRIERS

Commandeered ship as weapon (SAW)

Overview of Threat Scenarios

- WMD – Pacific Ocean Area of Operations
- SAW – Pacific Ocean and San Francisco Bay Area of Operations
- SBA – San Francisco Bay Area of Operations

Top-level SoS Quantitative Requirements

Mission	Probability of Success
Counter WMD	≥ 0.95
Counter SAW	≥ 0.90
Counter SBA	≥ 0.88

- QUANTITATIVE REQUIREMENTS DERIVATION

  ESTIMATED DAMAGE COST OF ATTACK TYPE (X)

  PROBABILITY OF ATTACK TYPE OCCURRENCE =

  EXPECTED VALUE OF DAMAGE WITHOUT MTR SYSTEM (X)

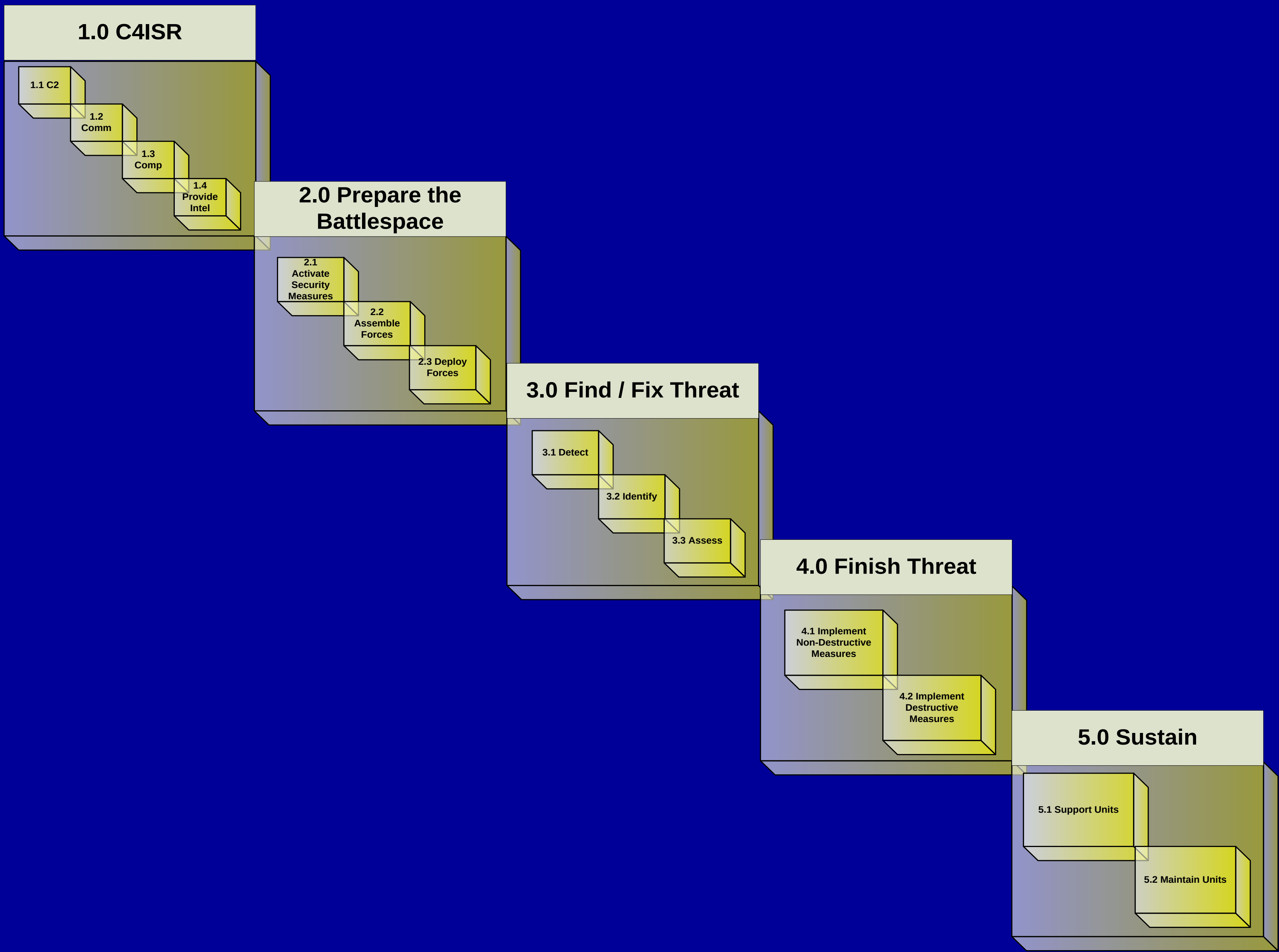
  SYSTEM P_S FOR EACH ATTACK SET TO EQUALIZE =

  EXPECTED VALUE OF DAMAGE WITH MTR SYSTEM

System of Systems Operational Requirements

Scenario	WMD	SAW	SBA
Mission Profile	Neutralize WMD device outside 100 NM	Neutralize AV by 15 NM or retake prior to impact	Prevent damage to vessels or infrastructure
Operational Distribution	Pacific Ocean 3 shipping routes 20 (6000 TEU) AVs	10 terrorists on board Approach and within San Francisco Bay	San Francisco Bay 13 HVUs (merchant & ferry) 1 attacking small boat
Performance Parameters	Time to intercept Search time Search P(Det)	Terrorist neutralize time Time to control ship	Time to detect Time to neutralize small boat
Utilization Requirements	1 → 20 day duration 24/7 availability	1 → 20 day duration 24/7 availability	1 → 30 day duration 24/7 availability
Effectiveness Requirements	95% Prob. of Success $$ impact on commerce System cost	90% Prob. of Success $$ impact on commerce System cost	88% Prob. of Success $$ impact on commerce System cost
Life Cycle Horizon	Average 10 years	Average 10 years	Average 10 years
Environment	Open Ocean Holding Area	Littoral and Port Poor visibility	Congested Port Poor visibility

Top Level SoS Functions



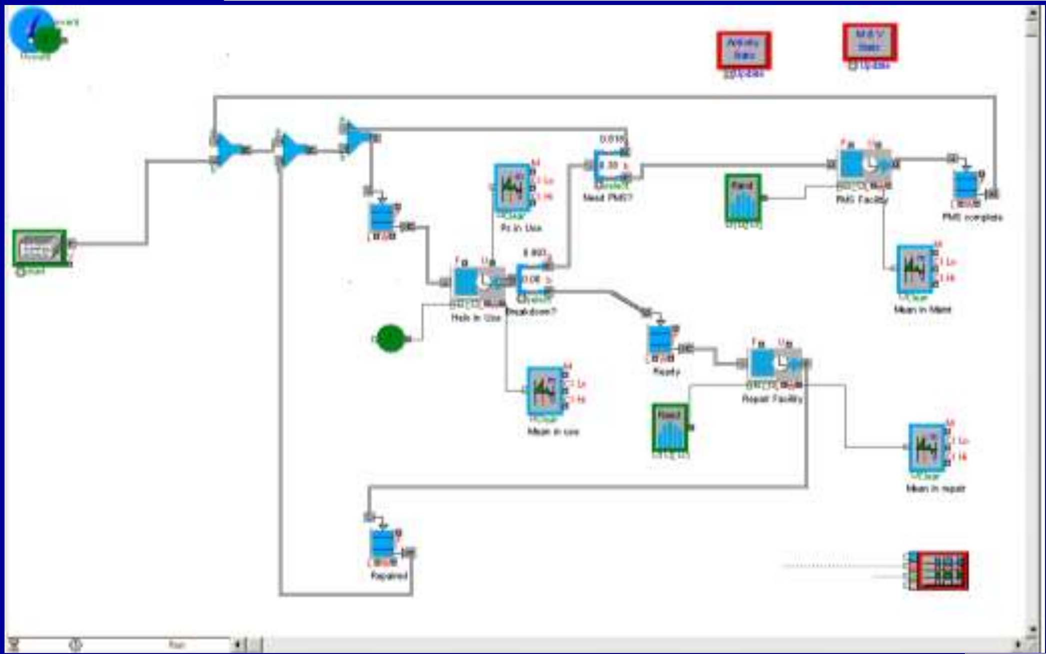
System Concepts by Function

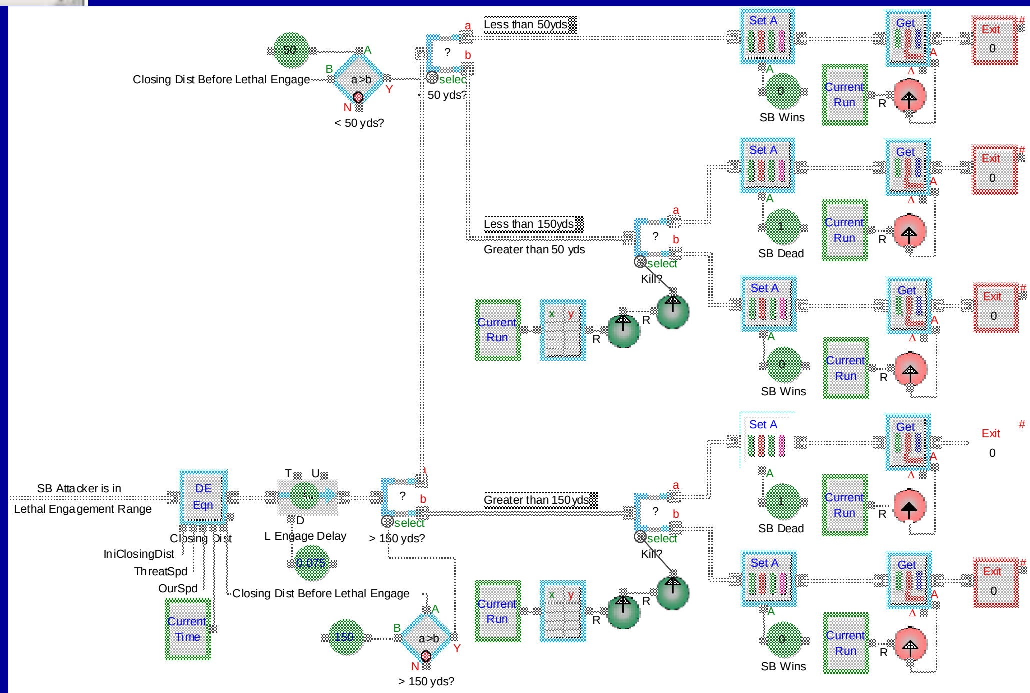
System Concept / Top Level Function	1	2	3	4
C4ISR	AREA-PS	AREA-OO	LOCAL-PS	LOCAL-OO
PBS(1,2) (WMD,SAW)	AO-CG/DDG/FFG/WHEC	AO-LCS/WMSL	MODIFIED MERCHANT	-
PBS(3) (SBA)	SMALL ESCORTS	MEDIUM ESCORTS	SMALL AND MEDIUM	HVU-BASED TEAMS
F/F(1) (WMD)	LRM & FISSION	LRM & HPGe	NaI & FISSION	NaI & HPGe
F/F(3) (SBA)	VISUAL	VISUAL AND RADAR	-	-
FIN(2) (SAW)	ESCORT / RECAPTURE	ESCORT / DISABLE	-	-
FIN(3) (SBA)	ORG WEPS	ORG WEPS & AIR SUPT	ORG WEPS & USVs	ORG WEPS, AIR & USVs

Allocated Performance Requirements

Scenario / Function	WMD 0.95	SAW 0.90	SBA 0.88
C4ISR	◆ Process time NMT 24 hrs	◆ Process time NMT 30 min (depending on intelligence latency)	◆ Process time NMT 1 hr
PBS	◆ Assemble teams and deploy vessels in less than 24 hrs	◆ Assemble teams and deploy vessels in less than 24 hrs ◆ Alert team with pilot	◆ Immediately start clearing non-essential boats ◆ Assemble crews and deploy escort vehicles in less than 1 hr
FIND/FIX	◆ Search 9400 TEU ship in less than 160 hr ◆ $P_d \geq 0.96$ $P_{FA} \leq 10^{-6}$ ◆ Dwell time ≤ 3 min per container	◆ Determine PAV status upon boarding ◆ Search PAVs with Escort teams given time	◆ Detect incoming small boats at sufficient range to allow warning, ID, and two shots prior to VA ◆ $P_S \geq 0.94$
FINISH	◆ Transfer to DoE JTO	◆ Disable PAV ≤ 21 min ◆ Sink PAV ≤ 21 min ◆ $P_S \geq 0.91$	◆ Defeat attack within 15 seconds ◆ $P_S \geq 0.94$

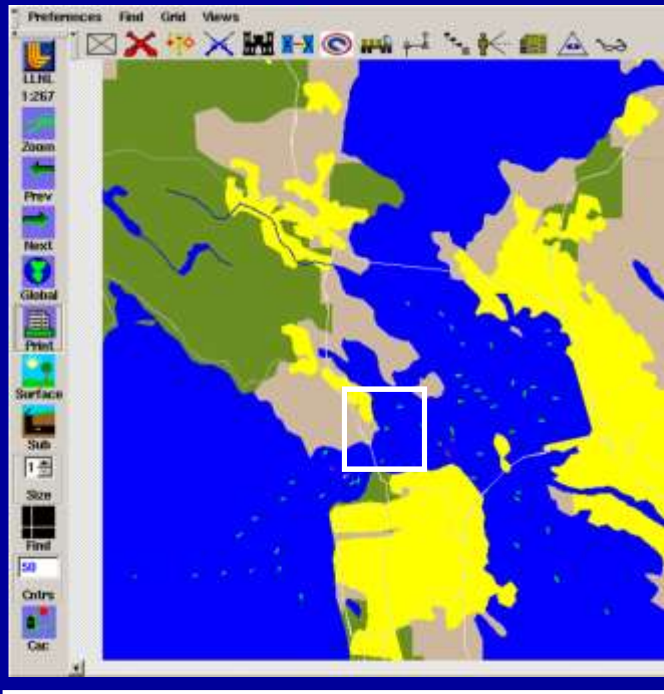
SoS EXTEND™ Model Examples

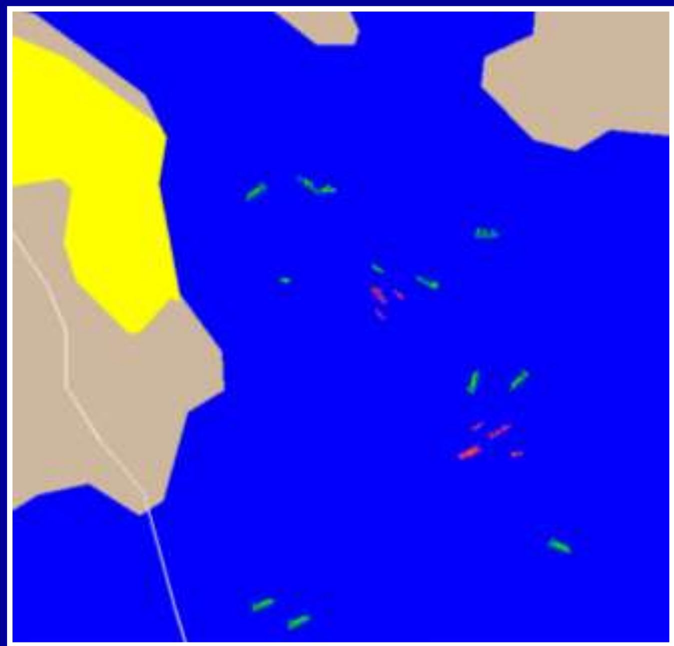




War Gaming

- Seek insights into potential terrorist tactics to counter MTR forces
- Joint Conflict and Tactical Simulation (JCATS)
- Validate SBA EXTEND™ model
  - Assumptions
  - MTR tactics, techniques, and procedures
  - Force structure

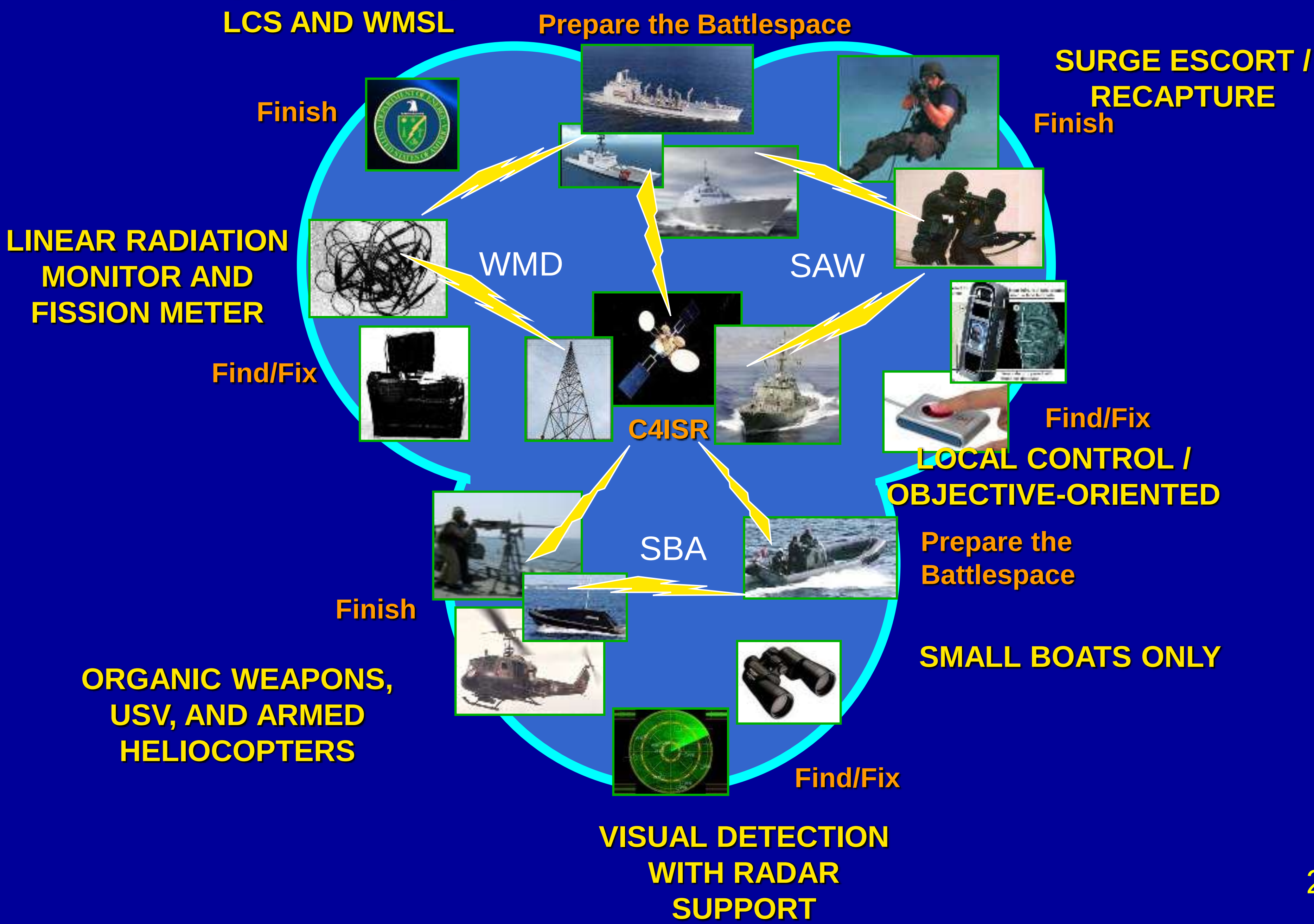




War Gaming

- Evaluate potential improvements to postulated CONOPS
- Joint Theater-level Simulation (JTLS)
  - Multiple PAVs serviced by a single U.S. ship
    - How far apart are targets?
    - Length of helo flights

Top-Down Cost Effective (TDCE) SoS Architecture



Overall Key Findings

- Specific intelligence is a necessary, but not sufficient, component of reliable and effective responses to terrorist threats
- Minimizing impact on commerce causes shifts away from traditional solutions and Concepts of Operations
- Inter-agency cooperation and coordination is critical to success
- Rules of Engagement and Concepts of Operations must enable independent action by forces without consulting HQ

Counter WMD Key Findings

- Surging National Fleet (USN and USCG) assets to meet incoming container ships affords search times of 100 – 200 hours per ship given intelligence latency of less than 180 hours
- Time available to search affords opportunities to spend tens of minutes per container and tens of hours per cargo hold

Counter SAW Key Findings

- SAW threat can be countered through employment of 10-man “Sea Marshall” teams with Harbor Pilots, but time is critical and a reliable method of disabling the ship must be immediately available
- Surging in response to SAW threat affords more time and options, but at significantly increased cost in resources
- Many key points impacting results are estimates of likely terrorist courses of action

Counter SBA Key Findings

- Close escort is more effective than barrier patrol in San Francisco Bay
- Prohibiting recreational boat traffic is critical to mission success
- Static infrastructure needs to be protected as well as commercial boat traffic
- Medium escort ships are effective but costly
- Unmanned Surface Vehicles (USV) are relatively cheap and effective

Questions?

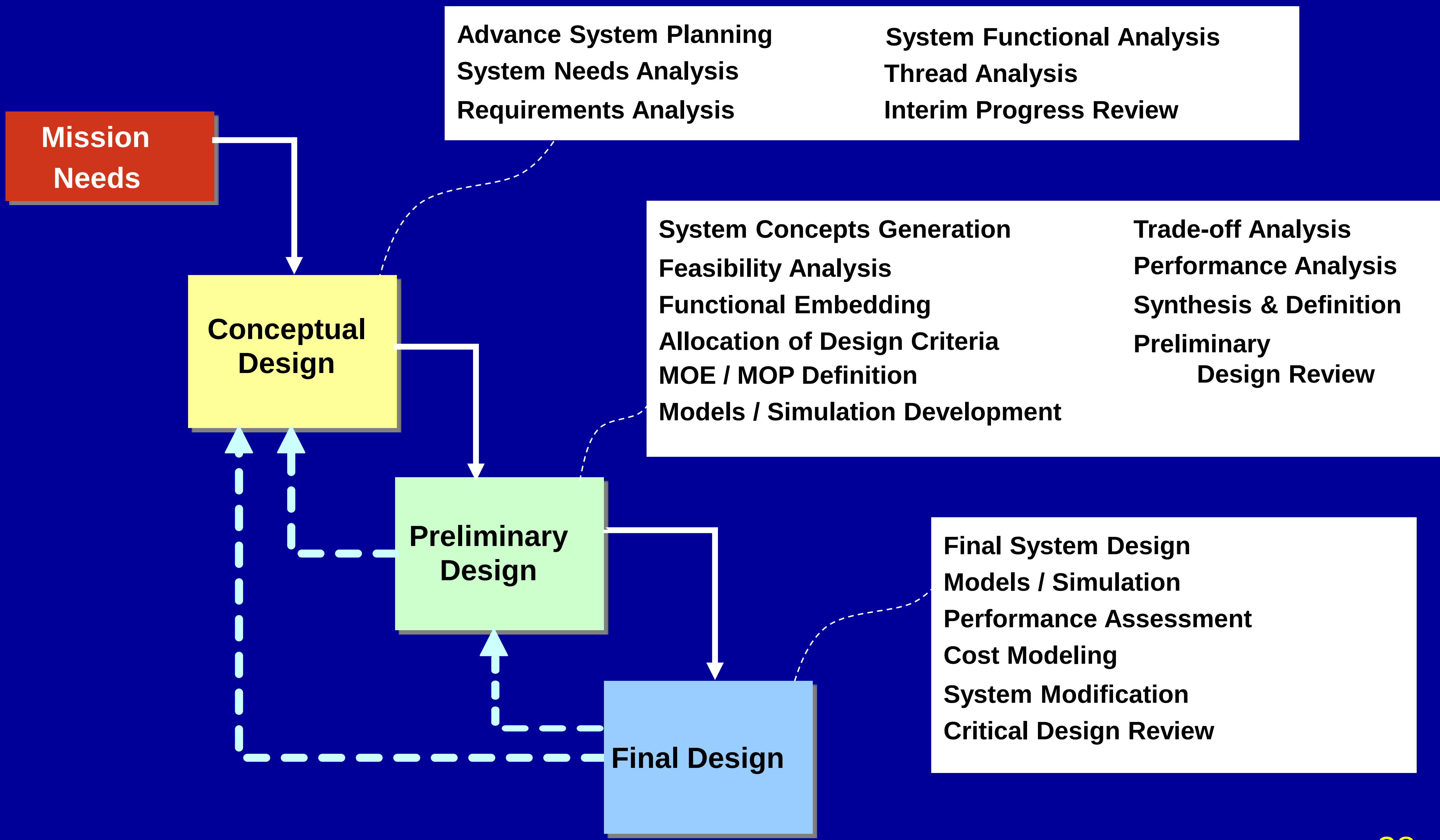
Systems Engineering Process

Ms. Jennifer Davis

Topics

- Systems engineering approach
- SoS problem definition
- SoS architecting methodology
  - Needs analysis
  - Requirements analysis
  - Architecture alternatives
    - Development
    - Assessment
      - Modeling and simulation
      - Cost analysis
    - Selection

Systems Engineering Approach

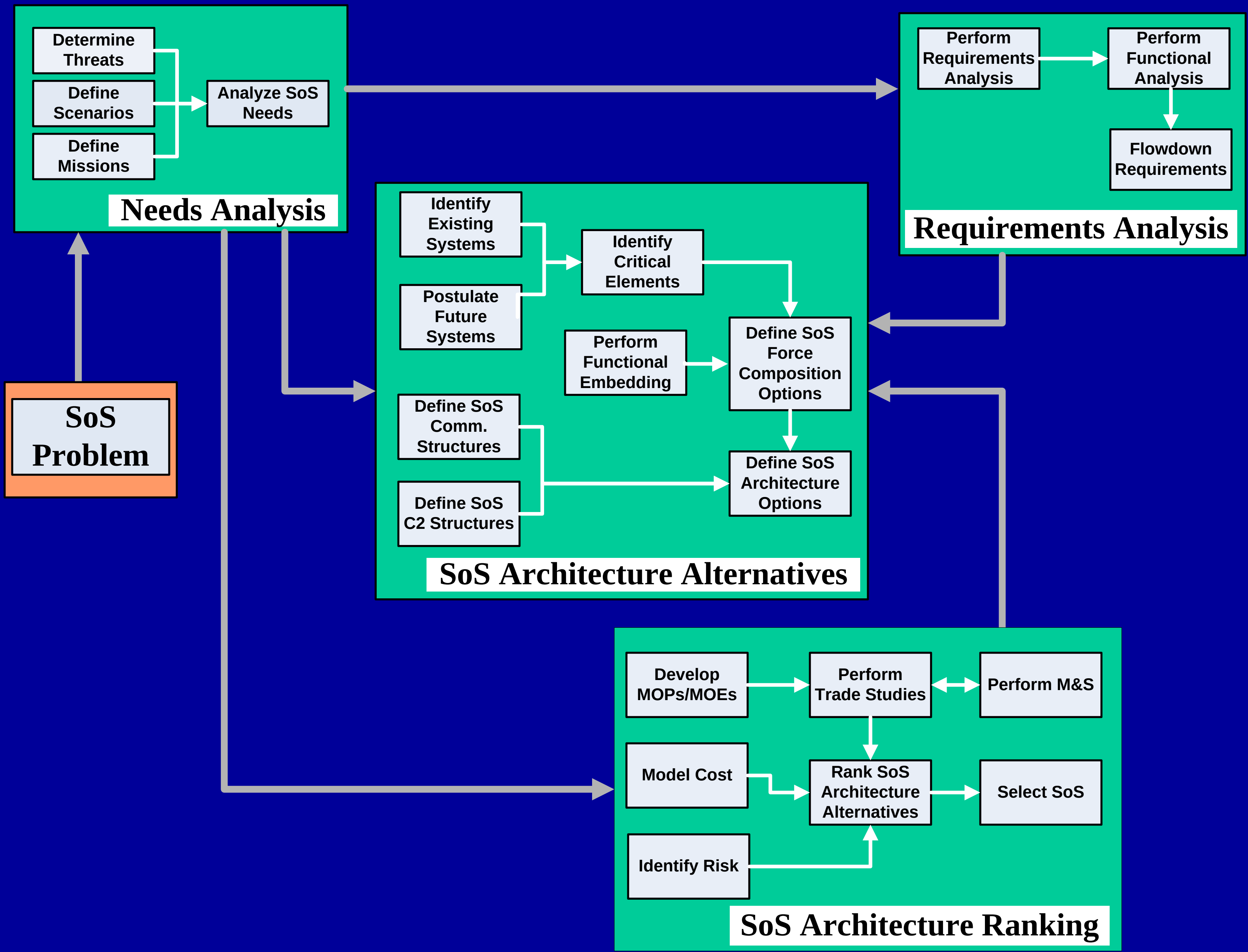


Problem Definition

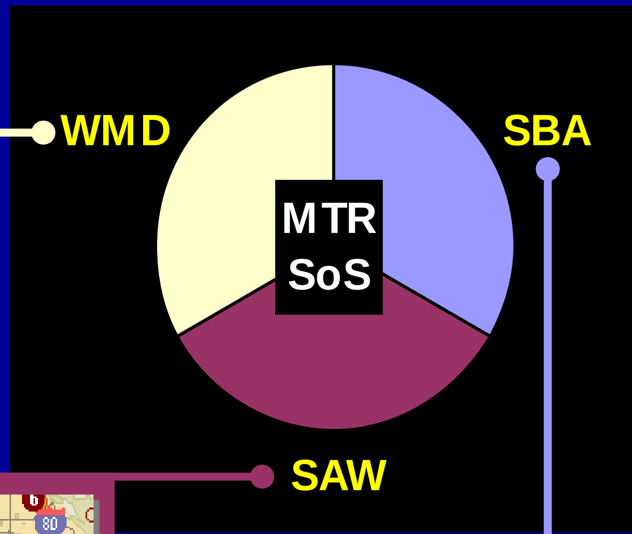
- National strategy documentation and guidance
  - National Strategy for Maritime Security
  - National Strategy for Homeland Security
  - Interviewed key stakeholders
- Stakeholder need
  - Near-term MTR SoS for neutralizing terrorist threats
  - Concepts of Operations
  - Characteristics
    - Low system cost
    - Low impact on commerce
    - Maximized use of existing assets

SoS Problem

SoS Architecting Methodology



Needs Analysis

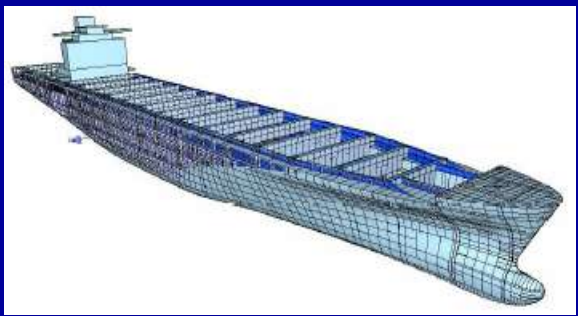


SoS needs

- Threats
- Scenarios
- Missions

Representative Maritime Terrorist Threats





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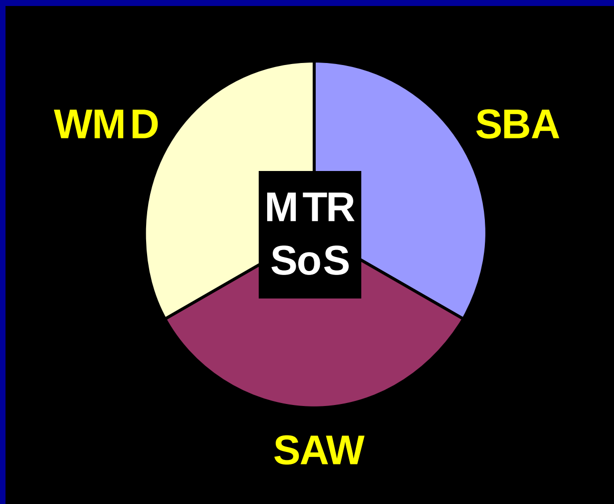




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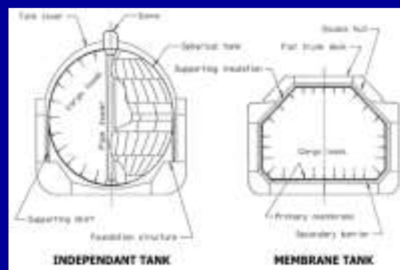

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Requirements Analysis Process

Operational Requirements

Functional Requirements

Process

- Mission needs
- Operational requirements
- Top level performance measures
- Top level functional analysis
- Top level performance requirements
- Functional decomposition
- Requirements allocation

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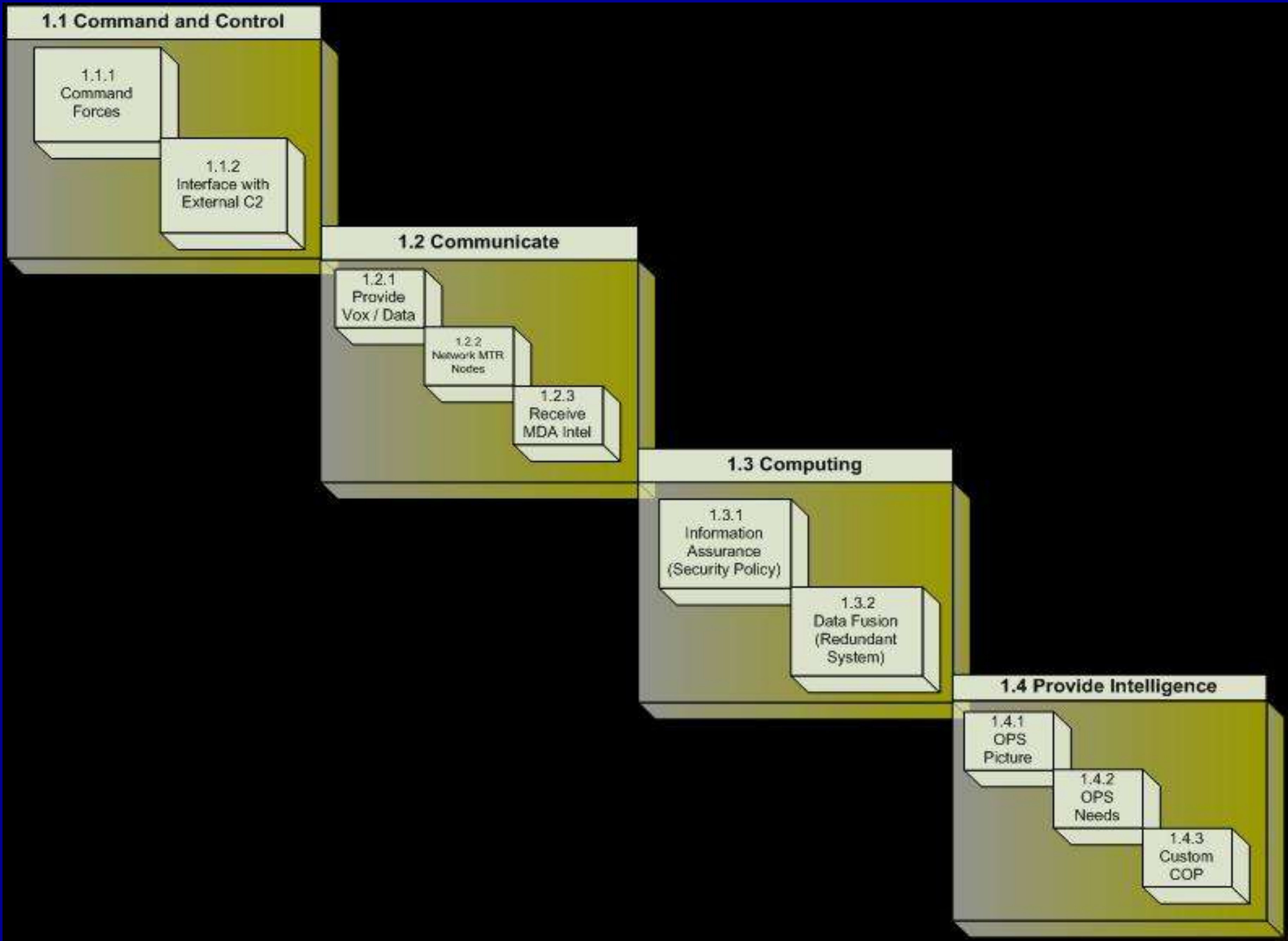
Functional Analysis

- Given
  - Need for system
  - Operational requirements
- SoS Design Requires
  - Identification of functions to be performed in support of mission accomplishment
  - Decomposition of identified functions
  - Break-down of system-level requirements into successively lower levels of detail
  - Assignment of requirements and resources to functions

Top Level SoS Functions



SoS Architecture Development

- As-Is architecture
  - Containing classified systems and Operations Orders
  - Based on
    - Stakeholder information
    - Classified literature
- Postulated architecture
  - System concept options for each top level function
  - Bottom Up Cost Effective Architecture (BUCE)
    - Lowest cost system concept for each top level function that expects to meet overall requirements
    - Aggregation of best system concepts

SoS Architecture Development (Cont'd)

- Orthogonal Array experiment-derived architectures
  - System concept options for each top level function
  - Orthogonal Array Experiment (OAE)
    - Simulation as experiment
    - Analysis of experimental results
  - Maximum Performance Architecture
    - Response is maximum SoS effectiveness
  - Top Down Cost Effective Architecture (TDCE)
    - Response is combination of cost and effectiveness
      - Minimum total SoS cost
      - Maximum overall SoS effectiveness

System Concept Alternatives

Top Level Function \ System Concept	1	2	3	4
C4ISR	AREA-PS	AREA-OO	LOCAL-PS	LOCAL-OO
PBS(1,2) (WMD,SAW)	AO-CG/DDG/FFG/WHEC	AO-LCS/WMSL	MODIFIED MERCHANT	-
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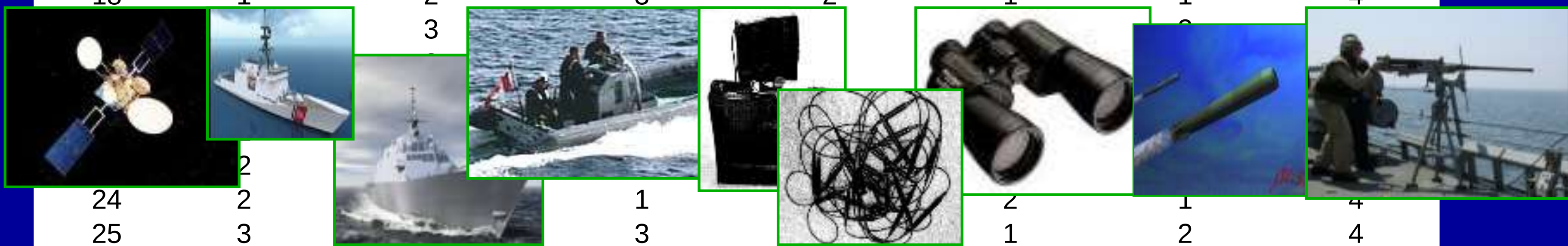
F/F(3) (SBA)	VISUAL	VISUAL AND RADAR	-	-
FIN(2) (SAW)	ESCORT / RECAPTURE	ESCORT / DISABLE	-	-
FIN(3) (SBA)	ORG WEPS	ORG WEPS & AIR SUPT	ORG WEPS & USVs	ORG WEPS, AIR & USVs

Orthogonal Array L_{32} (4^9)

TRIAL	C4ISR	PBS(1,2)	PBS(3)	F/F(1)	F/F(3)	FINISH(2)	FINISH(3)
1	1	1	1	1	1	1	1
2	1	2	2	2	2	2	2
3	1	3	3	3	1	1	3
4	1	1	4	4	2	2	4
5	2	1	1	2	2	1	3
6	2	2	2	1	1	2	4
7	2	3	3	4	2	1	1
8	2	2	4	3	1	2	2
9	3	1	2	3	2	1	2
10	3	2	1	4	1	2	1
11	3	3	4	1	2	1	4
12	3	3	3	2	1	2	3
18	1	2	3	2	1	1	4
24	2	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
25	3	[illegible]	3	[illegible]	1	2	4
26	3	2	4	4	2	1	3
27	3	3	1	1	1	2	2
28	3	1	2	2	2	1	1
29	4	1	3	4	2	2	2
30	4	2	4	3	1	1	1
31	4	3	1	2	2	2	4
32	4	2	2	1	1	1	3

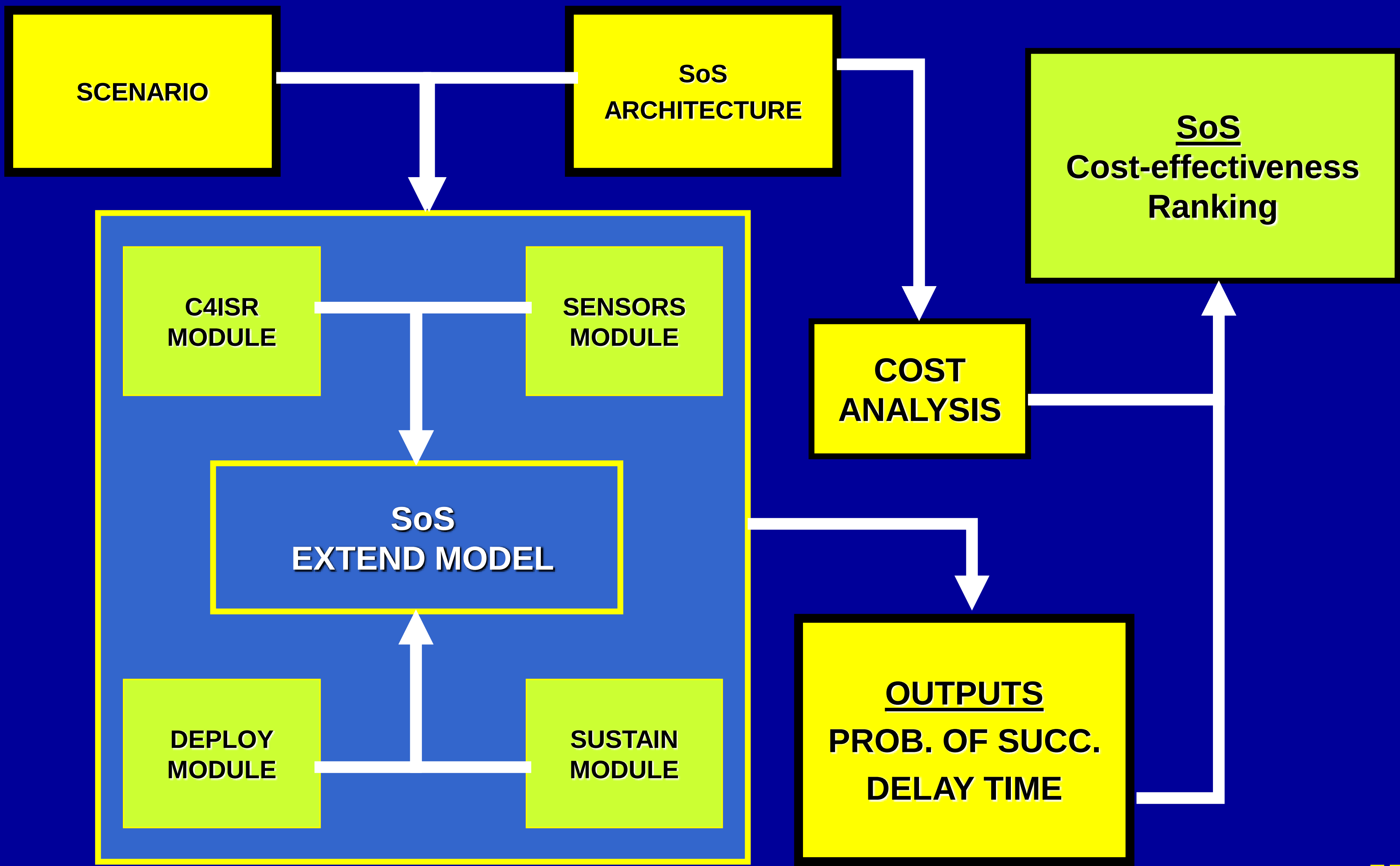
Trial	C4ISR	$PBS_{WMD,SAW}$	PBS_{SBA}	F/F_{WMD}	F/F_{SBA}	FIN_{SAW}	FIN_{SBA}
10	3	2	1	4	1	2	1



Modeling and Simulation Objectives

- To support architectural analysis
  - To assess different system concept options
  - To assess different combinations of system concepts
- To perform trade studies with respect to different concepts of operations

Modeling and Simulation Framework



Modeling and Simulation Tools

- Excel™
  - Container ship search patterns model
  - LLNL sensor detection models
  - Ship fuel consumption model
  - File input and output data storage
- MINITAB™ 14
  - Statistical data analysis tool
- Fatigue Avoidance Scheduling Tool (FAST)
  - Human factors vigilance level model

Modeling and Simulation Tools (Cont'd)

- EXTEND™
  - Platform reliability models
  - Command and control model
  - Trans-Pacific vessel intercept model
  - Commerce delay and damage model
  - SoS Integrating models
    - Inputs from lower level models
    - Outputs: SoS P_s and delay / damage cost
- Joint Conflict and Tactical Simulation (JCATS)
  - SBA interactive desktop wargame
- Joint Theater-Level Simulation (JTLS)

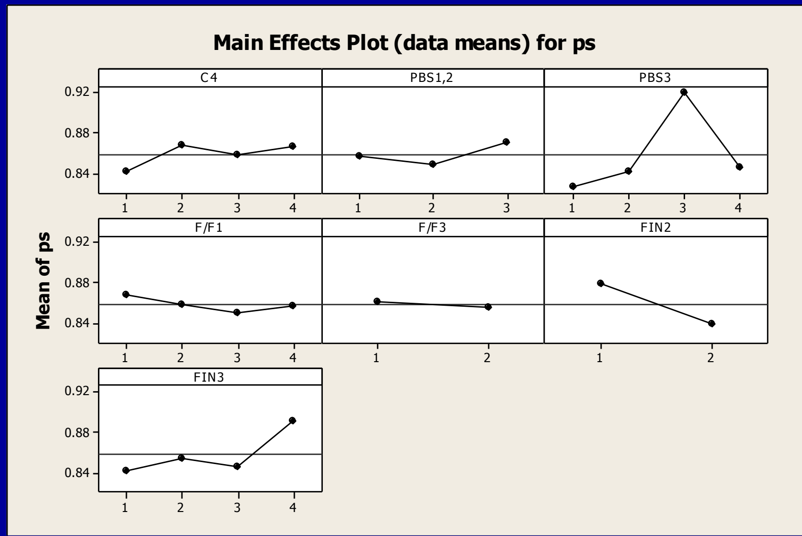
Cost Estimation Methodology

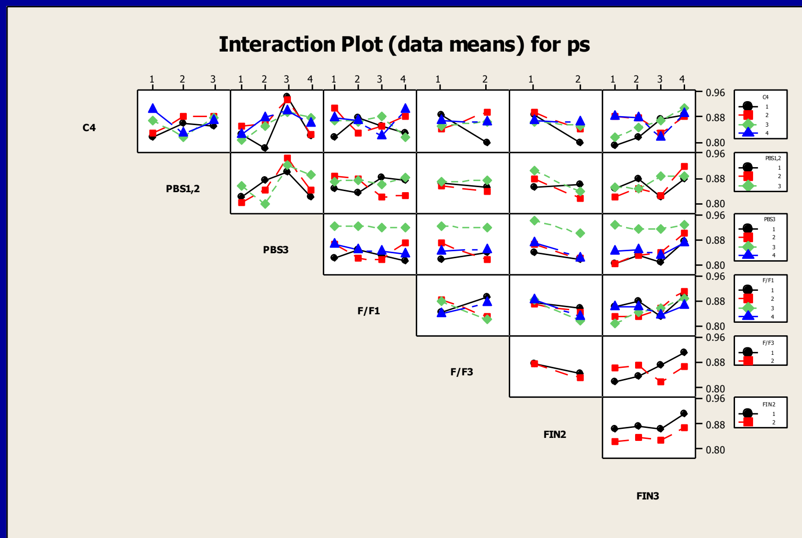
- Total cost is the combination of
  - Procurement
  - Operating and Support (O&S)
  - Delay / damage
- New system procurement cost estimates
  - Identification/scaling of analogous systems
  - Entire unit cost attributed to MTR SoS
- O&S costs via VAMOSC* and analogous systems
  - VAMOSC annual costs modified to account for
    - Expected time in MTR training, exercises, and actual operations
    - Sprint speed fuel
- Delay / damage costs via EXTEND SoS models
- All costs normalized to FY2006$M

*Naval Center for Cost Analysis Visibility and Management of Operating and Support Costs Database

OAE Data Analysis

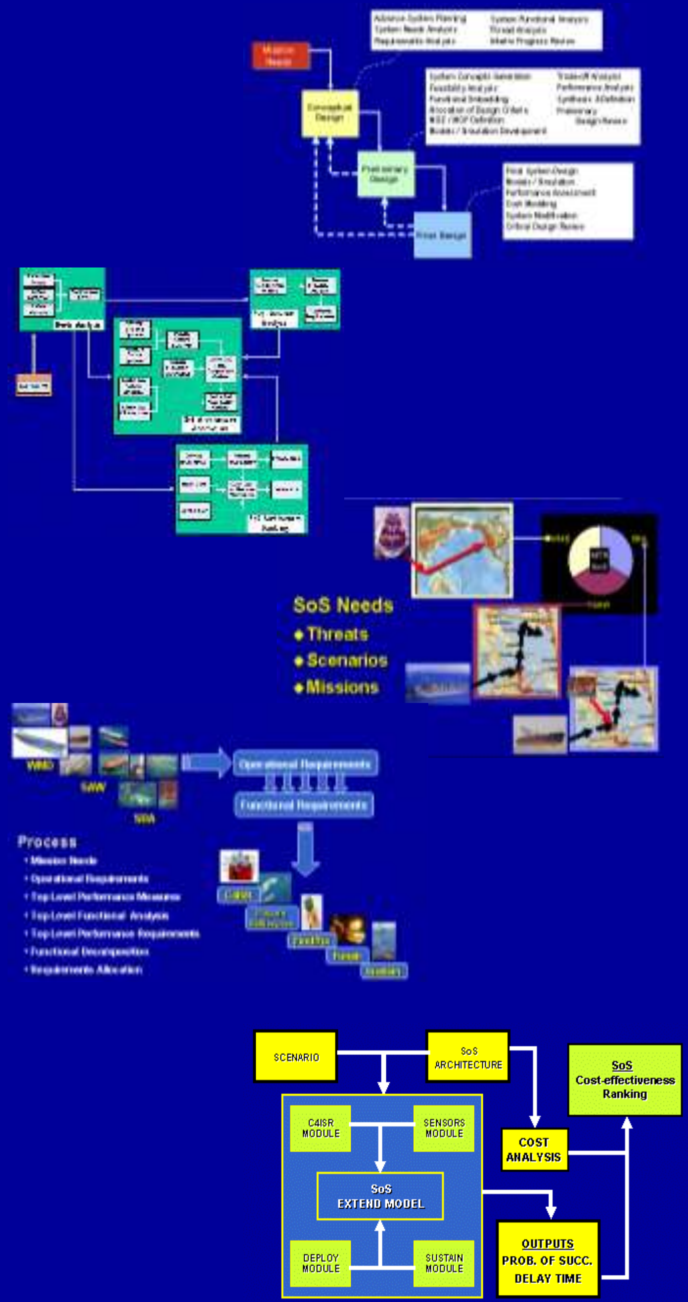
- MINITAB™ 14 served as tool to perform statistical data analysis
- Response functions maximized
  - System probability of success for each mission (Maximum Performance Architecture)
  - Total cost and system probability of success for each mission (TDCE Architecture)
- All seven factors (functions) considered
  - Main effects assessed
  - Interactions assessed
- Selected "best" architectures based upon
  - Effectiveness alone (Maximum Performance Architecture)
  - Cost effectiveness (TDCE Architecture)





Systems Engineering Summary

- ◆ Systems engineering process
- ◆ SoS problem definition
- ◆ SoS architecting methodology
  - ● Needs analysis
  - ● Requirements analysis
    - – Operational
    - – Performance
    - – Functional
  - ● Architectural alternatives
    - – Development
    - – Assessment
    - – Selection



Questions?

MTR SoS Architectures and C4ISR Systems

ENS Shaunnah Wark, USN

Topics

- Overview
- SoS architecture alternatives
  - Maximum Performance
  - Bottom-Up Cost Effective
  - Top-Down Cost Effective
- C4ISR system alternatives
- C4ISR modeling and simulation
- Summary

SoS Architecture Alternatives Overview

- Alternatives based on system concepts
  - Mission
  - Function
- Alternatives bounded by
  - Existing systems
  - Programs of record
  - 5-yr technology timeframe
- Three alternatives selected according to
  - Maximum Performance
  - Bottom-Up Cost Effectiveness
  - Top-down Cost Effectiveness
- Each architecture consists of
  - Physical view
  - Functional view
  - Operational view

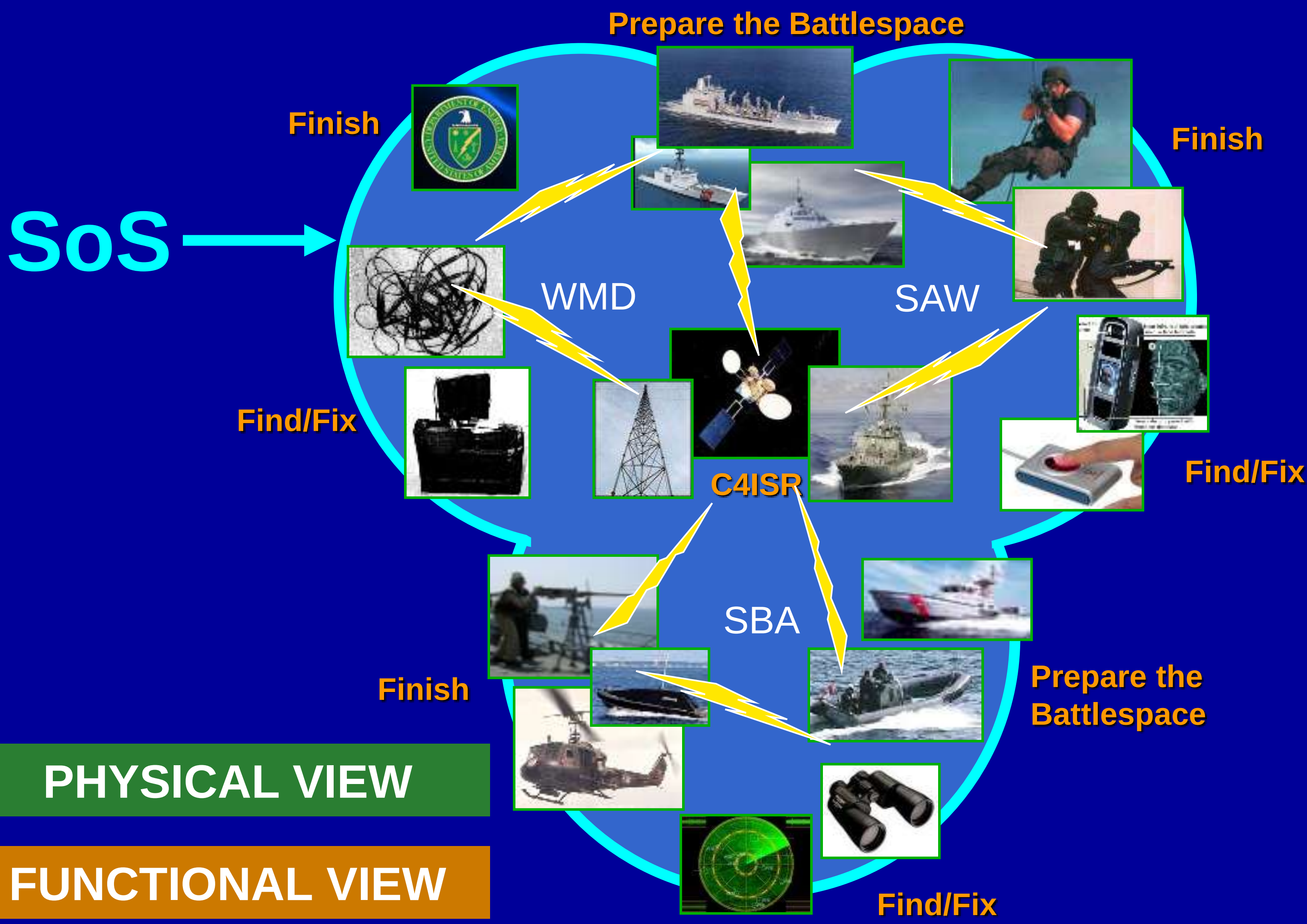
Maximum Performance MTR SoS Architecture

PHYSICAL VIEW

FUNCTIONAL VIEW

OPERATIONAL VIEW

Maximum Performance MTR SoS Architecture



PHYSICAL VIEW

FUNCTIONAL VIEW

OPERATIONAL VIEW

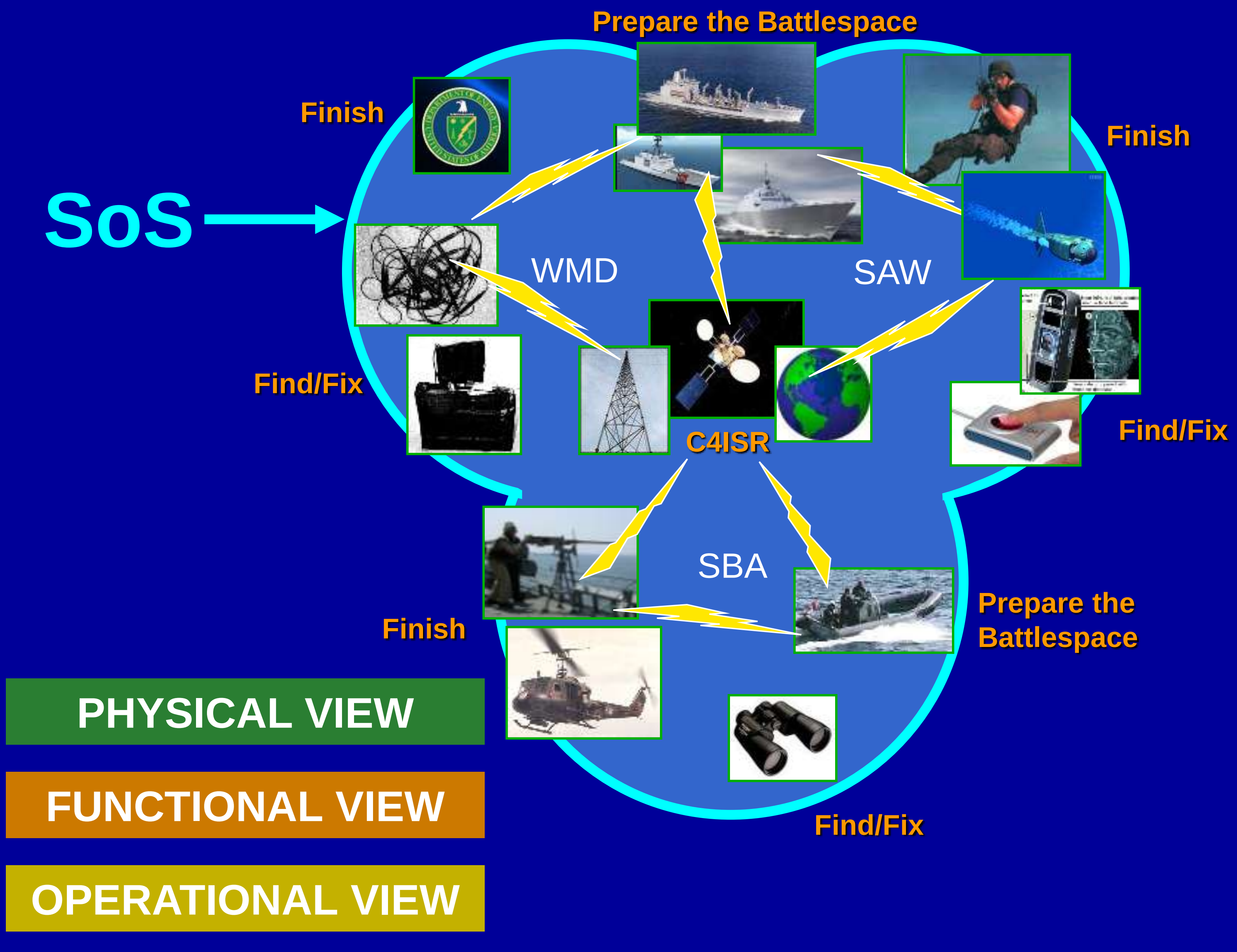
Bottom-Up Cost Effective MTR SoS Architecture

PHYSICAL VIEW

FUNCTIONAL VIEW

OPERATIONAL VIEW

Bottom-Up Cost Effective MTR SoS Architecture



Top-Down Cost Effective MTR SoS Architecture

PHYSICAL VIEW

FUNCTIONAL VIEW

OPERATIONAL VIEW

Top-Down Cost Effective MTR SoS Architecture

PHYSICAL VIEW

FUNCTIONAL VIEW

OPERATIONAL VIEW

C4ISR System Topics

- C2 concept alternatives
  - Area vs. local span of control
  - Problem-solving vs. Objective-oriented command structure
  - Common communications and computational infrastructure
- Analysis via modeling and simulation
- Model results
- Summary

C4ISR System Concepts

C2 concept options:

- Area control & problem-solving command (APS)
- Area control & objective-oriented command (AOO)
- Local control & problem-solving command (LPS)
- Local control & objective-oriented command (LOO)

Common elements:

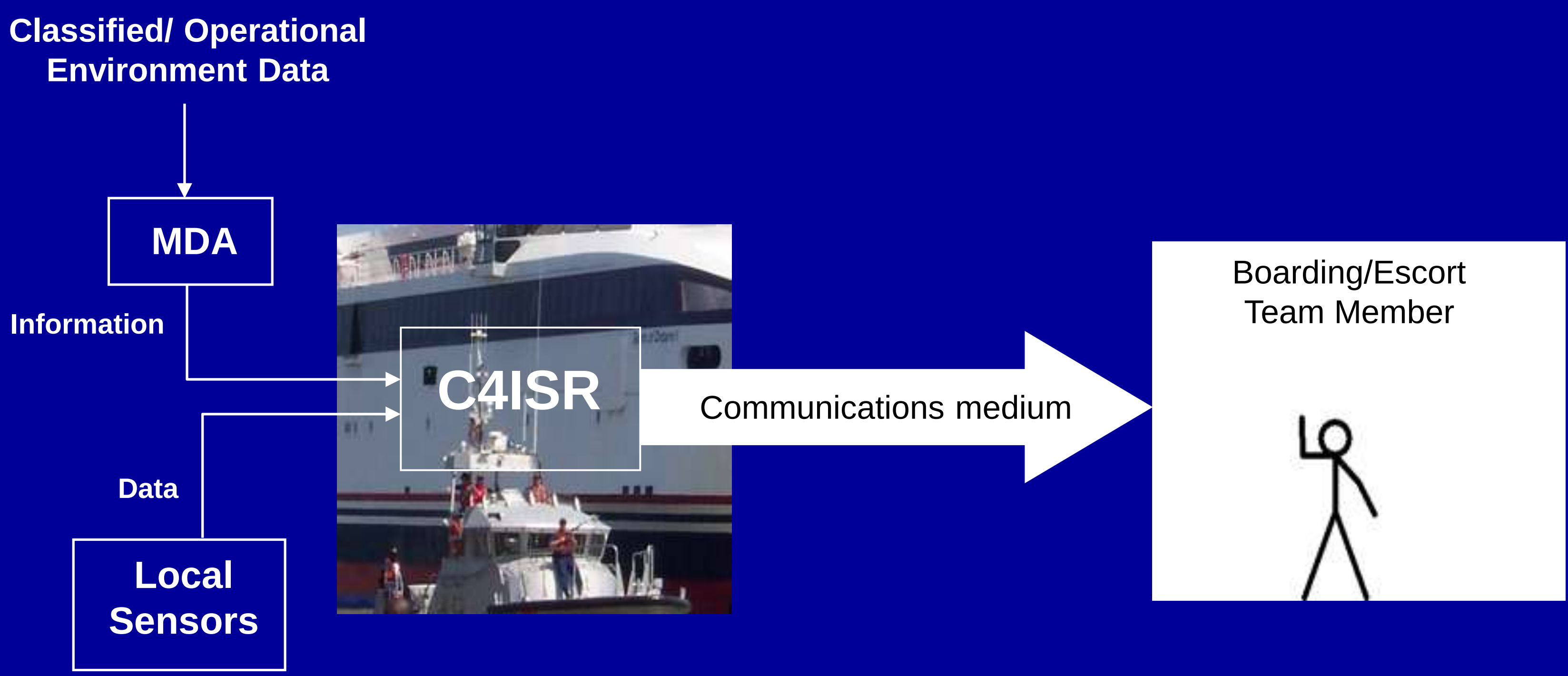
- Communications – LAN, WMAN, WAPS
- Compute – Defense in Depth, Hybrid Data Fusion
- Provide Intelligence – Specific COP + CIP

Area Span of Control

- Centralized control of all mission assets
- C4ISR system at shore-based headquarters
- Conserves system cost
- Improves coordination of forces
- Increases C4ISR delay time

Local Span of Control

- Centered around a single HVU
- C4ISR system resides on escort vessel or is portable for use on HVU itself
- Provides greatest speed and least operational risk in the event of technology failure
- Increases system software cost



Command Structure Alternatives

Problem-solving

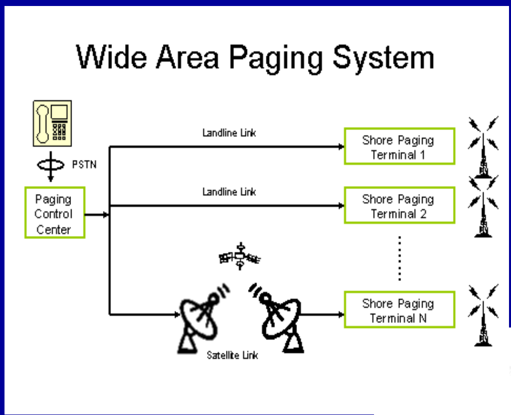
- Traditional military approach
- Directives articulate missions and objectives
- Direct two levels of subordinates
- Substantial guidance on methodology

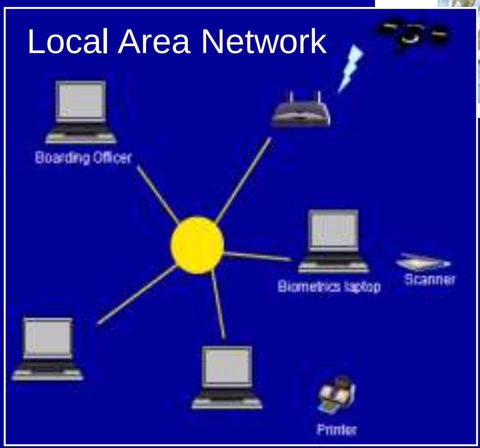
Objective-oriented

- Net-centric approach
- Shared awareness
- Commander's Intent
- Subordinate initiative
- Stresses synchronization

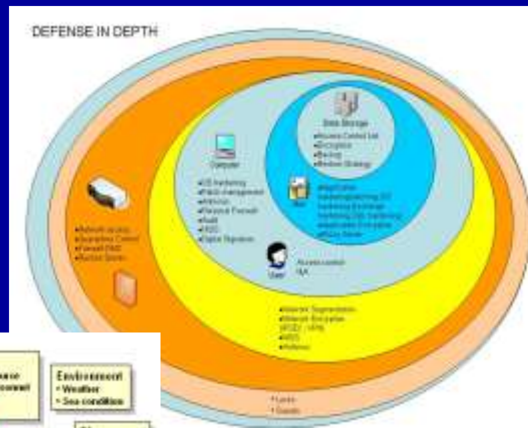
Common Infrastructure

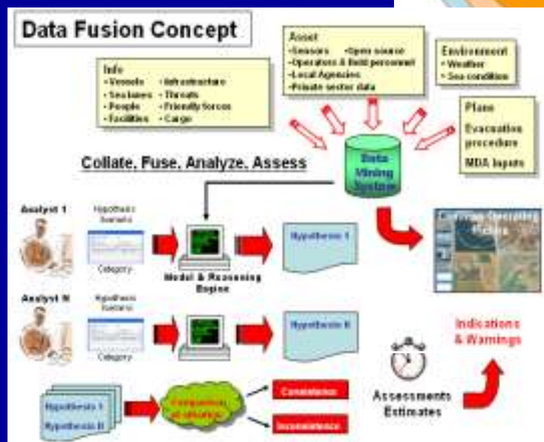
Communications

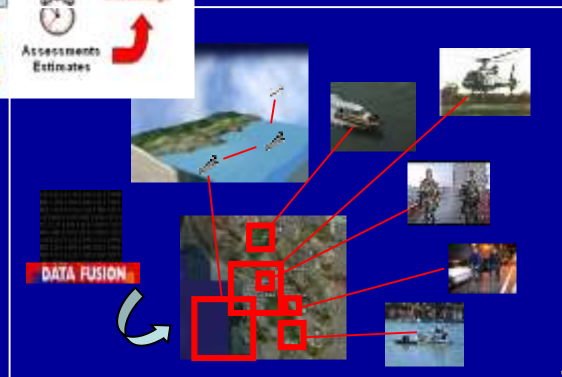




Computers

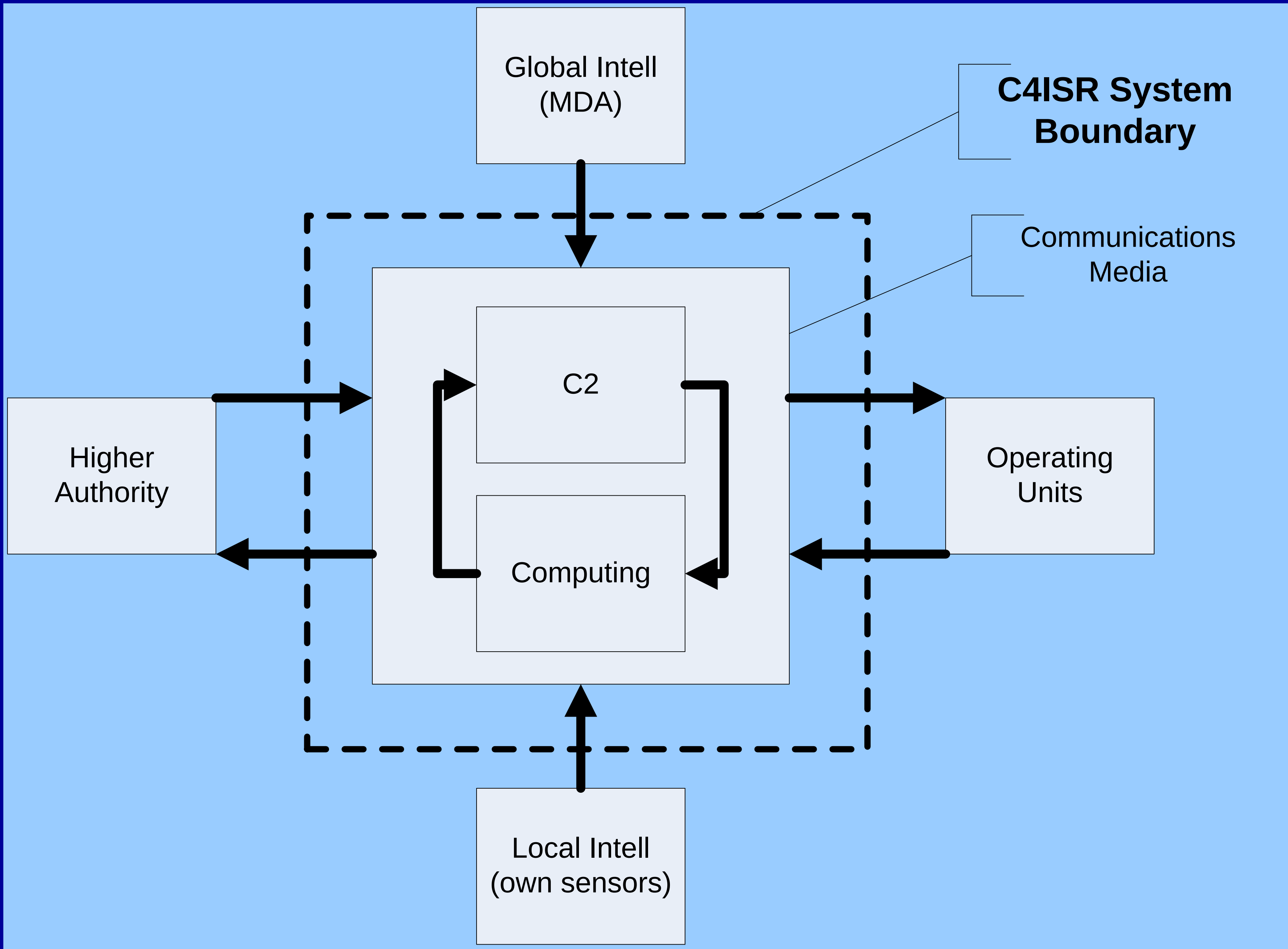






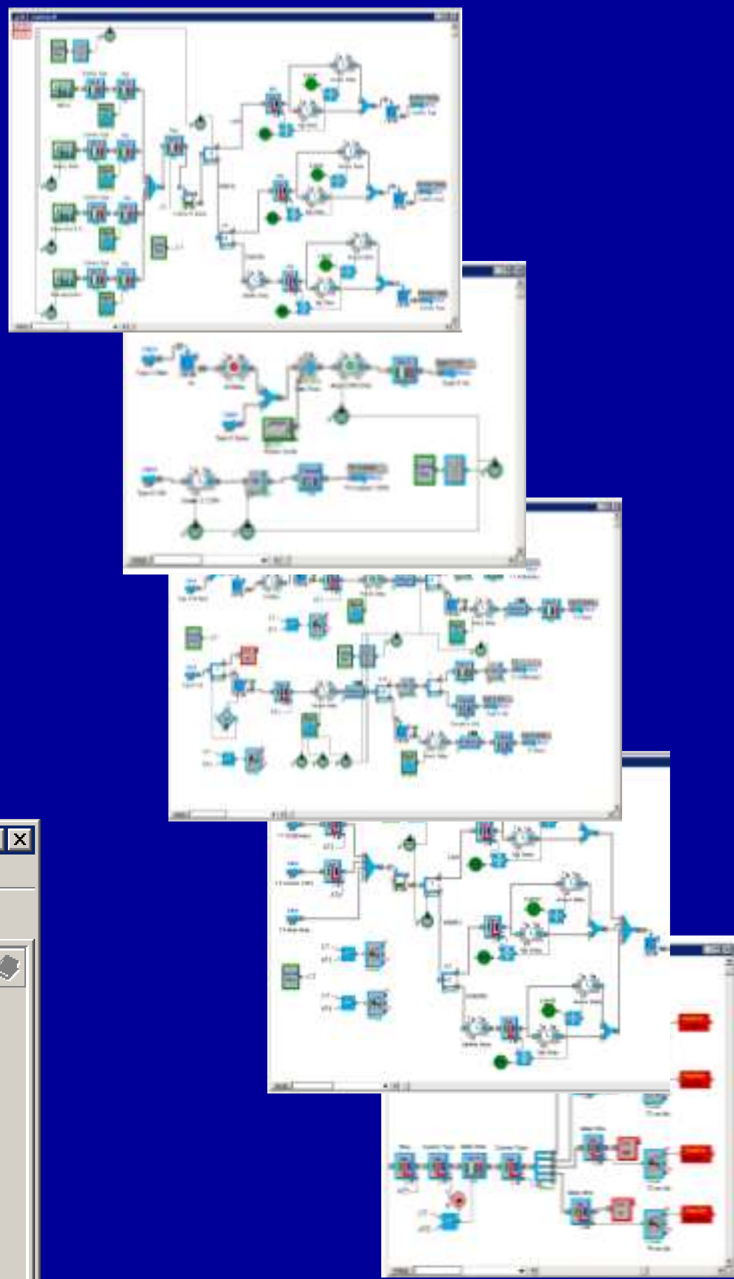
Custom COPs

C4ISR System Diagram



C4ISR Modeling and Simulation

- **EXTEND model generates and processes 4 types of communications items**
- **12 input variables per concept option**
  - Record 1 – APS
  - Record 2 – AOO
  - Record 3 – LPS
  - Record 4 – LOO
- **Output is average delay time for each item type**



DB Viewer - [C4 Options in C4ISR Model FINAL]

File Edit Insert Data View Help

All

C4 Options
C4ISR Delays
Current Sea Stat
Excel Tabs
Indexed Fields
Intel Latency
Radiation Detect
RAP Team Arriva
Sea State Delay
Sea State Distrib
Simulation Setup
Simulation Time
Taguchi Runs
Time to Underwa
US Interceptor S
Viewer Tabs

Table(4) : C4 Options

	Node to Node	H.A. Order	Node Prmsn Rqst	COP Create	COP Review Min	COP Review	COP Review Max	C COP Create	C COP Unbatch	ROE Orders Unbatch	Comms IN DE Select	Comms OUT DE Select
1	15	6	6	1	0.5	2	5	0.5	20	20	0.2	0.1
2	15	60	60	1	0.5	2	5	0.5	20	20	0.1	0.1
3	3	6	6	0.5	0.25	1	2	0	1	1	0	0.9
4	3	60	60	0.5	0.25	1	2	0	1	1	0	0.9

Simulation Results

- Delay times are the total time for item flow through C4ISR model, i.e., be “processed”
- During simulation, mission models dynamically draw delay times from C4ISR Delays database
- Results for stand-alone C4ISR model run of 1000 time units per option displayed below

	Comms Type	H.A.Order	Node Request	Intel Data	Node to Node
	Field #	1	2	3	4
C4ISR Option	Area PS	25.1	24.9	19.8	0.060
	Area OO	9.5	9.9	7.3	0.054
	Local PS	11.6	14.8	5.6	0.051
	Local OO	6.7	7.2	3.05	0.047

Note: Table displays average delay times in minutes

Final C4ISR System Concepts

BUCE architecture

- Area span of control

Maximum Performance and TDCE architectures

- Local span of control

Common elements:

- Command structure – Objective-oriented
- Communications – LAN, WMAN, WAPS
- Compute – Defense in Depth, Hybrid Data Fusion
- Provide Intelligence – Specific COP + CIP

Summary

- Three SoS architectures capable of executing WMD, SAW, and SBA missions
  - Maximum Performance
  - Bottom-Up Cost Effective
  - Top-Down Cost Effective
- Recommend Top-Down Cost Effective MTR architecture
- Final C4ISR elements
  - Control
    - Area (BUCE)
    - Local (Maximum Performance, TDCE)
  - Command structure – Objective-oriented
  - Communications – WAPS, WMAN, LAN
  - Compute – Defense in Depth
  - Provide Intelligence – Specific COP + CIP

Questions?

Counter WMD Mission

LT Brian Connett, USN

Administrative Note

- WMD mission briefing – 2 parts
- Part 1:
  - Now
  - Here
  - UNCLASSIFIED
  - FOR OFFICIAL USE ONLY (FOUO)
  - NOFORN/Rel: SGP

- Part 2:
  - 1330 – 1410
  - Secure Tactical Briefing Laboratory (STBL)
  - CLASSIFIED
  - SECRET/NOFORN

Topics

- Foundation
- WMD primer
- Scenario assumptions
- System concepts
- Modeling, simulation and analysis
- Results and recommendations

Proliferation Security Initiative*

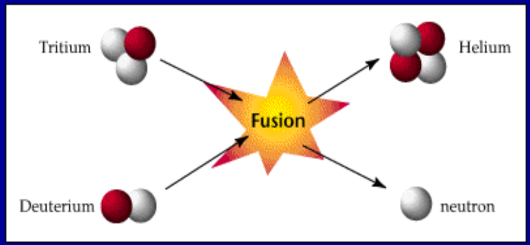
- May 31, 2003 – Krakow, Poland
- Eve of G8 Summit, Evian, France
- Stop & impede shipments of WMD
  - Dynamic, active approach to Counter Proliferation
  - Effective and coordinated collaboration

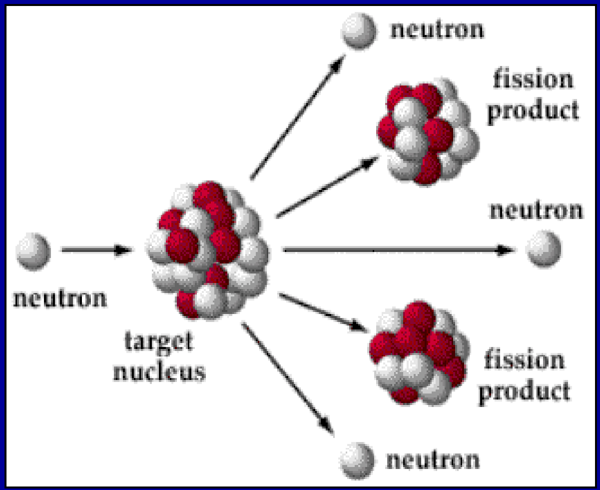
SOMMET D'EVIAN
2003

*31 May 2003 Krakow, Poland with 11 Founding Countries; Supported by the 109th US Congress

WMD Primer

- Nuclear weapons
  - Most destructive weapon
    - Immediate destruction
    - Death
    - Severe property damage
  - Sub-categories
    - Fission explosives
    - Fusion explosives
    - Enhanced radiation weapons
- Radiological weapons
  - "Dirty Bomb"
  - Conventional explosive with radioactive material embedded for dispersal





Sources of Radioactive Materials for Weapons

- Medical
- Industrial
- Agricultural
- Spent fuel

Terrorist Assumptions

- Weapons smuggled on board innocent ship
- Weapons not escorted by terrorists
- Weapons loaded at any port

Response Force Assumptions

- Weapons need to be found beyond 100 nm from coast of United States
- Weapon Carrying Ship to be handed over to Department of Energy Joint Technical Operations
- Unsearched ships to be detained at 100 nm

Scenario

- ◆20 Ships
  - ●2000 – 10000 TEU
- ◆Port of origin
  - ●Southeast Asia
  - ●Legitimate shipping company
- ◆Voyage across Pacific
  - ●Closest land of approach
    - –Yokuska, Japan
    - –Kodiak, AK
    - –Oahu, Hawaii
- ◆Nuclear device
  - ●Plutonium or Uranium
  - ●IAEA Significant Quantity
- ◆Point of No Return

Factors Influencing Detector Selection

- Device emissions
  - Gamma rays
  - Neutrons
- Device shielding effects
  - Self
  - External
- Energy loss over distance
  - $1/r^2$
- Background radiation
- Detector efficiency
- Integration time

Find / Fix System Concepts

- **Detectors**
  - **Sodium Iodide (NaI)**
  - **Linear Radiation Monitor (LRM)**
    - **80’ of cord allows simultaneous search of <u>9</u> containers**
- **Detectors and Identifiers**
  - **High Purity Germanium**
  - **Fission Meter**
    - **Long integration time capability**

WMD Mission CONOPS
◆ Top-Down Cost Effective Architecture Systems
• C4ISR – Local C2 / Obj-oriented
• PBS – LCS / WMSL
• Find/Fix – LRM / Fission meter
◆ Bottom-Up Cost Effective Architecture Systems
• C4ISR – Area C2 / Obj-oriented
• PBS – LCS / WMSL
• Find/Fix – LRM / Fission meter
ax-Performance Architecture Systems
• C4ISR – Local C2 / Obj-oriented
• PBS – LCS / WMSL
• Find/Fix – LRM / Fission meter

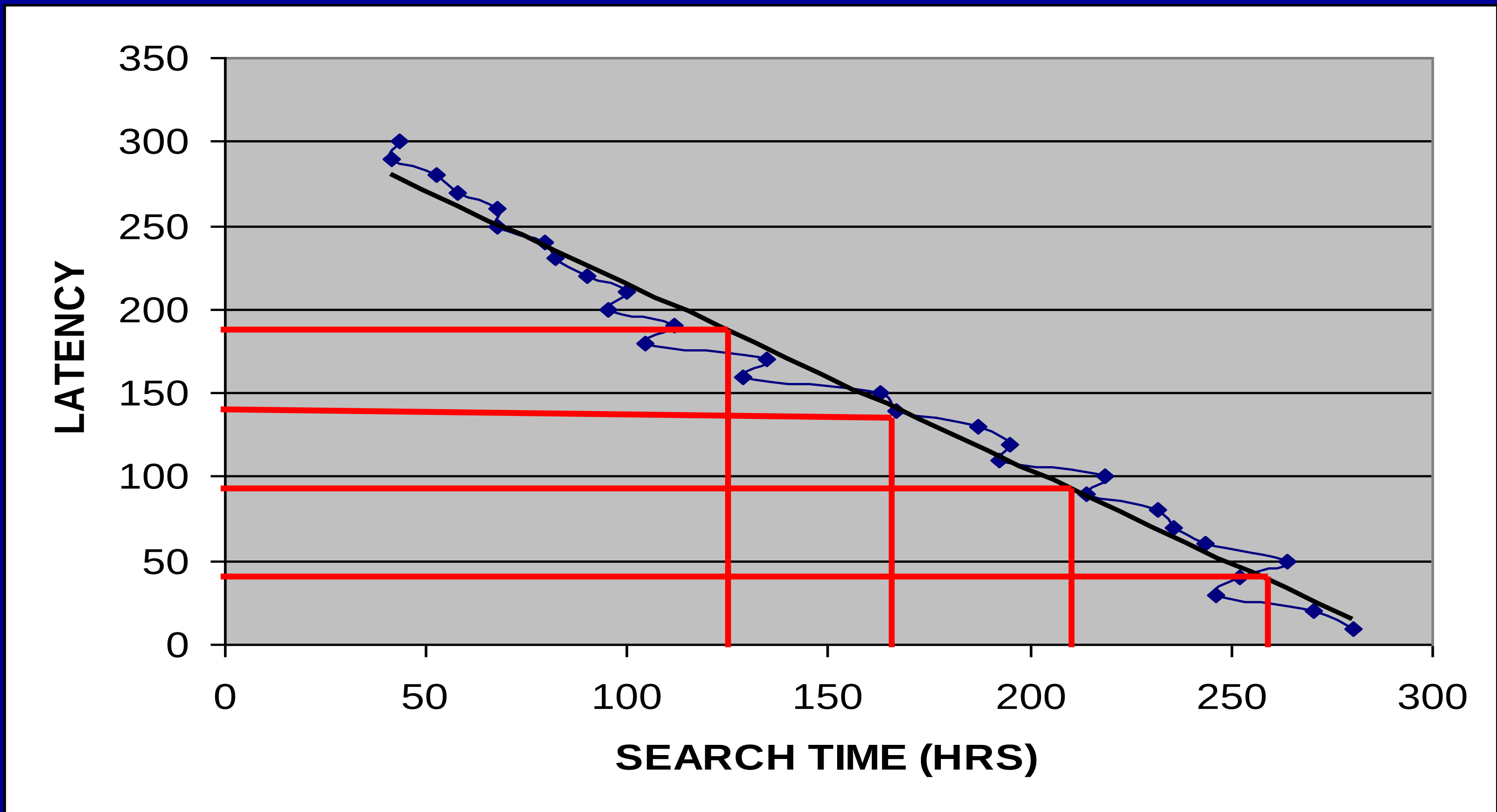
Modeling, Simulation and Analysis

- Probabilistic modeling
- Potential Attack Vessel Generator Module
  - Generates 20 PAVs
  - Attributes randomly assigned / reflect expected value
- Ship Intercept Module
  - Plots track eastbound across Pacific
  - Readies ships to intercept once SoS receives intel
  - Actual intercept
- Container Search Module
  - Monte Carlo simulation results
  - Multiple look protocol for each container

*Monte Carlo Simulation provided by Lawrence Livermore National Laboratory

WMD Results

- Intelligence latency < 180 hours yields sufficient search time without delaying ships (even with 20 vessels to search)
- All architectures achieve 0.99 Ps



Questions?

Counter SAW Mission

Maj Michael Shewfelt, USMC

Topics

- Historical examples
- Scenario assumptions
- System concepts
- Modeling, simulation and analysis
- Results and recommendations

Ships as Potential Weapons

- **1947 April 16, Texas City, Texas, SS *Grandcamp***
  - **Fire and detonation of approximately 17,000,000 pounds ammonium nitrate**

- **1980 May 9, Tampa, Florida, Sunshine Skyway Bridge, Summit Venture**

- **1989 March 23, Prince William Sound, Alaska, Exxon Valdez**

Ships as Potential Weapons

- **Deliberate attacks - other forms of transportation**
  - **1995 April 19, Oklahoma City truck bombing**
  - **2001 September 11, New York City & Wash DC airliner attacks**

Scenario

- 20 Ships
  - Cargo / Megaships
  - Oil tankers
  - Liquid propane/natural gas tankers
- Port of origin
  - Southeast Asia
  - Legitimate shipping company / method
- Length of voyage across Pacific Ocean
  - Three routes
  - Closest land of approach
- Terrorists on board
  - One or more ships
  - Average of 10 per cell
- Point of impact - San Francisco Bay
  - Port facilities
  - Bridges
  - Airport
  - Cultural centers




Terrorist Assumptions

- Terrorists capable of operating commercial ships
- Terrorists remaining inconspicuous until near target
- Terrorist response to boarding
  - If still covert
    - Remaining concealed
      - Resisting when detected
    - Exposing and engaging boarding team
  - If already in control of ship
    - Prevent boarding by fending off boarding attempts
    - Engaging boarding team when on board ship

Response Force Assumptions

- 12-man Hostile VBSS teams and delivery platforms available for each intercepting U.S. ship

- PAVs can be disabled by kinetic strike against propellers and/or rudders

- ROE enables local command and control to facilitate timely response

System Concepts Explored

- Deploy Forces
  - Current ships
  - Program of Record ships
  - COTS modification
- Detect and Identify
- Recapture / Disable
  - Surge operations
  - Non-surge operations

System Concepts

Deploy Forces

(1) Current ship systems

- Cruiser
- Destroyer
- Frigate
- High Endurance Cutter (USCG)

(2) Program of Record ship systems

- Littoral Combat Ship (LCS)
- Large Maritime Security Cutter (WMSL)

(3) COTS modification

- NASSCO Tote Orca-class trailer ship
- WallyPower 118'–yacht interceptor

System Concepts

◆ **Detect and Identify**

- Techniques for crew search and identity verification
  - Facial recognition / fingerprinting

◆ **Recapture / Disable**

(1) Surge Escort / Recapture

- Sortie warships, provide armed escort on board ship during Pacific transit
- Search ship for any terrorists
- Terrorists in control, attempt to recapture

(2) Sea Marshal Escort / Disable

- Armed escort on board ships during harbor pilot on-load (10 Sea Marshals)
- Secure five critical spaces on ship
- Terrorists in control, disable from shore battery

Concept of Operations (1)

- All commercial ships intercepted as far away from CONUS as possible
  - MDA system provides PAV locations
  - Boarding teams activated
  - Boarding teams deployed
  - Assets surged to intercept PAV
    - San Diego, CA
    - Kodiak, AK
    - Japan
    - Oahu, Hawaii

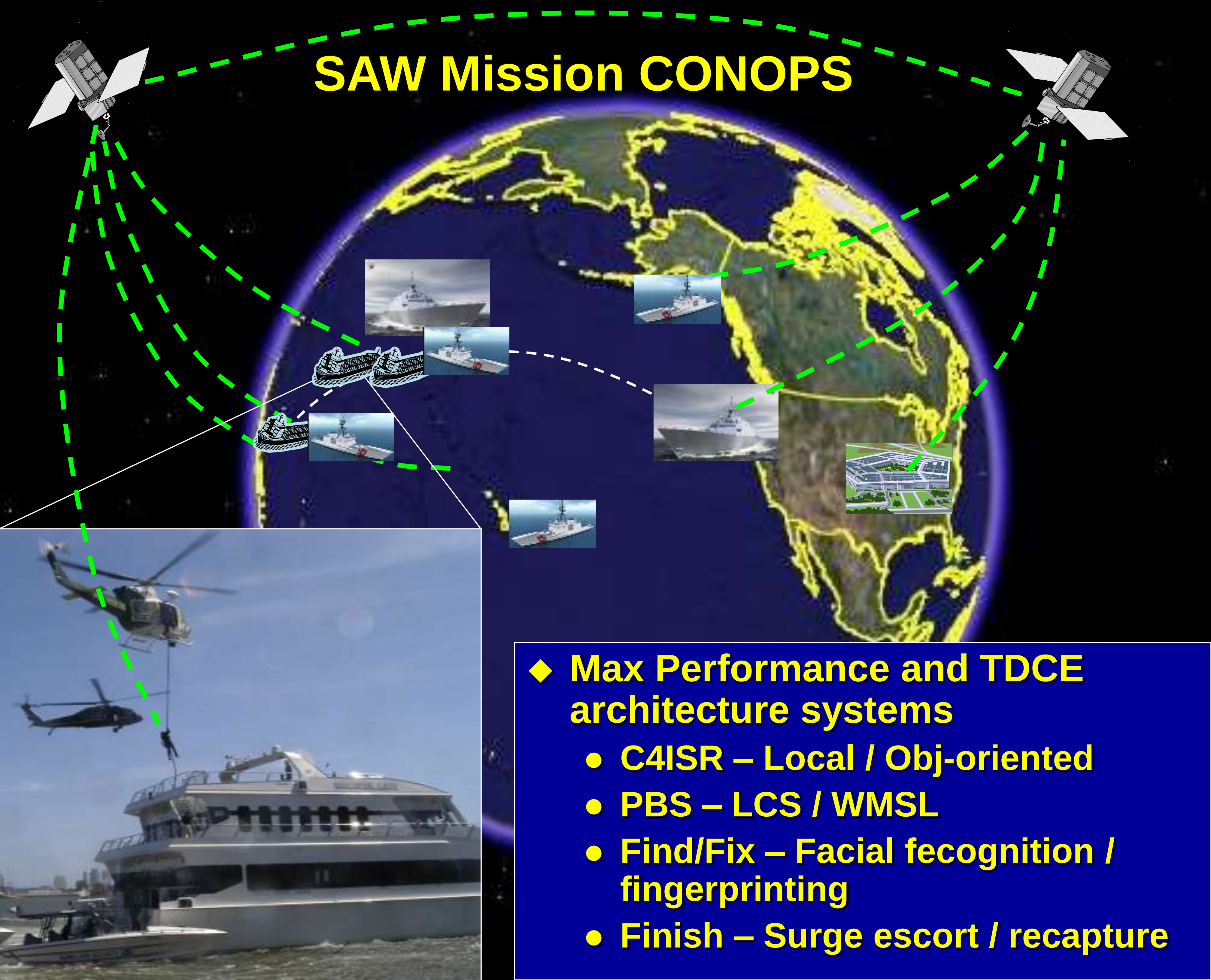
Concept of Operations (1) Cont'd

- Search method
  - Detection and identification
    - Team boards ship, searches ship and verifies identities of personnel
- No terrorists located
  - Team escorts ship for remaining portion of transit
- Terrorists located
  - Ship under terrorist control is retaken
  - Ship that remains under terrorist control is disabled
    - More time available to handle situation

Concept of Operations (2)

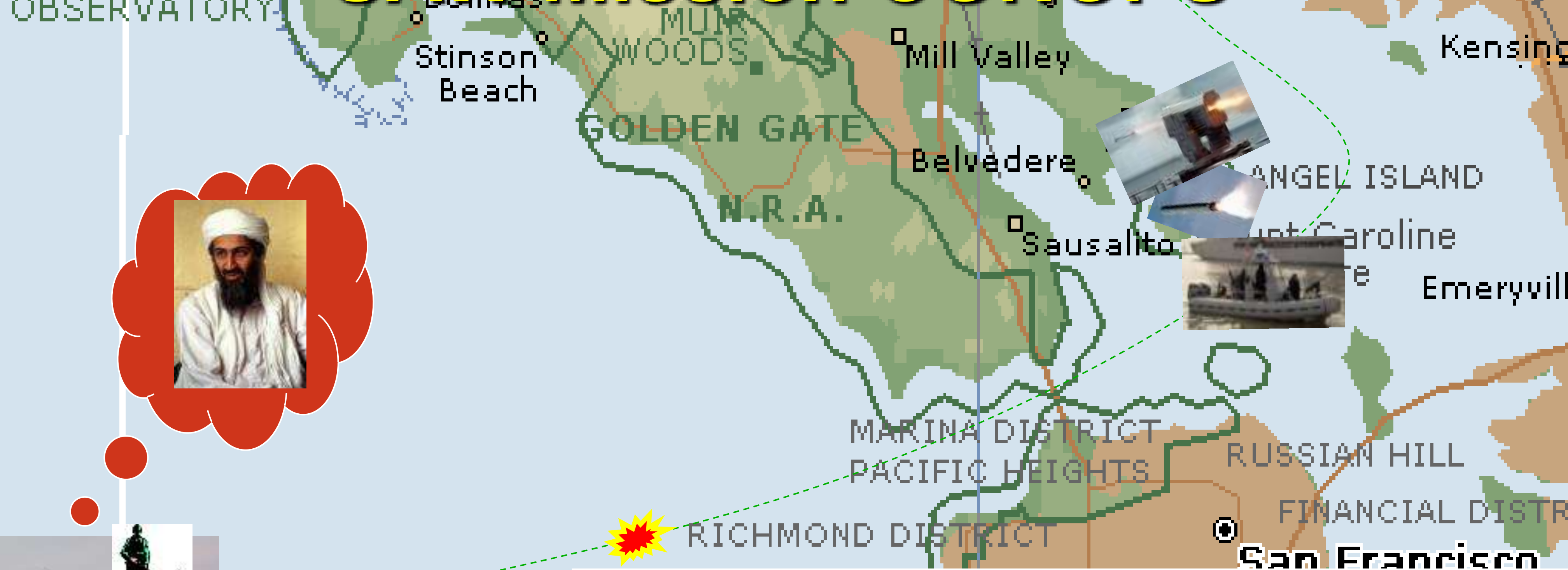
- All commercial ships intercepted at the Harbor Pilot boarding location close to Golden Gate Bridge
  - MDA system provides PAV locations
  - Sea Marshal teams activated
  - Sea Marshal teams deployed
  - Sea Marshal teams board ships and escort into the bay to port facility
  - Sea Marshal teams simply secure five critical spaces of ship
  - Sea Marshal teams search or verify crew as time permits
  - Ships under terrorist control are disabled

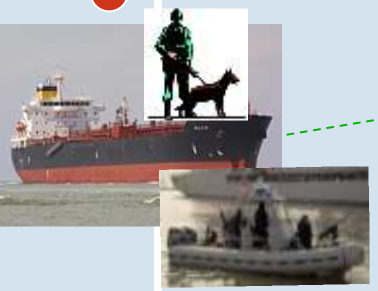
SAW Mission CONOPS



- Max Performance and TDCE architecture systems
  - C4ISR – Local / Obj-oriented
  - PBS – LCS / WMSL
  - Find/Fix – Facial fecognition / fingerprinting
  - Finish – Surge escort / recapture

SAW Mission CONOPS





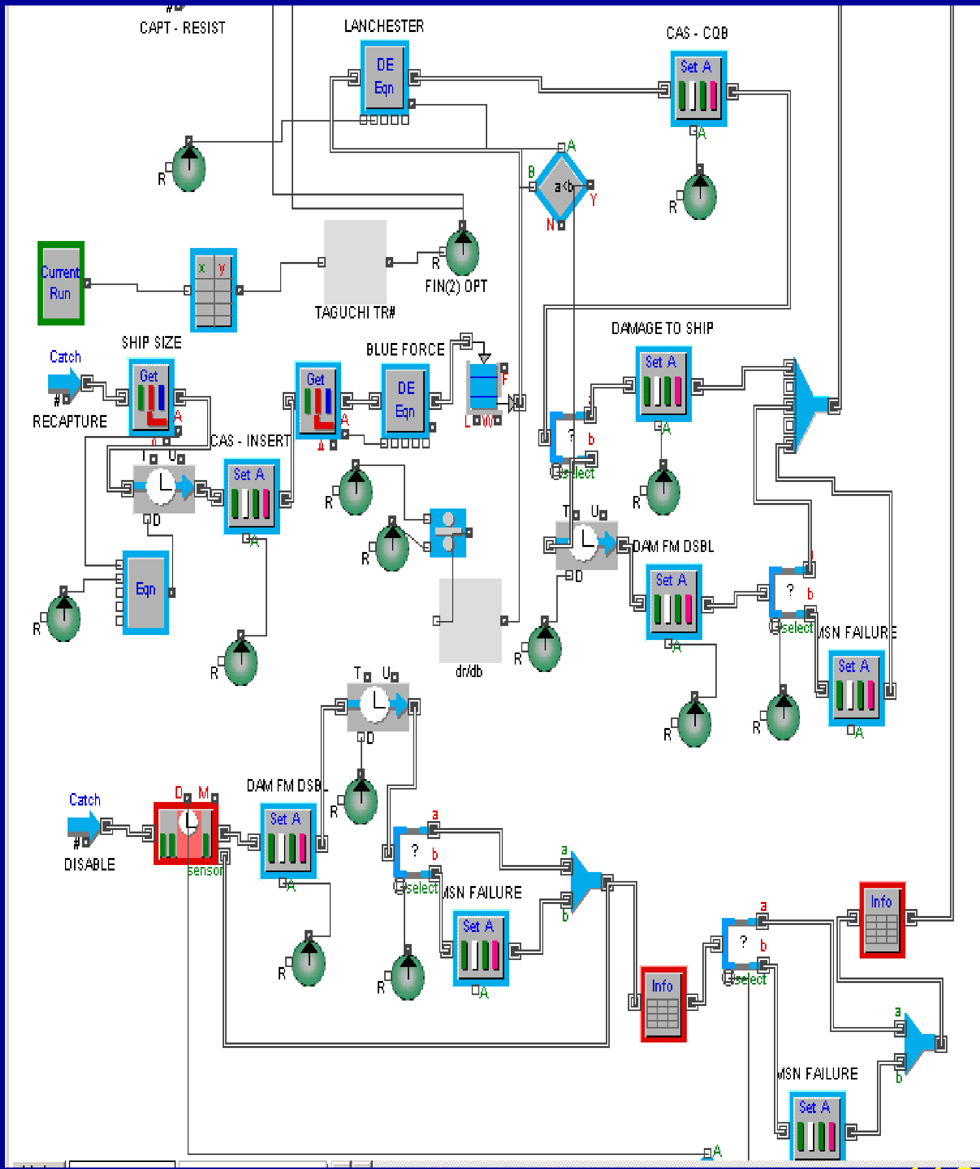
- **Bottom-Up Cost-Effective architecture systems**
  - **C4ISR – Area / Obj-oriented**
  - **PBS – LCS / WMSL**
  - **Find/Fix – Facial recce / fingerprinting**
  - **Finish –**
    - **Sea marshal teams board PAV with Harbor Pilot**
    - **Secure control spaces of PAV for duration of transit**
    - **If team encounters resistance or faces a hijack attempt, disable ship with shore battery**

Modeling, Simulation and Analysis

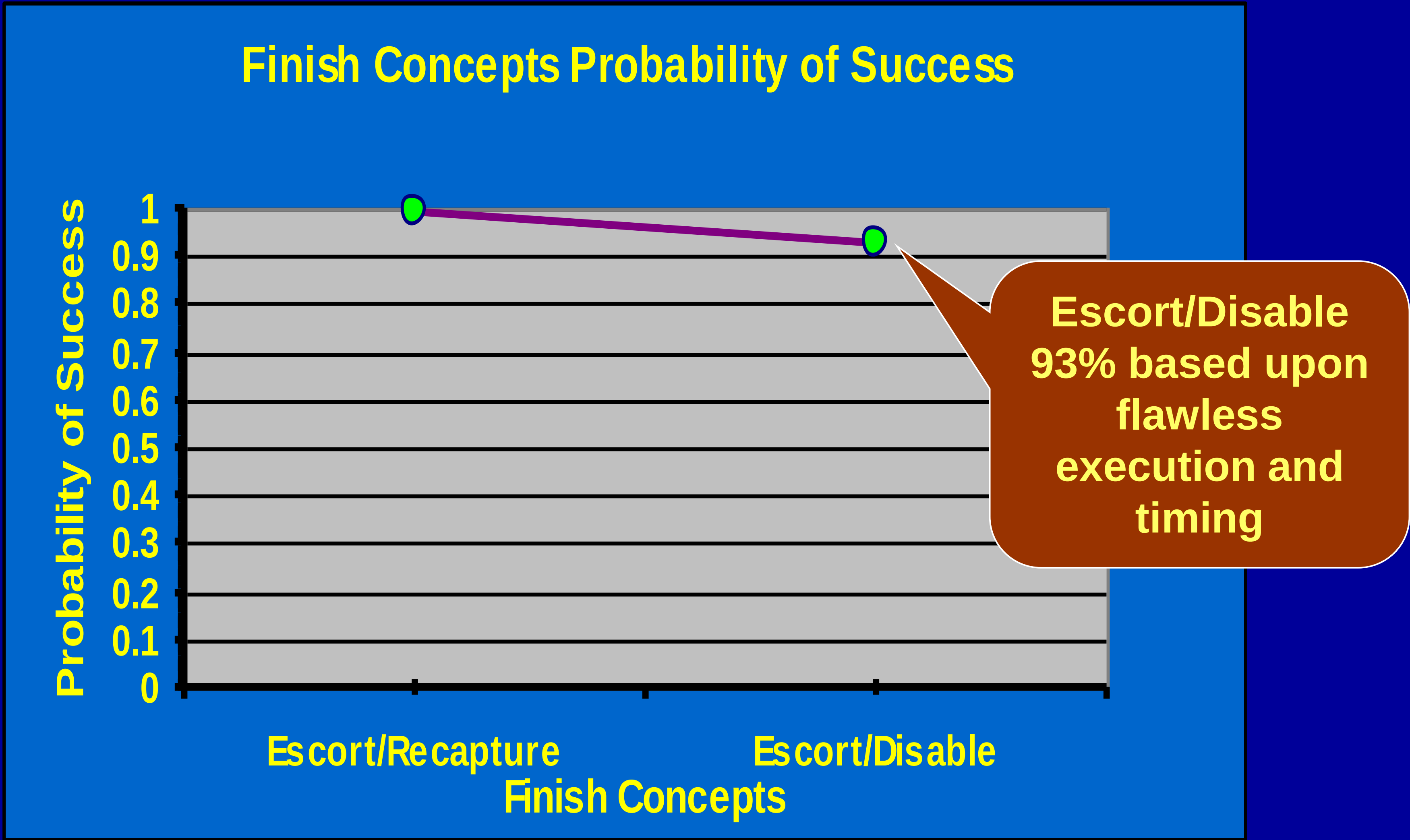
- Probabilistic modeling
  - PAV generator parameters
    - Number of stops
    - Length of stops
    - Normal speed of advance
    - Number of terrorists on board (if any)
  - Ship intercept parameters
    - U.S. interceptor readiness to surge
    - Interceptor locations
    - Intercept geometry and timing
  - Engagement modeling
    - Terrorist status
    - Terrorist reactions
    - Insertion of U.S. forces
    - Close Quarter Battle between U.S. forces and terrorists
    - Ship damage
    - Ship disabling attempts and damage suffered

Modeling, Simulation and Analysis

- EXTEND engagement model
- Inputs
  - Terrorist seizure mentality
  - Terrorist response to boarding
  - Relative combat skills of U.S. and terrorists
  - Disabling weapons probability of success
- Outputs
  - Architecture P(success) in scenario
  - Damage suffered by ship in combat and/or disabling



Analysis Results



- Escort/Recapture 99% effective
- More time to prosecute threat before reaching CONUS
- Large operating cost increase as compared to Escort/Disable

Non-quantifiable Impacts

- Alternative courses of action by terrorists
- Terrorist priority of actions
  - Go / No Go criteria

Recommendations for Further Study

- Analysis into development and employment of non-lethal weapons to disable large ships
  - Minimize risk of sinking
  - Without causing significant damage

- More detailed analysis of large vessel re-capture
  - Potential responses by terrorists
  - Number of boarding team members required for timely, effective recapture

- Potential multi-purpose use of COTS modification ships
  - Counter drug operations
  - Littoral operations

Questions?

Counter SBA Mission

LT Joe Oravec, USN

Topics

- Historical examples
- Scenario assumptions
- System concepts
- Modeling, simulation and analysis
- Results and recommendations

Historical Examples

- USS *Cole*
- M/V *Limburg*
- ABOT/KAAOT
- *Superferry 14*

SBA Scenario

- Suicide boat attack in San Francisco Bay
- Potential targets
  - Crude oil tankers
  - Passenger ferries
  - Critical infrastructure
- Single attacker
  - Blends in with recreational boaters to get close to target
  - Attacks at high speed
- Current ROE & Coast Guard regulations
  - 500 yard buffer zone from HVU
  - 100 yard "no entry" zone
  - Immediate engagement without consultation with higher authority

SBA Scenario

- Heightened alert level set
- Recreational boat restriction active
  - Enforced by local law enforcement and USCG auxiliaries
- JIATF activated

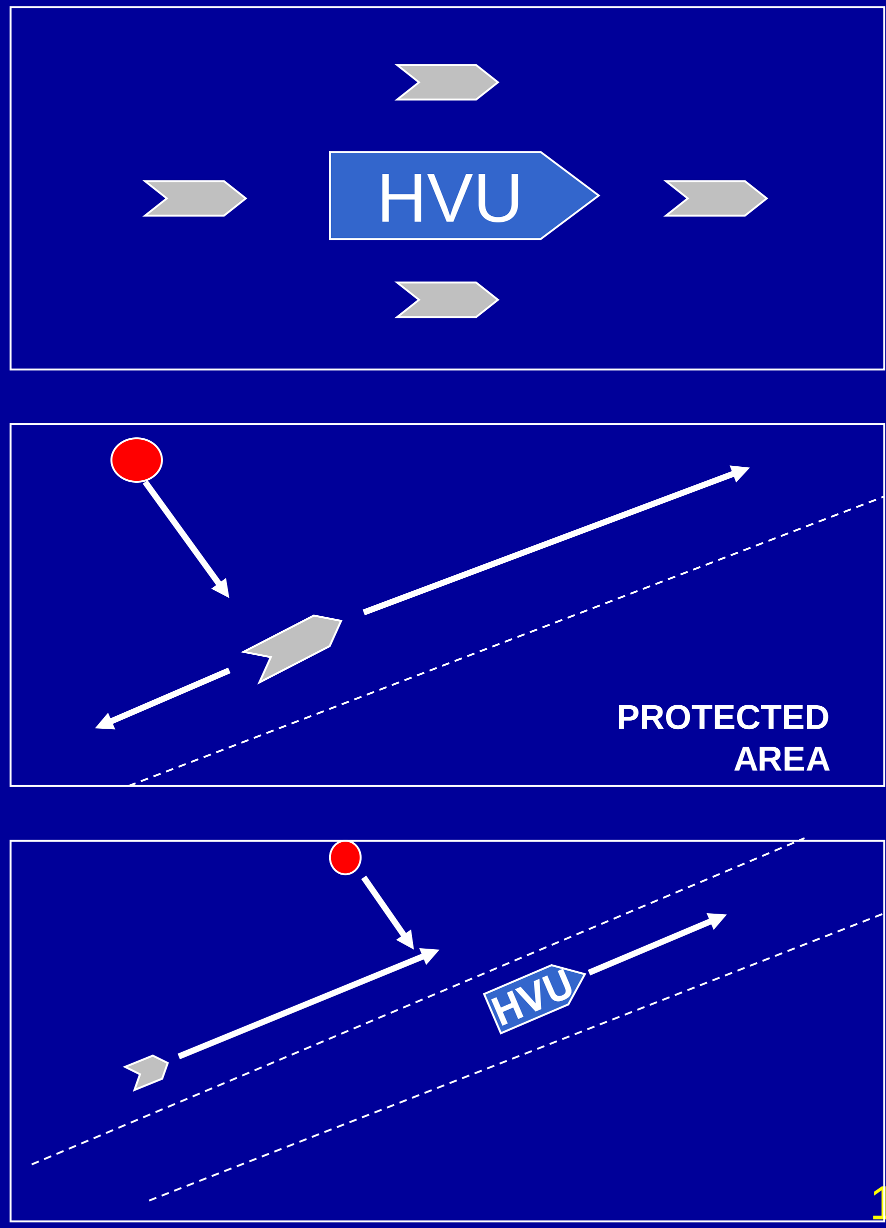
System Concepts Explored

- Close escort vs. barrier patrol
- Small vs. medium escorts
- Traditional escorts vs. teams on board HVU
- Addition of armed helicopters
- Addition of unmanned surface vehicles (USV)
- Use of non-lethal weapons (NLW)

Close Escort vs. Barrier Patrol

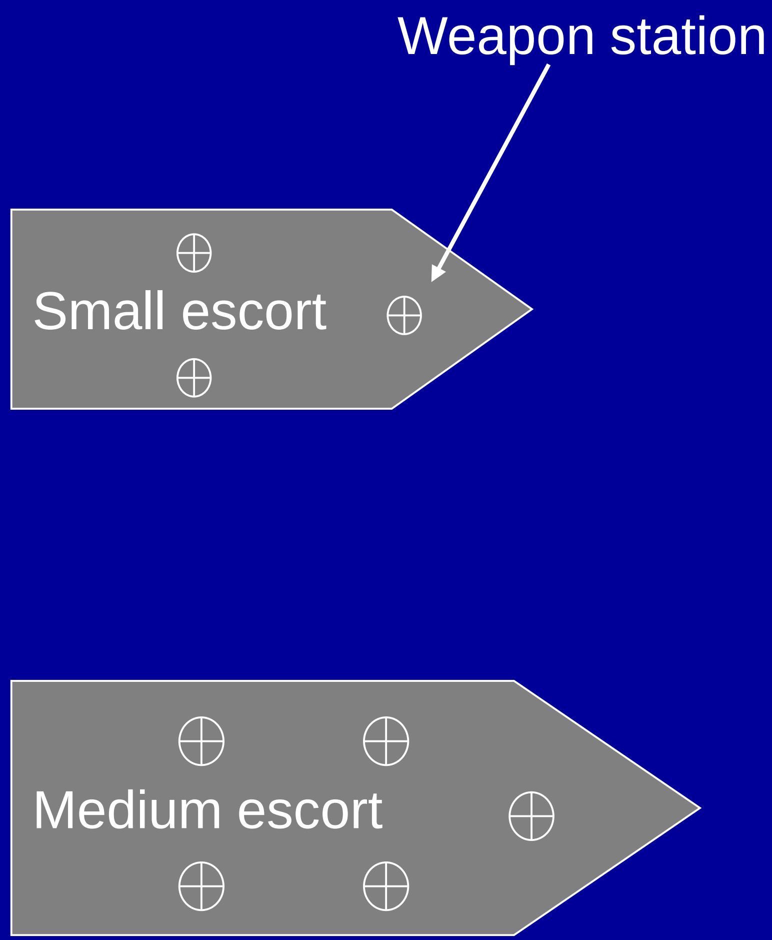
- Close escorts to follow HVU to destination and defeat any attacks

- Barrier patrol to intercept incursion of protected area



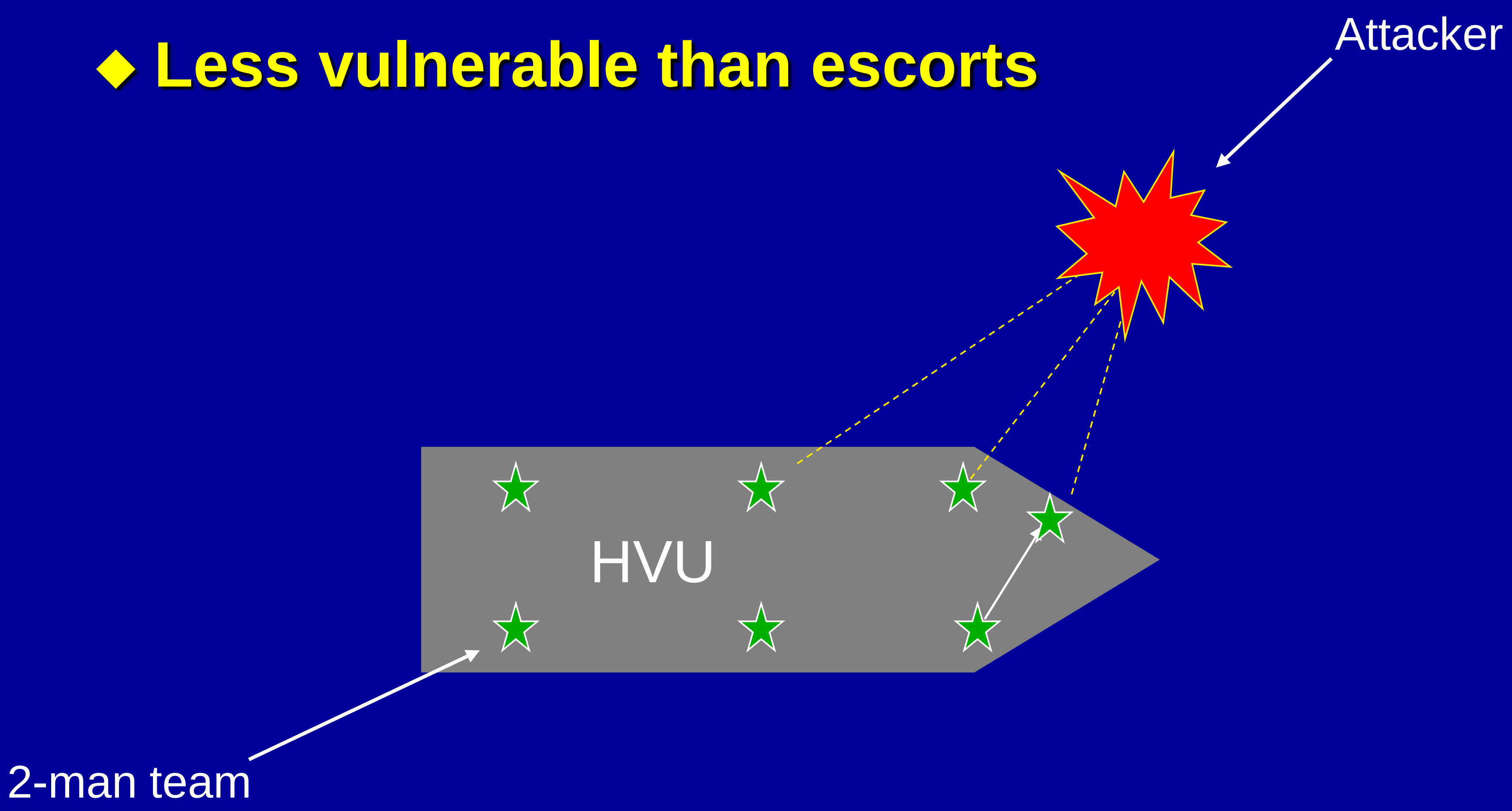
Small, Medium Escort Differences

- Number of weapon stations
  - Affects probability of kill
- Endurance
  - Affects force structure
- Maneuverability
  - Affects escort formation & probability of kill



Traditional Escorts vs. Teams

- Teams can reposition quickly to meet threats
- Low cost option
- Less vulnerable than escorts



Benefits of Armed Helicopters

- Scouting / challenging
  - Reduces engagement decision time
- Engagement capability

Benefits of USV

- Scouting / challenging
  - Reduces engagement decision time
- Reduces risk to small boat crews

Non-lethal Weapons

- **Employ NLW as warning device**
  - **Discriminates targets from innocent boaters**
- **Need an intermediate step between warnings and use of deadly force - especially in CONUS**
  - **Risks of collateral damage**
  - **Time is limited**

SBA CONOPS

MARE ISLAND
Microsoft® MapPoint®
Point Reyes Station
Nicasio
Rafael Village
Ignacio
GLENCOVE
SOLANO
Suisun Bay
Rodeo
Port Costa
Benicia
Nichols
Clyde
Olema
Marinwood
San Pablo Bay
Hercules
Martinez
Lagunitas
Sleepy Hollow
Santa Venetia
MARIN
Fairfax
Pinole
Pacheco
San Rafael
San Anselmo
80
El Sobrante
Concord
Alamere Falls
Kentfield
San Quentin
Pelican Lake
Mount Tamalpais 2571 ft
Larkspur
CONTRA COSTA
San Pablo Reservoir
Pleasant Hill
POINT REYES BIRD OBSERVATORY
Corte Madera
El Cerrito
Kensington
Walnut Creek
Stinson Beach
Albany
Grizzly Peak
Lafayette
ANGEL ISLAND
Orinda
Berkeley
Glorietta
Alamo
Emeryville
Moraga
Piedmont
Danville
RUSSIAN HILL
CALIFORNIA
FINANCIAL DISTRICT
San Francisco
Alameda
GOLDEN GATE PARK
TWIN PEAKS
MISSION DISTRICT
COAST RANGES
PARKSIDE
MIRALOMA PARK
Lake Chabot
ST. FRANCIS WOODS
BAY VIEW
Castro Valley
SAN FRANCISCO
CROCKER-AMAZON
San Bruno Mountain
ALAMEDA
Daly City
Colma
San Francisco Bay
Hayward
PACIFIC OCEAN
Pacific Manor
South San Francisco
Edgemar
RUSSELL CITY
MOUNT EDEN
Pacifica
San Francisco International Airport
BAUMBERG
CARPENTER
Rockaway Beach
San Bruno
Union City
Millbrae
Burlingame
PABRICO
North Peak
Hillsborough
San Mateo
SAN MATEO
Montara
Newark
Moss Beach
Scarper Peak
Belmont
Jarvis Landing
Princeton
El Granada
Vallejo Beach
37° 30'
©2006 Microsoft Corp.
122° 30'
San Carlos
Redwood City

Modeling, Simulation and Analysis

- Probabilistic modeling
  - Hits required to kill attacker (negative binomial)
  - Weapon probabilities of kill (conditional probability, binomial distribution)
    - Parameters
      - Range
      - Attacker speed
      - Probability of hit
      - Rate of fire
      - Ammunition capacity
      - Multiple weapons
      - Coordinated fires
      - Coordinated reloading
  - Platform probability of kill
    - Weapon combinations
    - Firing arcs
  - Formation probability of kill (probability trees)
    - Maneuverability
    - Firing arcs
    - Separation distance

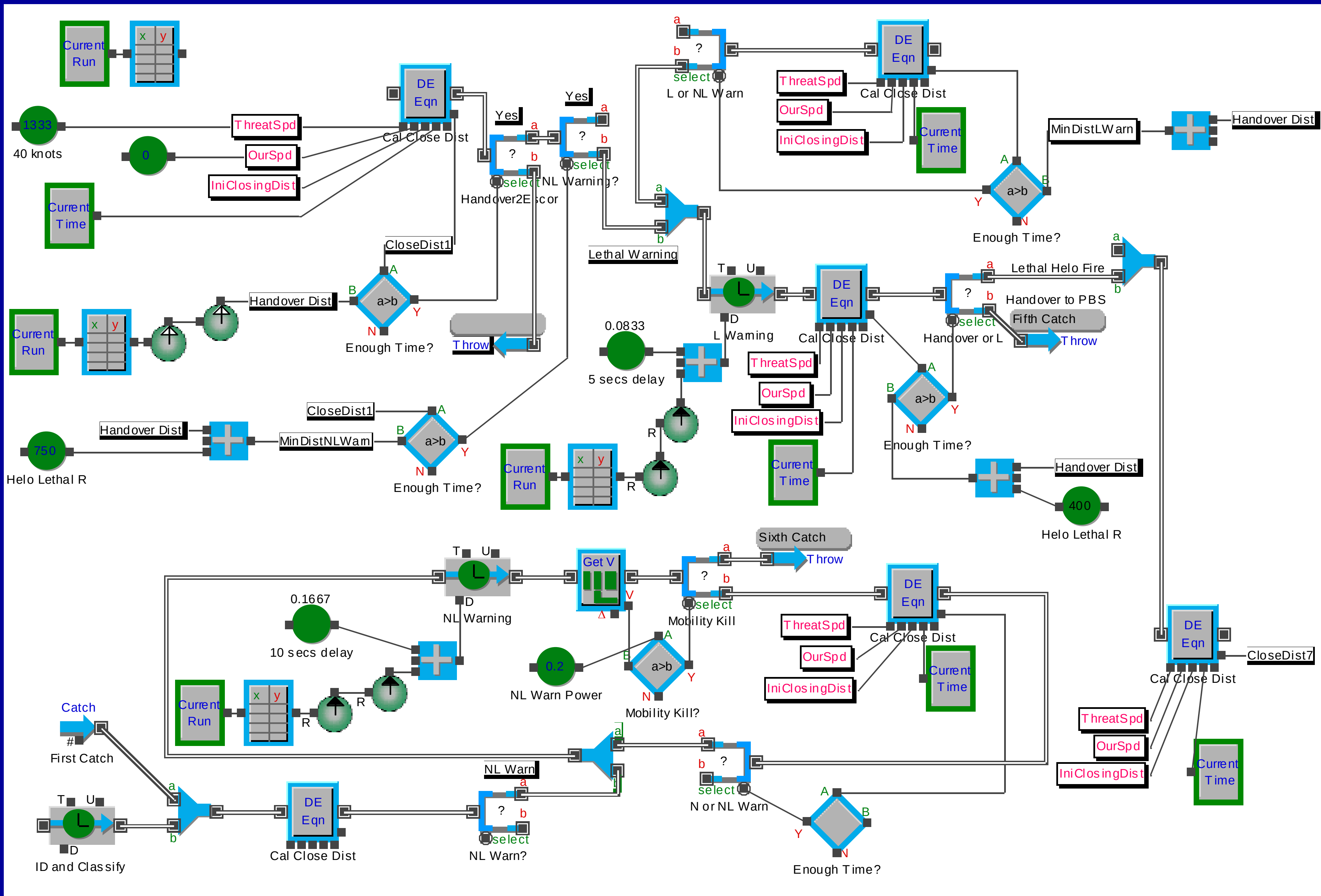
Modeling, Simulation and Analysis

- EXTEND engagement model
- Inputs
  - Attacker initial distance (d_0)
    - (d_0)~Nor(μ,σ^2) so then d_0 ~ Nor(500yd,22500yds)
  - Escort option maximum engagement distance
  - Escort option P(kill)
  - Escort option ID & classification time
  - Finish option P(kill)
  - Finish option ID & classification time
  - Finish option d_0
  - C4ISR initial delay
  - Win / lose parameter (distance)
- Outputs
  - Architecture P(success) in scenario

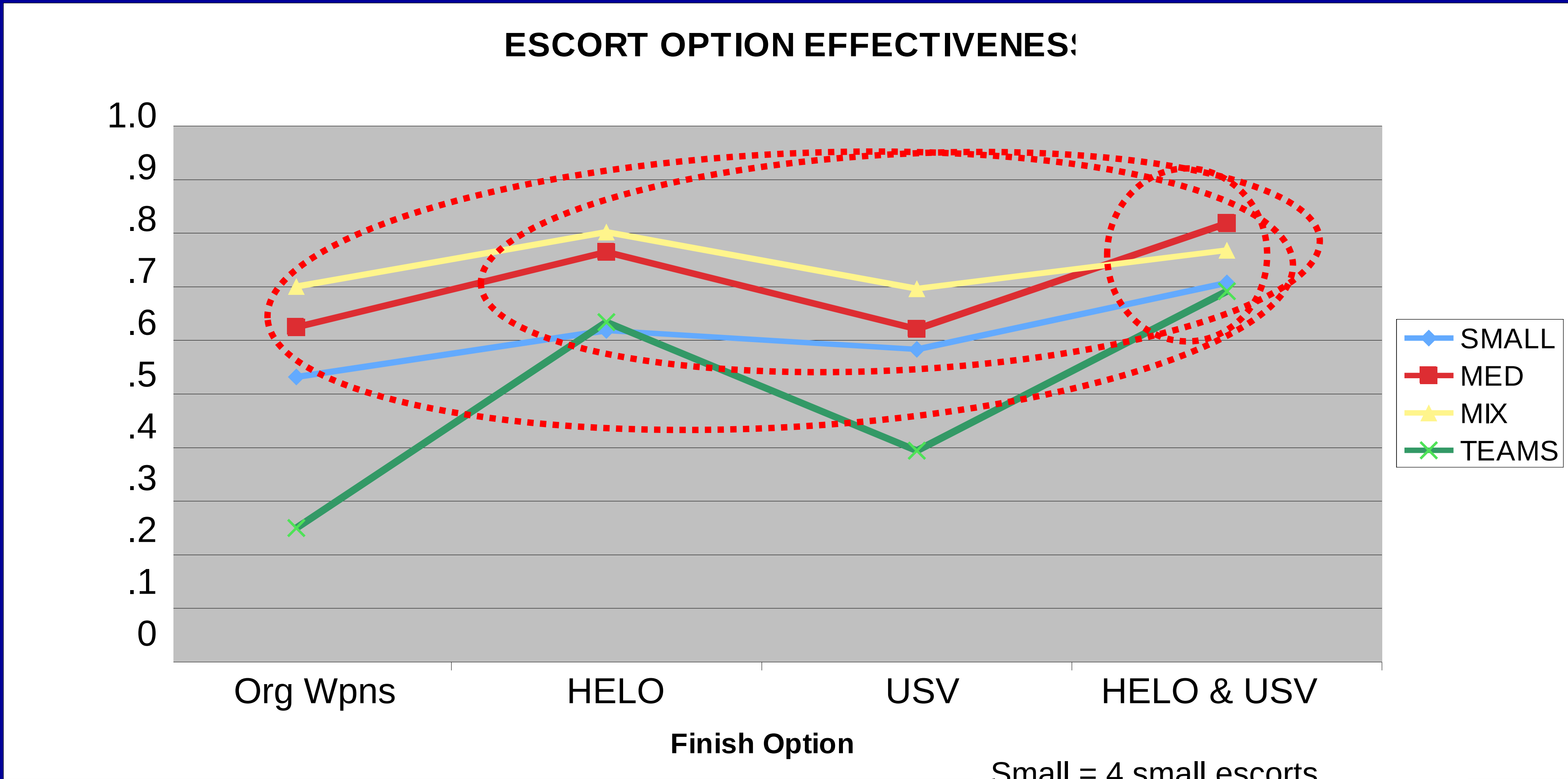
Modeling, Simulation and Analysis

- EXTEND commerce delay model
- Inputs
  - Number of escorts
  - Number of HVU
  - C4ISR initial delay
- Outputs
  - HVU delay time in hours

EXTEND SBA model



Escort Option Effectiveness



Small = 4 small escorts
Medium = 2 medium escorts
Mix = 2 small, 2 medium

Non-quantifiable Impacts

- “Deterrence” effect of escorts
  - Effect on terrorist planning and operation (impact on enemy OODA loop)
- Routine patrols by helicopters / surface vessels
  - Intel gathering
  - Local area knowledge
  - Improvement in detection / discrimination ability
- Duration of operation
  - Loss of alertness

Recommendations for Further Study

- Engagement geometry (formations, escorts, and attacker)
- Anti-vehicle non-lethal weapons
- High P(kill) weapons
- Feasibility of control system for USV
- Feasibility / effect of armed USV
- Enforcement of recreational boat restriction

Questions?

SoS Sustain Overview

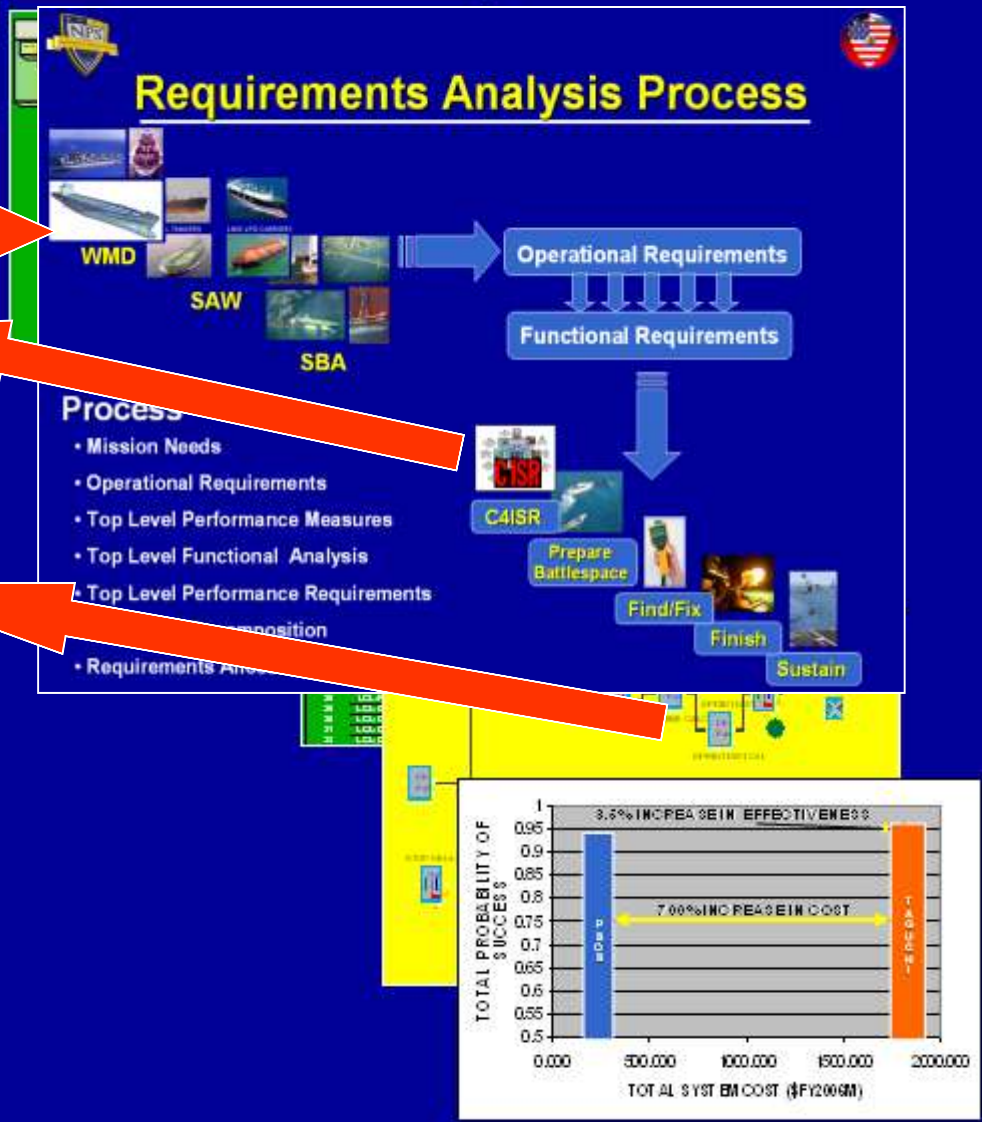
LT Jared “Chewy” Chiurourman, USN

Topics

- Sustain function interaction within the SoS
- Summary of results
- Sustain models
  - Ship Fuel Consumption Model (ShiFCoM)
  - Watch Team Sleep Analysis Model (WaTSAM)
  - Small Boat Availability and Reliability Model (SARM)
  - Helicopter Availability and Reliability Model (HARM)
- Take-aways

Project Phase Overview

- Needs Analysis
- Requirements Analysis
- Functional Analysis
- Architecture Development
- Modeling and Simulation
- Cost Analysis
- Effectiveness Analysis
- Architecture Recommendation



Bottom Line Up Front: Summary of Results

Model	Results	Effects
ShiFCoM	LCS: consumes fuel more efficiently allowing higher transit speed	WMD/SAW mission CONOPS
	LCS: smaller fuel capacity limits its unsupported endurance	Architecture Cost Effectiveness
	FFG-7, WHEC-378, and WMSL failed to meet all operational requirements	
WaTSAM	Watch teams more efficient when rotated off-ship every 24 hours	WMD/SAW/SBA mission CONOPS
	Shortened shift watches keep efficiency from falling below acceptable levels	Architecture Cost Effectiveness
SARM	Conservative estimate requires 112 RHIBs in stock to ensure that almost 100% of the time 72 are available for the SBA mission	Architecture Cost Effectiveness
HARM	34 SH-60Bs must be stocked to ensure that 99% of the time 26 are available for the SBA mission	Architecture Cost Effectiveness

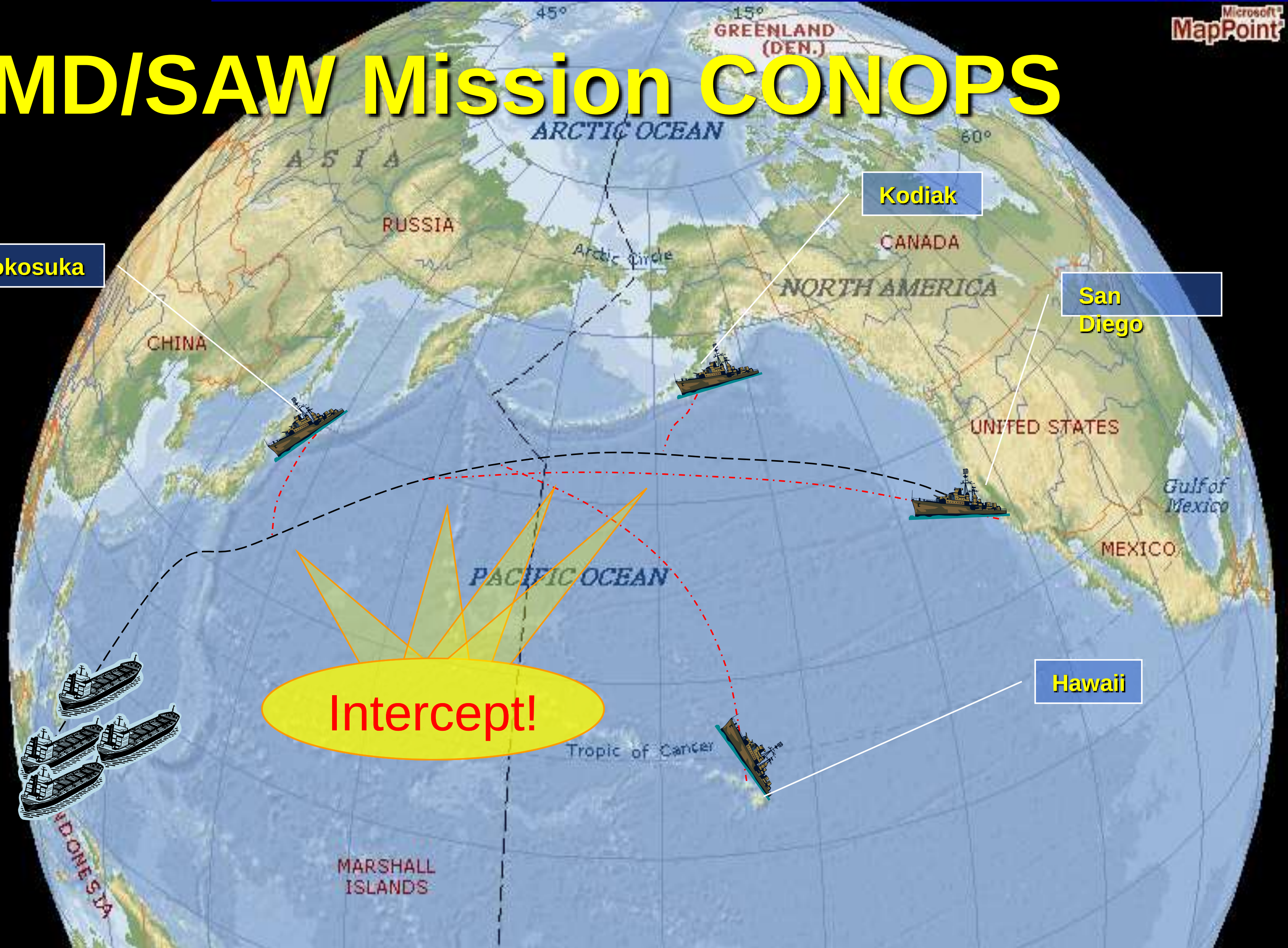
Sustain Functional Implementation

Ship Fuel Consumption Model
(ShiFCoM)

Ship Fuel Consumption Model

- Requirement: sprint speed ≥ 24kts, higher is better
- Modeling tools
  - Deployment EXTEND model results used as input
  - MS EXCEL model generated output
- Constraints
  - 4 Pacific U.S. bases considered
  - 9 ship types considered
  - Must have ≥ 10% fuel at intercept
- Purpose
  - Determine ship suitability for mission
  - Calculate ship maximum optimized sprint speed
  - Determine ship's fuel cost for mission

WMD/SAW Mission CONOPS

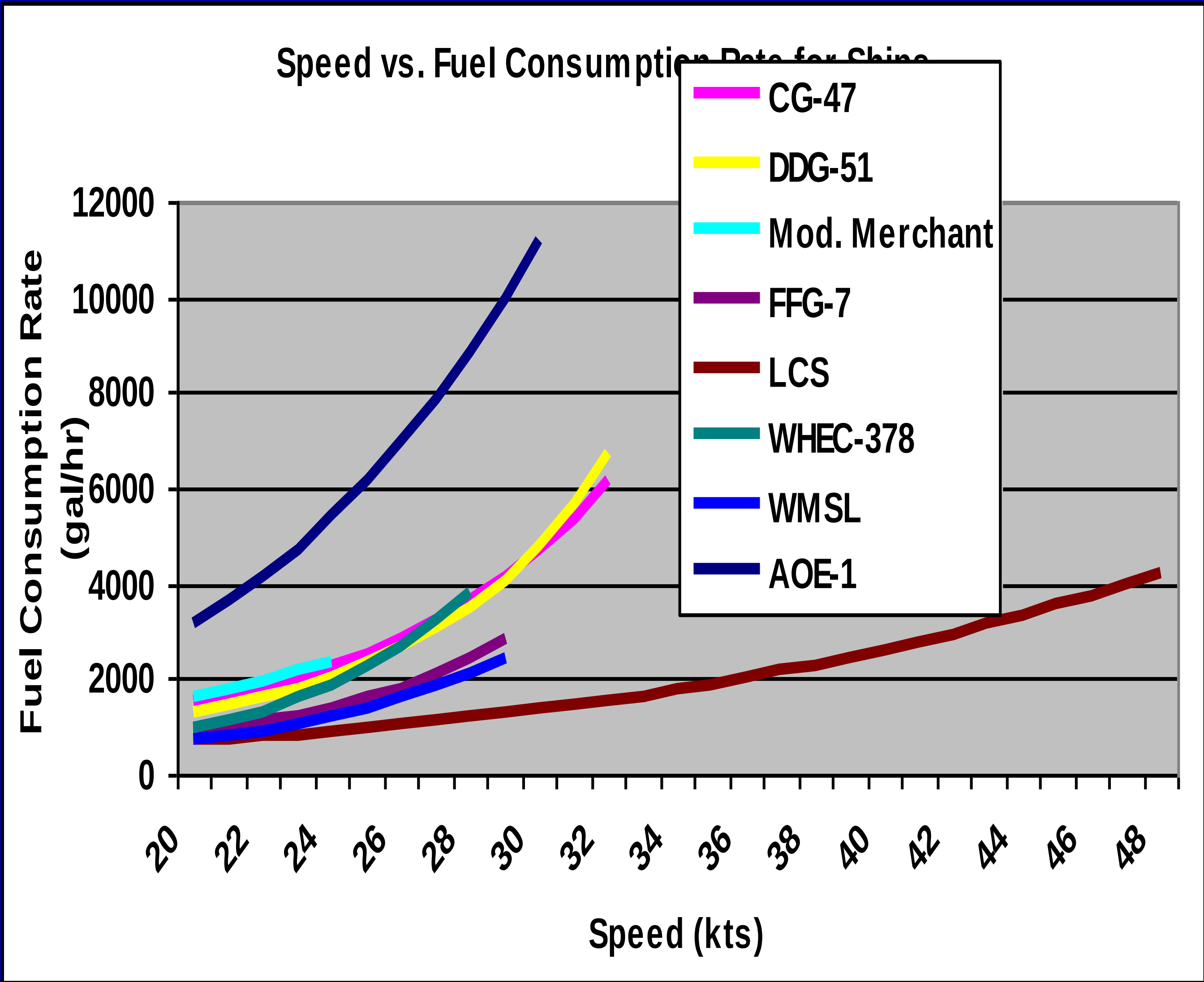


- MDA system provides container ship locations
- Search teams activated and deployed
- National Fleet assets surged to intercept at best speed
- MSC ships tasked to rendezvous for UNREP no later than 24 hours after intercept

WMD/SAW Mission CONOPS

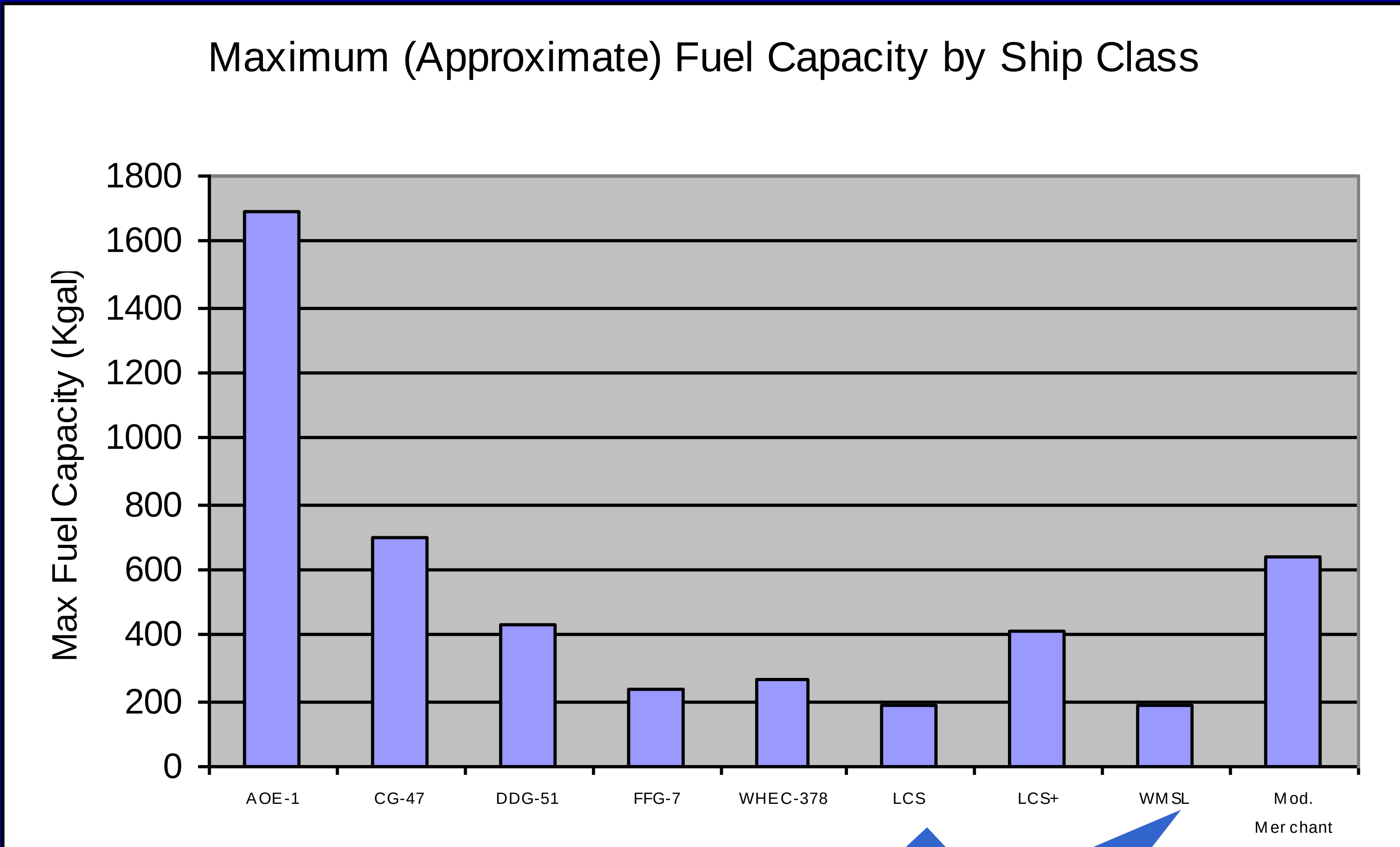
- **At sea intercept allows multiple *days* of search**
- **Ships escort PAVs & provide support to teams during search**
- **WMD Mission: Discovered devices will be turned over to Department of Energy JTO Teams for disarmament**

Ship Fuel Consumption Rates



- Best MPG: LCS
- Worst MPG: AOE-1
- WMSL slightly better than WHEC-378 at high speed
- Similar fuel consumption rate curves
  - CG-47 & DDG-51
  - WMSL & FFG-7
- FFG-7 better than DDG-51 or CG-47

Ship Fuel Capacity (Estimated)



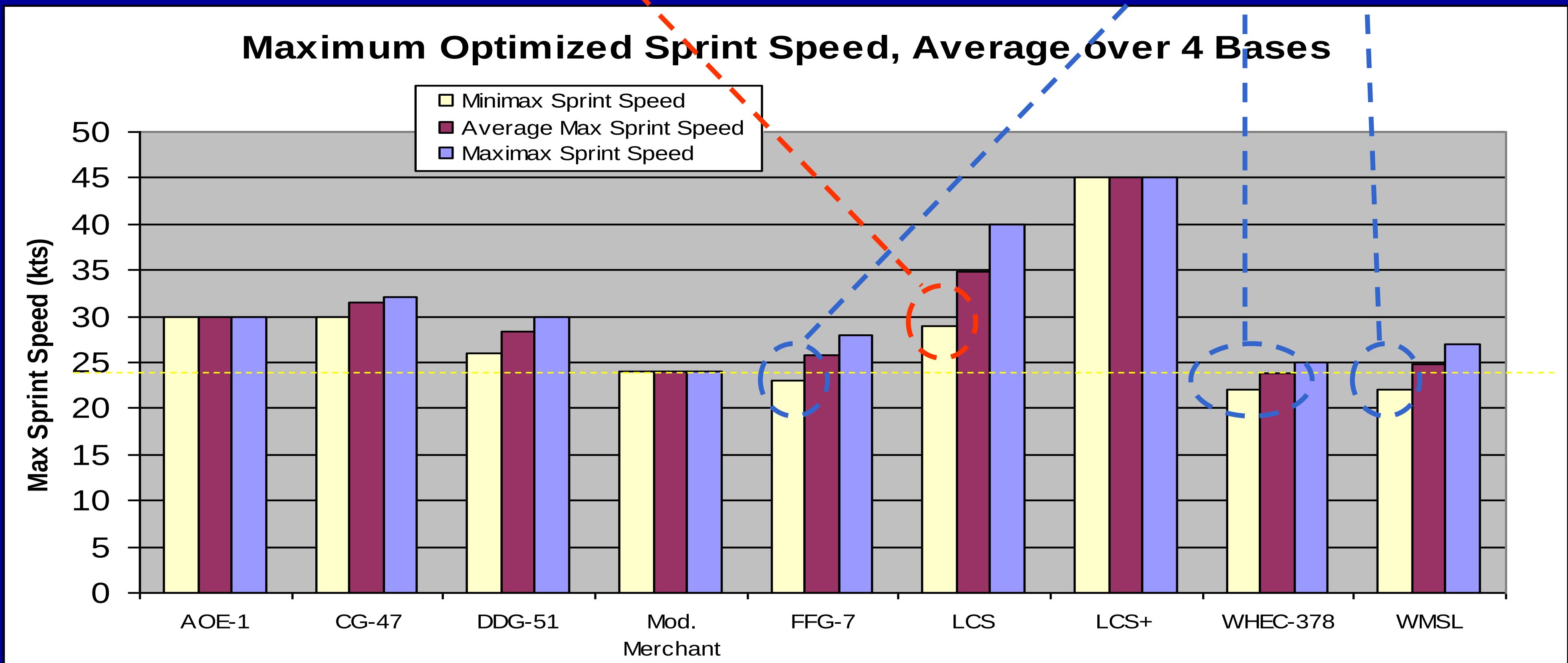
LCS & WMSL have smallest fuel capacity

Optimized Ship Sprint Speeds

- **Highest optimized max sprint speeds: LCS, CG-47, AOE-1**
- **LCS+ affords large gain in sprint speed (45 kts!) due to hypothetical fuel tank**

Long distance decreases LCS max optimized speed

Fails to meet sprint speed requirement from all bases

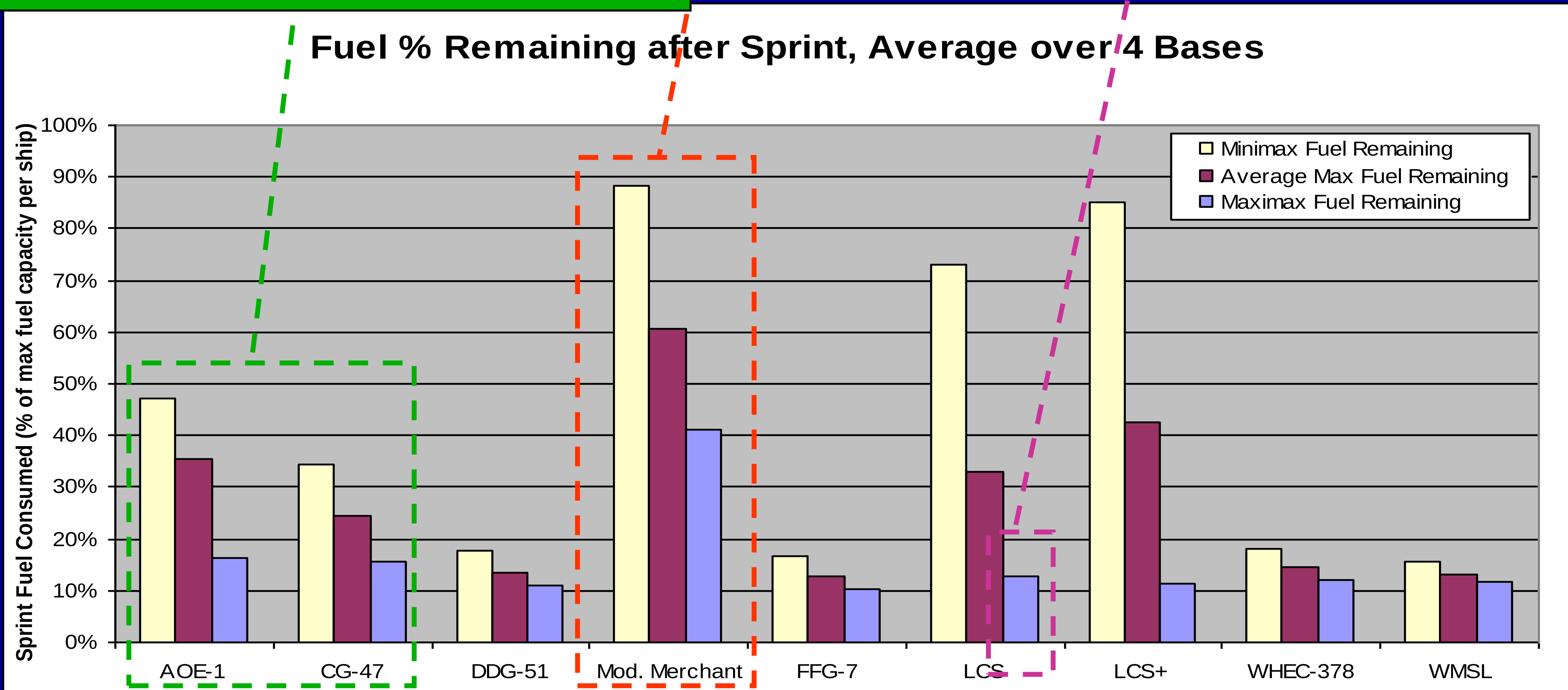


Fuel % Remaining after Sprint to Intercept

- Mod. Merchant has largest % of fuel remaining
  - Sprint @ lower speed (24kts)
  - Most likely able to continue mission in case of MSC rendezvous delay

- AOE-1, CG-47 have larger % of fuel remaining @ higher speeds

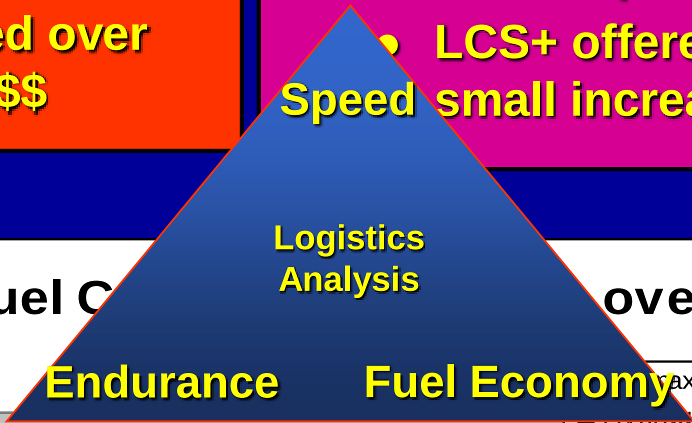
- LCS high sprint speed comes at a price

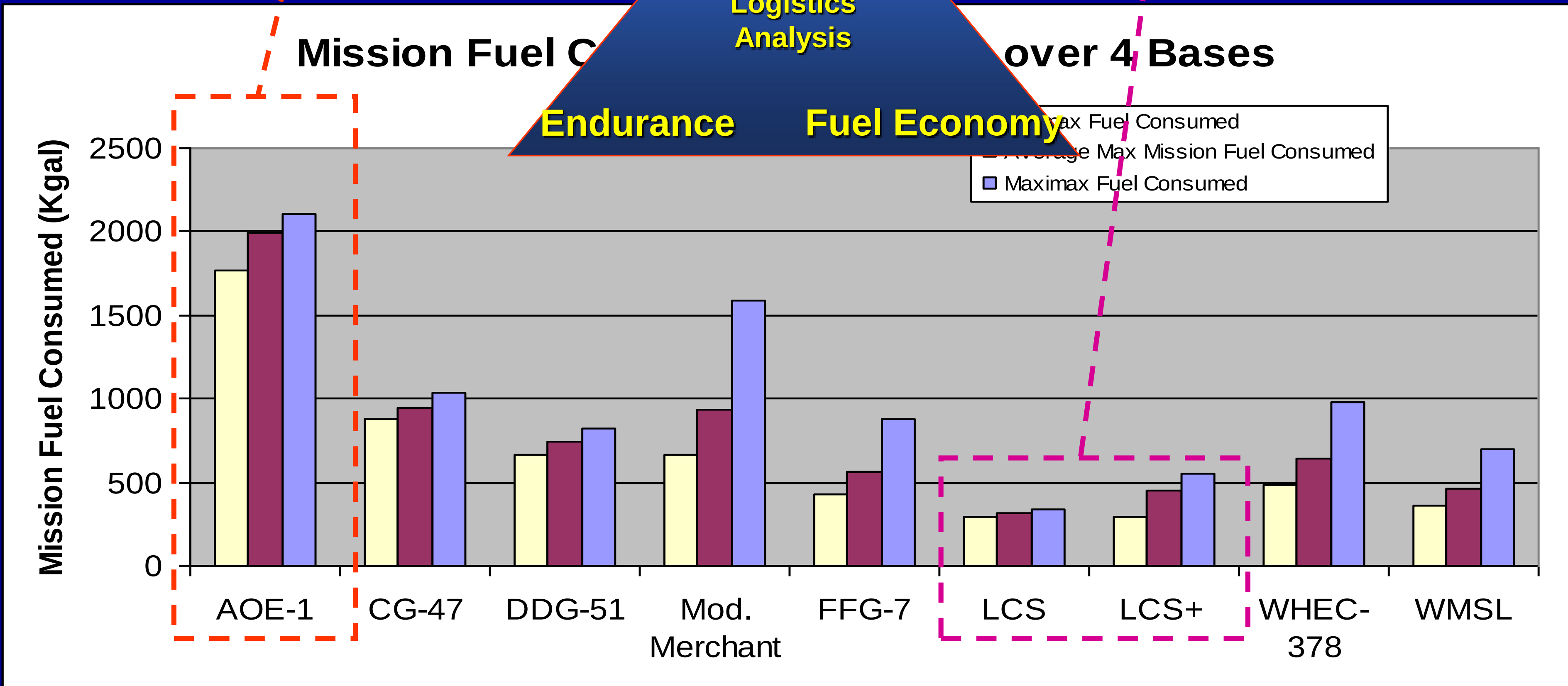


Total Mission Fuel Consumption

- AOE consumed largest amount of fuel
  - High speed but poor fuel economy
  - Useful for high speed over long distance, but $$$

- LCS consumed smallest amount of fuel
  - Best fuel economy, highest speed
  - Indicates future fuel savings if LCS used in place of other ships
  - LCS+ offered even higher speeds at small increase in fuel consumption





Sustain Functional Implementation

Watch Team Sleep Analysis Model (WaTSAM)

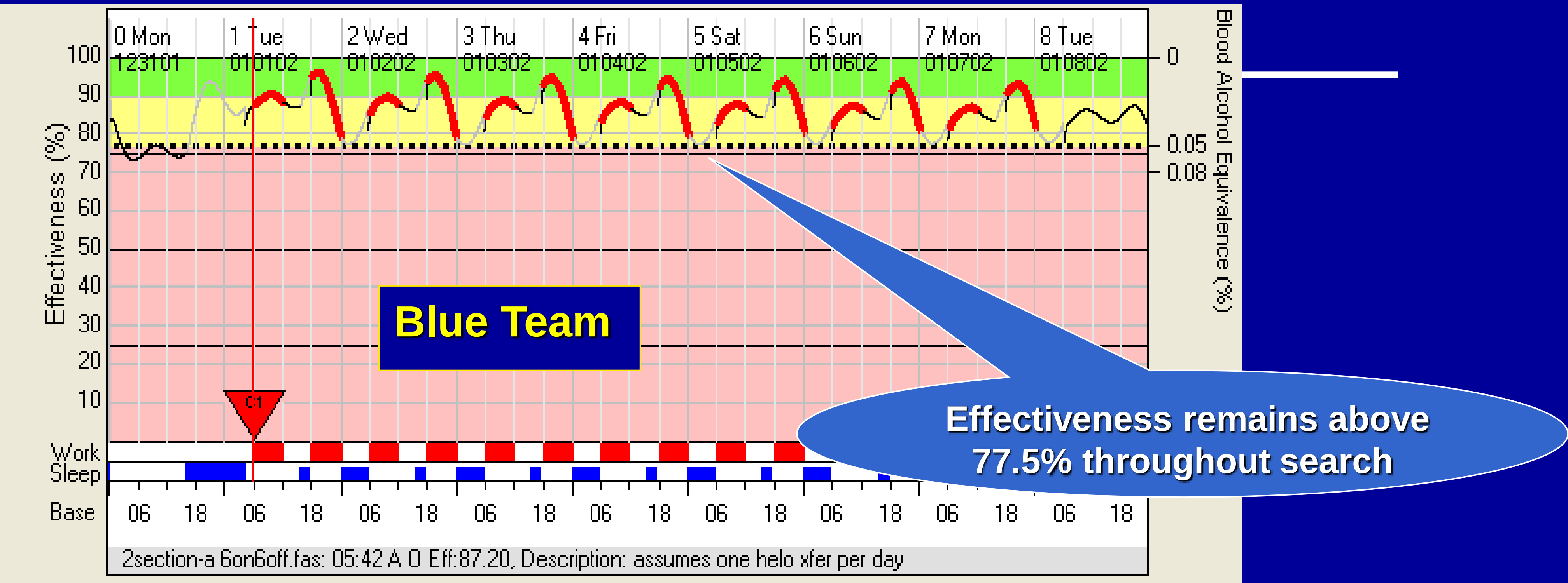
Watch Team Sleep Analysis Model (WaTSAM)

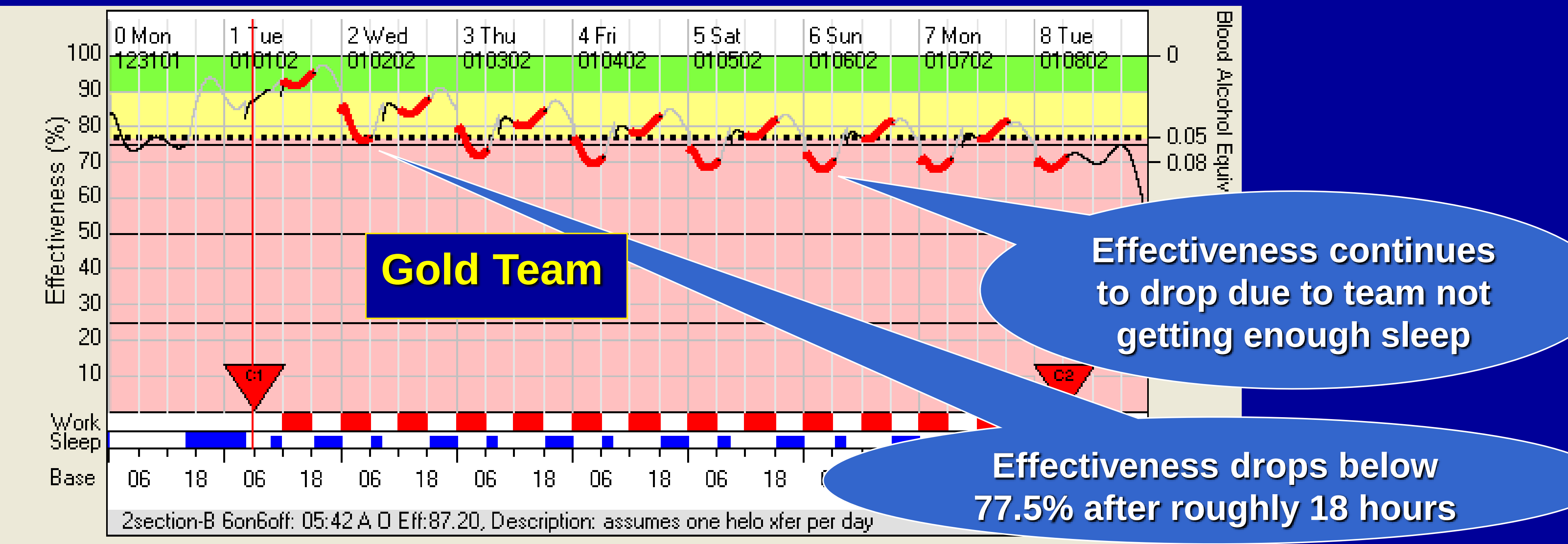
- Purpose: Maximize WMD/SBA mission P_s by controlling fatigue
- Requirement:
  - Individual worker cognitive “effectiveness” must not drop < 77.5%
- Constraints
  - Unsupported, watch teams limited to 2 shifts (Blue / Gold)
  - Supported, more shifts permissible, individual work-breaks possible
- Method
  - Fatigue Avoidance Scheduling Tool (FAST) used for 7-day model
- Assumptions
  - Teams start mission well-rested
  - Teams sleep when not working
- Note: FAST does not measure affects on alertness from working long hours; only from loss of sleep

Watch Team Sleep Analysis Model Results

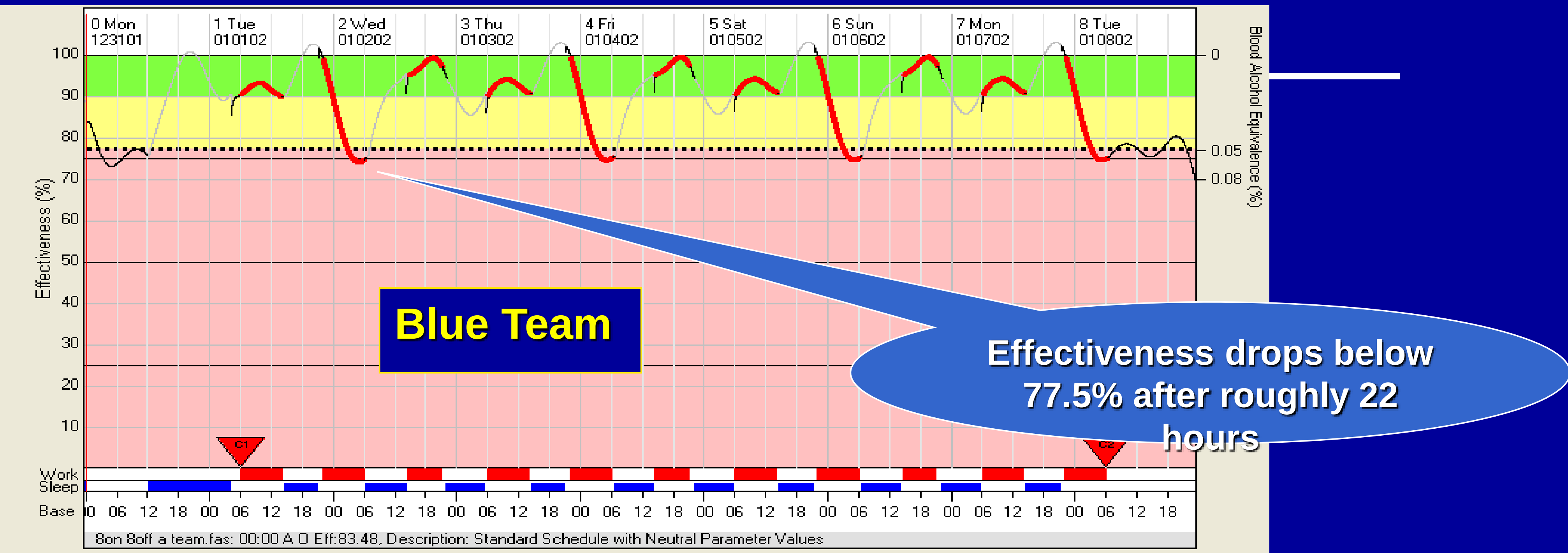
- **Results**
  - Unsupported 2-section watches fail effectiveness requirement
    - 6-hour watch shows the most frequent drops in effectiveness
    - 8 & 12-hour watches show approximately equal drops in effectiveness
  - Supported multi-section watches meet effectiveness requirement
    - Effectiveness remains ≥ 77.5% for duration of search
    - Teams get less sleep due to transfer on/off ship (but more breaks)
- **Recommendations**
  - Multi-section watch rotation with breaks
  - Shorter watches during periods of normal "lows" in circadian rhythm to avoid drops in effectiveness (i.e. dog watches)
  - Ensure berthing accommodations are planned for during missions…space is a factor aboard ships
  - Use of military ship support throughout mission minimizes amount of consumables teams must carry off-ship

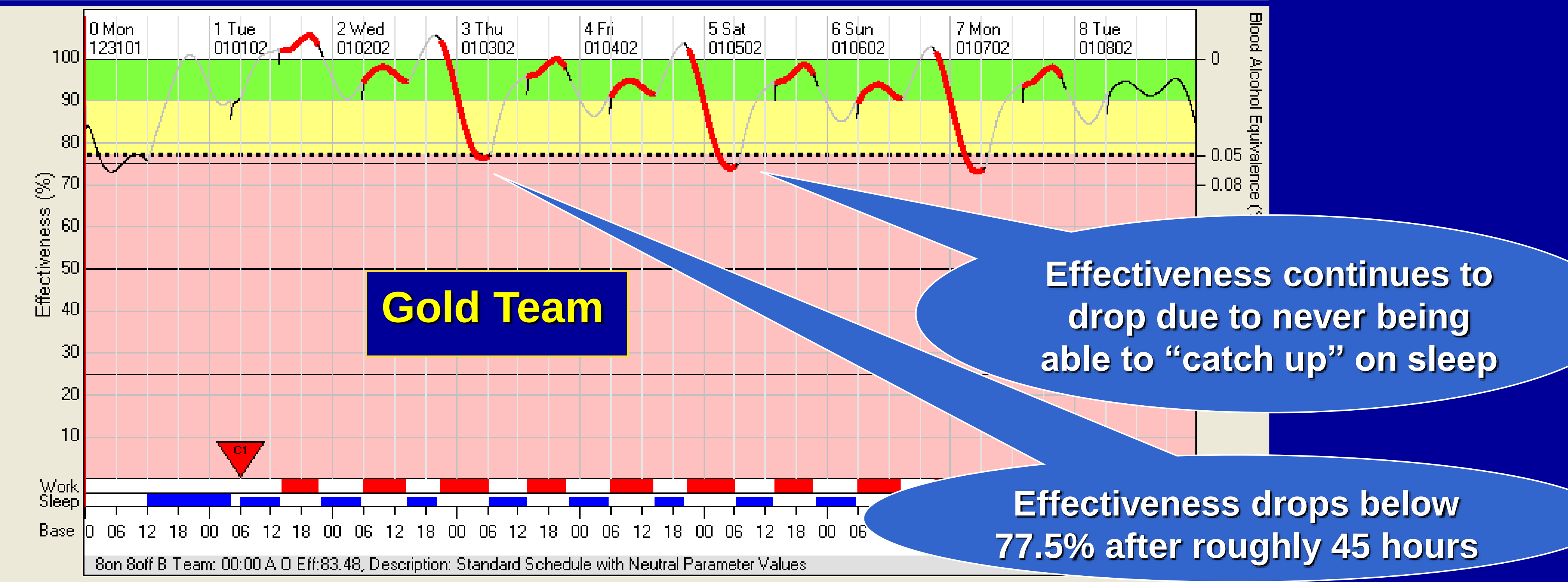
Unsupported – 6 on / 6 off Results



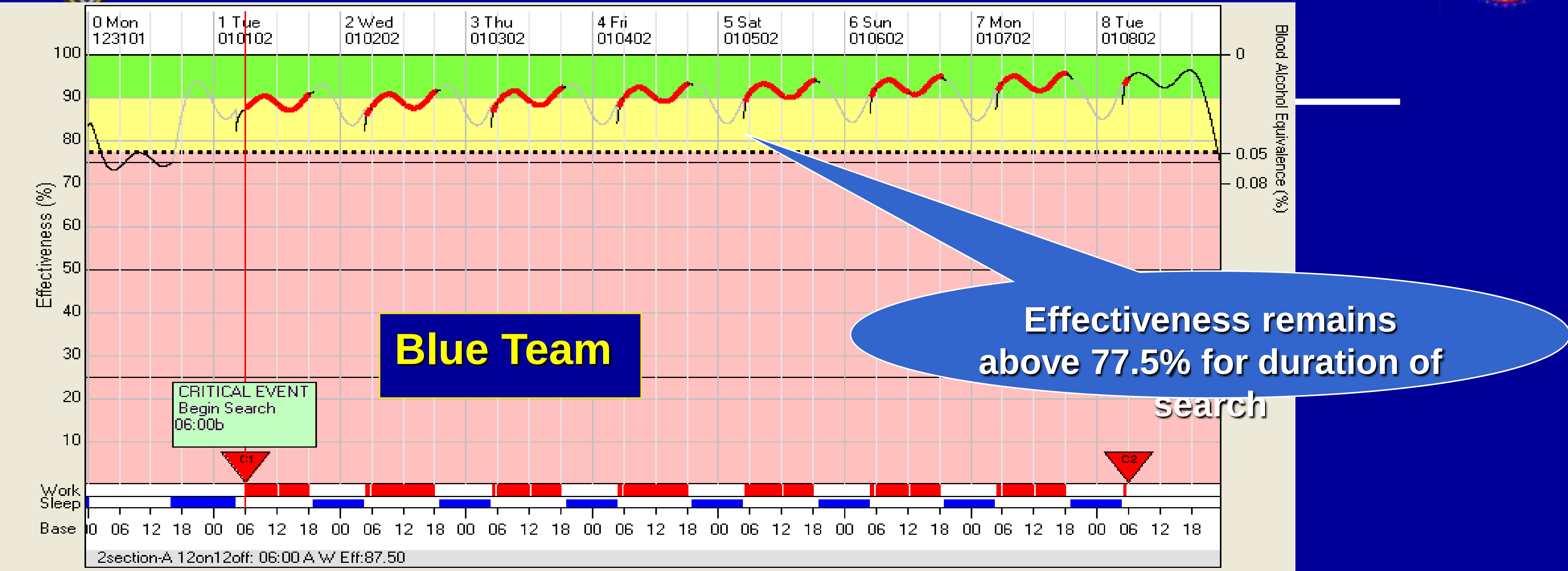


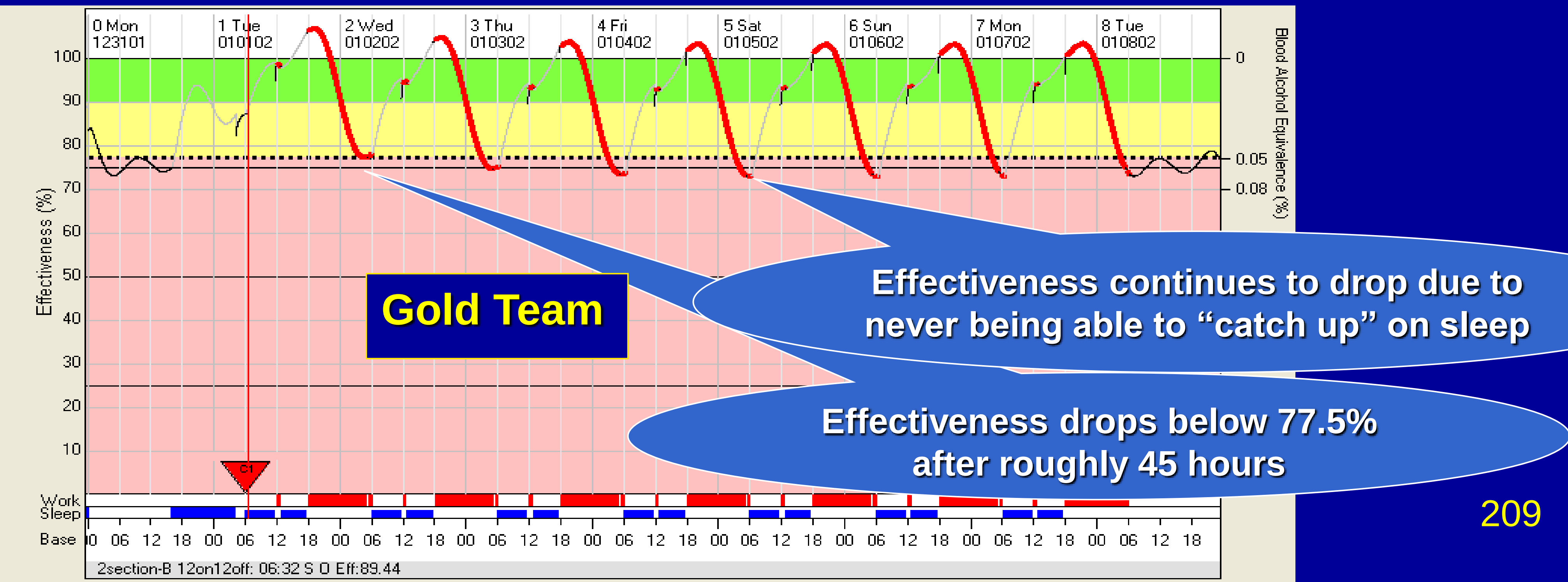
Unsupported – 8 on / 8 off Results



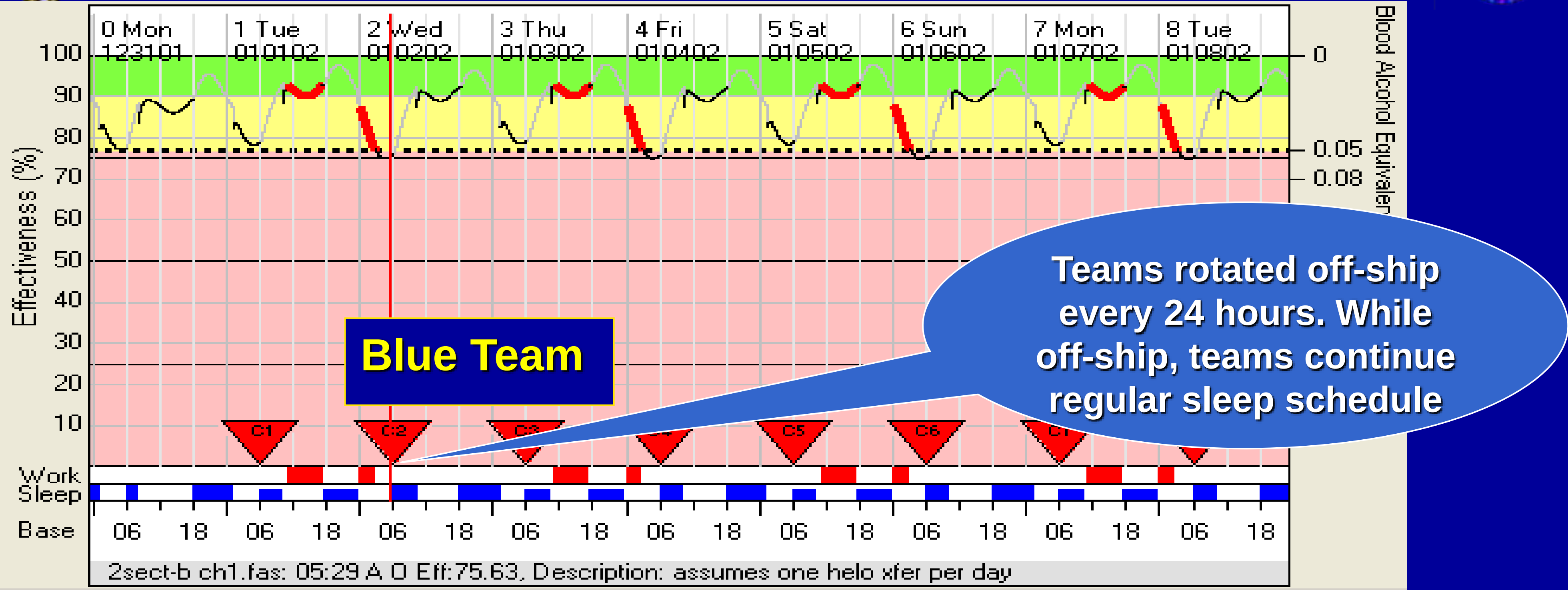


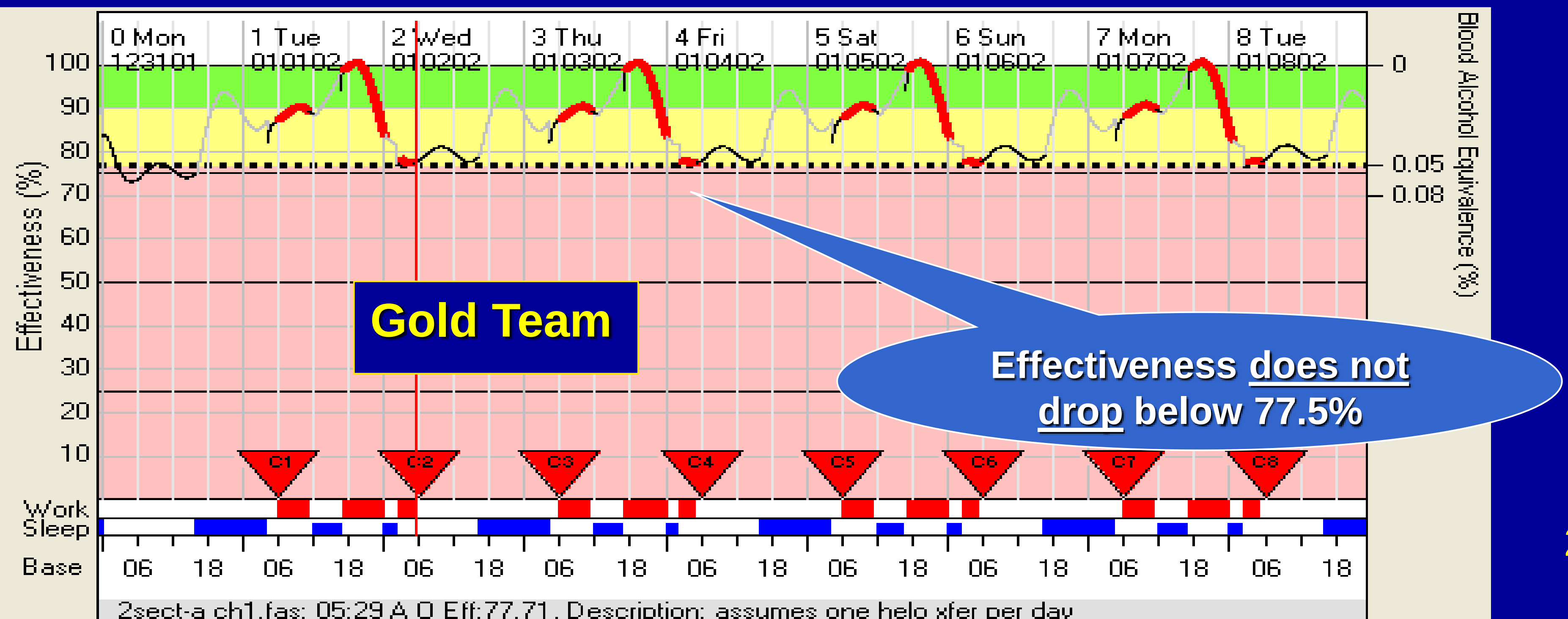
Unsupported – 12 on / 12 off Results





Supported – 6 on (with breaks) / 6 off / 24 off-ship Results





Sustain Functional Implementation

Small Boat Availability and Reliability Model (SARM)

Small Boat Availability and Reliability Model (SARM)

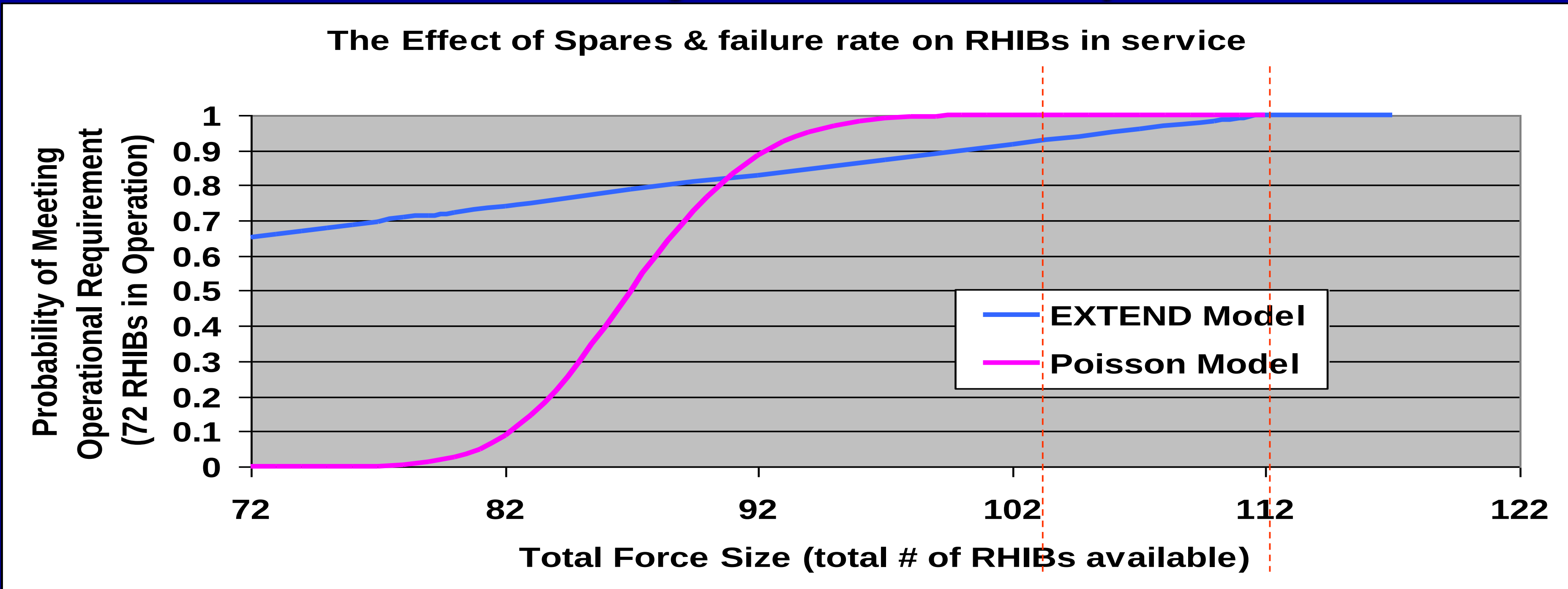
- **Purpose**
  - **Account for effects from Reliability & Operational Availability (A_o) in SoS by modeling units with lower reliability / higher maintenance requirements**
  - **Small boats & helicopters identified as candidates for modeling**
- **Requirements**
  - **PBS function: 72 small boats must be operating in the harbor during a 14-hour period per day for 30 days**
  - **Sustain function: SoS must "work" 99.99% of the time**
- **Method:**
  - **EXTEND reliability model**
  - **EXCEL Poisson reliability model**
  - **EXCEL binomial availability model**

Reliability =	91%
Op. Availability =	99%
λ (failures per hour) =	.0017

*based on NSW 11-m RHIB DT/OT results

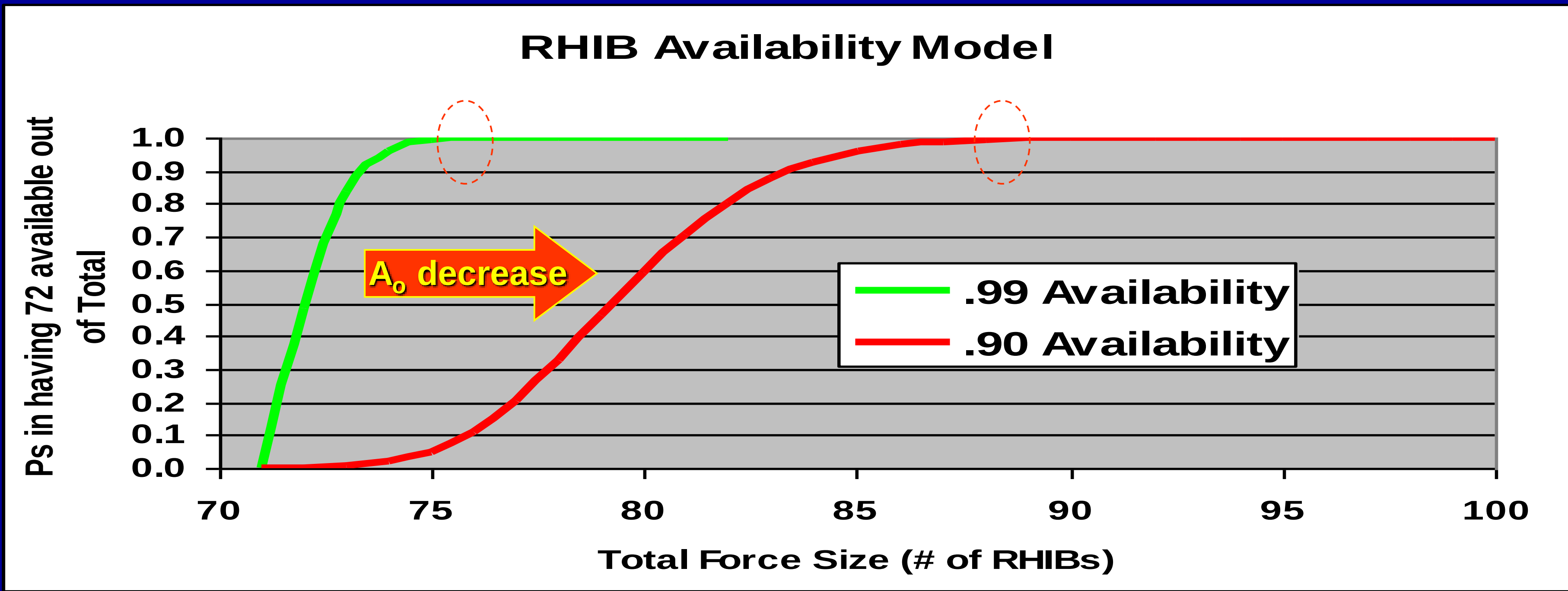
SARM Reliability Results

- **EXTEND model results: RHIB inventory ≥ 112 keeps 72 RHIBs almost always available**
  - **RHIBs at different points in service life accounted for**
  - **Linear slope due to uniform likelihood for a break to occur**
  - **Provides a more conservative approach**
- **Poisson model results: RHIB Inventory ≥ 104 keeps 72 RHIBs almost always available**
  - **"Memoryless" distribution does not account for service life of RHIBs**
- **EXTEND & Poisson models agree at RHIB inventory ≈ 91 and 112**



SARM Availability Results

- **Effect of A_o on total inventory of RHIBs:**
  - **To ensure 72 RHIBs are almost always available:**
    - A_o of 90% ≈ 88 RHIBs…therefore 112 total RHIBs will be sufficient
    - A_o of 99% ≈ 76 RHIBs
    - Each 1% drop in A_o requires ~1.33 RHIBs to compensate
    - As RHIB maintenance needs increase, total inventory must increase to ensure a constant number are always available



Sustain Functional Implementation

Helicopter Availability and Reliability Model
(HARM)

Helicopter Availability and Reliability Model (HARM)

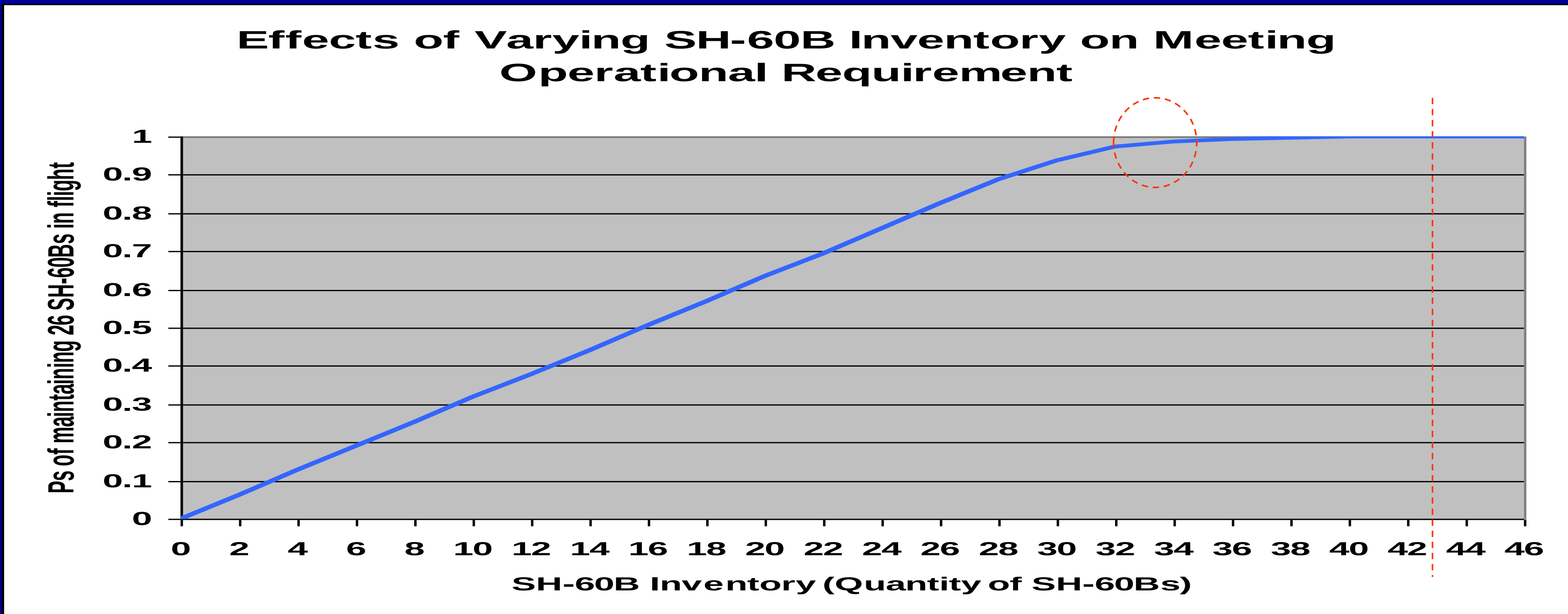
- Requirements
  - FINISH function: 26 helicopters must be operating during a 7-hour period per day for 30 days
  - Sustain function: SoS must “work” 99.99% of the time
- Method
  - EXTEND availability & reliability model
  - Model includes both availability & reliability (unlike SARM) due to larger maintenance requirement for SH-60Bs

Reliability	99%
Op. Availability	62%
λ (failures per hour)	.0009

*based on NAVAIR data for SH-60B

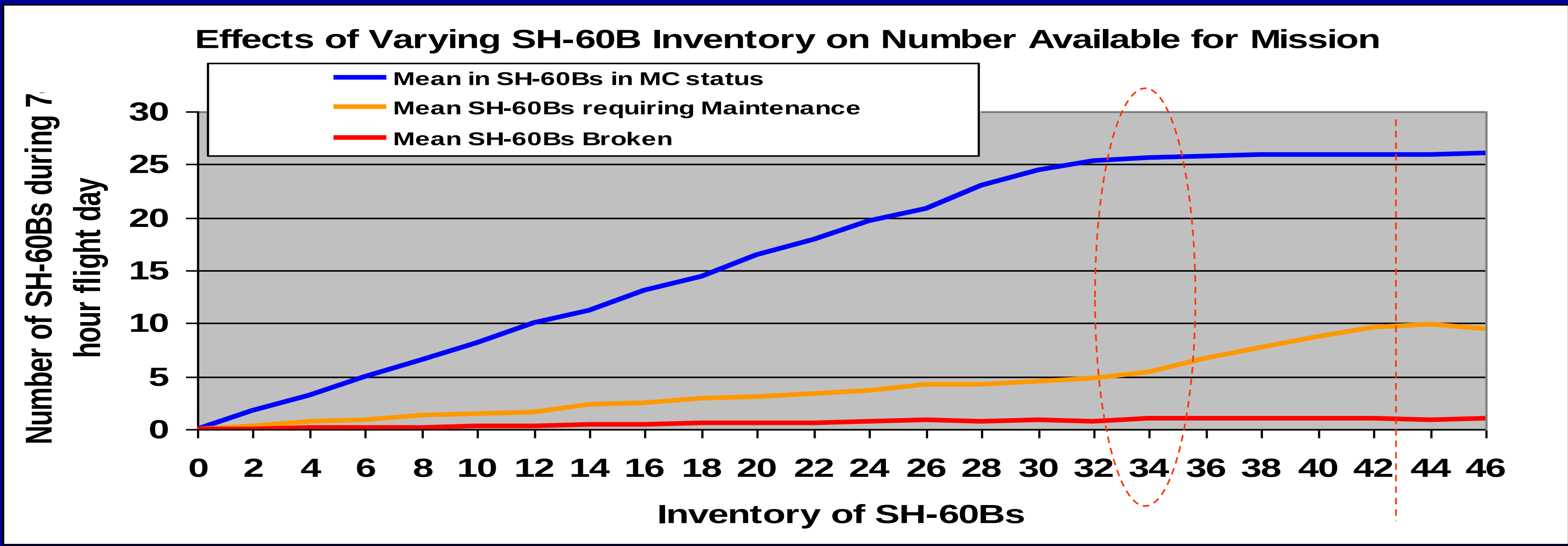
HARM Results

- SH-60B inventory ≥ 43 keeps 26 SH-60Bs almost always available (99.99% of the time)
- Elbow occurs in slope at inventory = 34; corresponding to probability = 98.91%
  - After inventory = 34, rate of increasing gains drops
  - Cost for increasing probability of success above 98.81% comes at .13% per additional SH-60B.
  - Recommend SH-60B inventory maximum at 34 unless P_s requirement (99.99%) is inflexible.



HARM Results

- SH-60Bs maintenance trend is roughly linear (slope ≈ 35%)
  - "Elbow" also occurs in maintenance slope at ≈ 34 SH-60Bs: thereafter maintenance rate increases
  - SH-60B inventory ≥ 43 shows no effects from availability
  - EXTEND model maintenance rate ≈ NAVAIR SH-60B A_o (35% compared to 38%)
- SH-60B failure trend is roughly linear (slope ≈ 5%)
  - SH-60B inventory ≥ 43 shows no effects from reliability
  - EXTEND model failure rate slightly > NAVAIR data (5% compared to 1%) …but in the ball park
  - Model may be more conservative than real life



Take-aways

- **Fuel consumption**
  - **Fuel efficiency has a large effect on max transit speed**
    - **future ship designs should consider speed *as well as* economy to enable ships to enter theatres quickly and at lower cost**
  - **Speed, Fuel Economy and Endurance must be optimized together in order to minimize mission fuel costs**
  - **LCS provides a step towards a more optimized cost solution**
- **Fatigue**
  - **Future reductions in manning will require fatigue considerations for watch rotation scheduling**
- **Operational Availability and Reliability**
  - **Maintenance needs and failure rates affect total inventory size in order to keep the system working when components are down**
  - **High probability to keep the system operating despite maintenance / failures comes at a price**
  - **Use of memoryless distribution showed different results than simulation – assumptions must be understood when planning**

Questions?

Summary and Conclusions

LCDR Andrew “Chunder” Kessler, USN

Mission Need Statement

During all environmental conditions, the MTR system must stop the terrorist attack outside of the range of lethal effects and do so with minimal impact on commerce and economic cost.

Top-level SoS Quantitative Requirements

Mission	Probability of Success
Counter WMD	≥ 0.95
Counter SAW	≥ 0.90
Counter SBA	≥ 0.88

- QUANTITATIVE REQUIREMENTS DERIVATION

  ESTIMATED DAMAGE COST OF ATTACK TYPE (X)

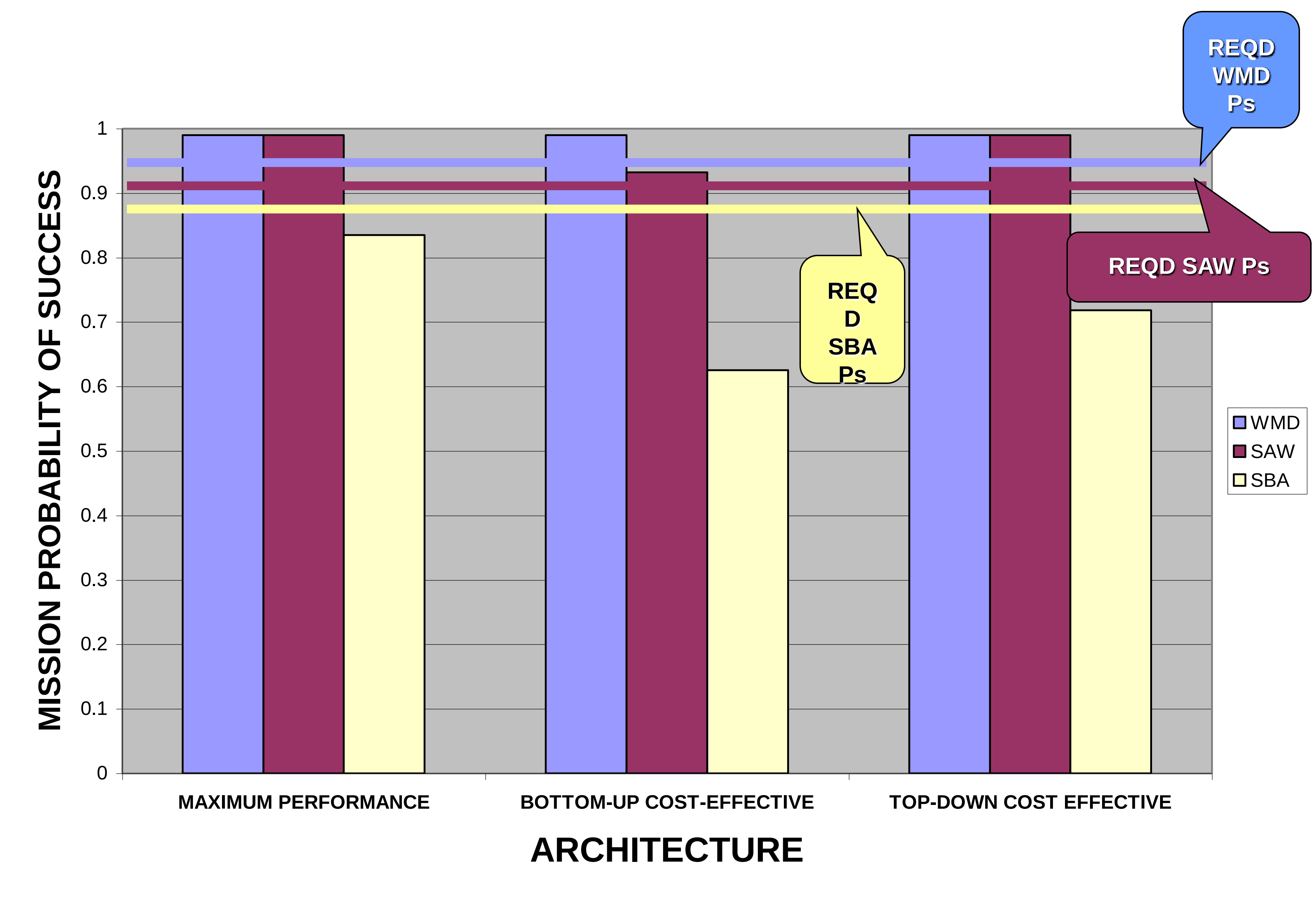
  PROBABILITY OF ATTACK TYPE OCCURRENCE =

  EXPECTED VALUE OF DAMAGE WITHOUT MTR SYSTEM (X)

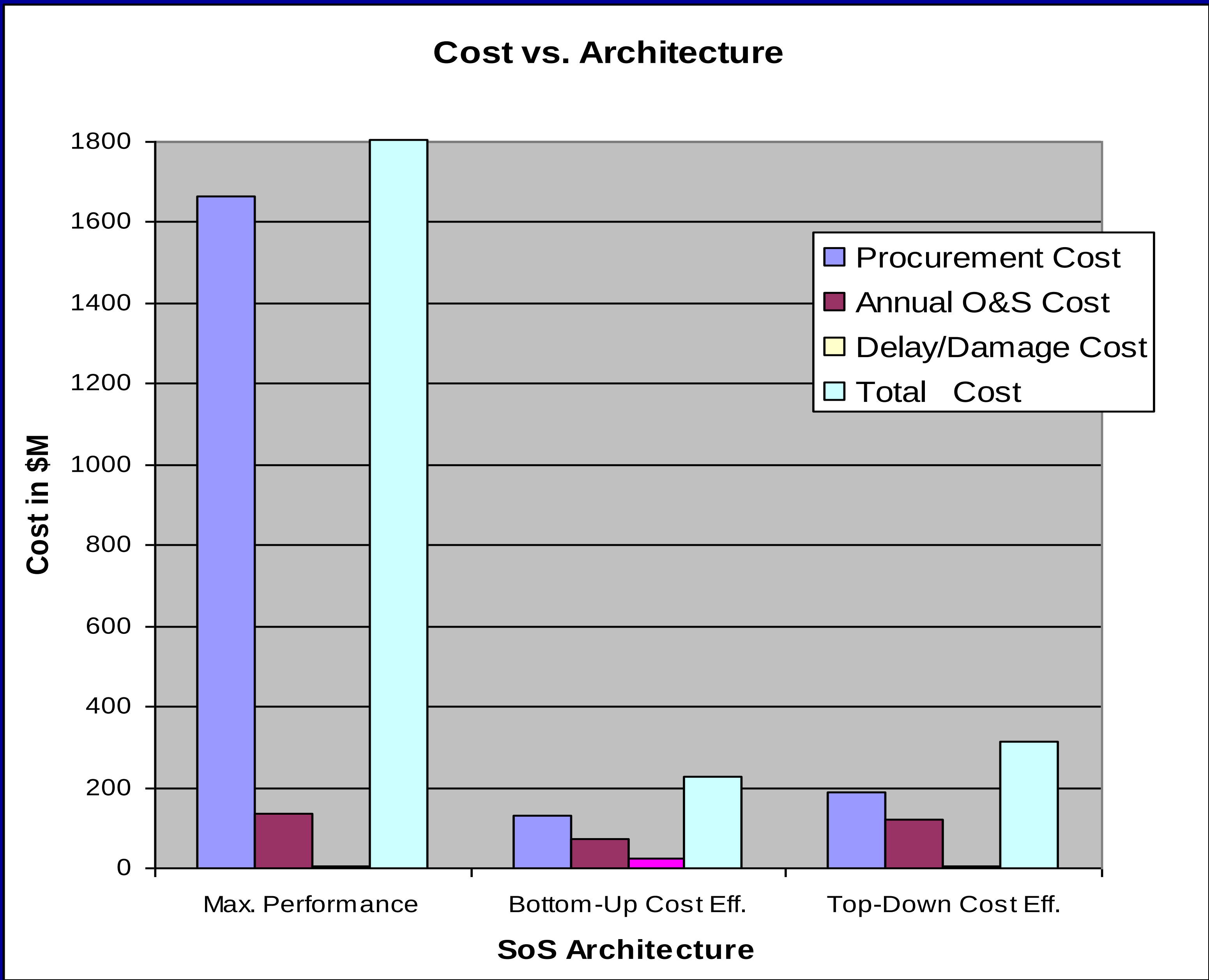
  SYSTEM P_S FOR EACH ATTACK SET TO EQUALIZE =

  EXPECTED VALUE OF DAMAGE WITH MTR SYSTEM

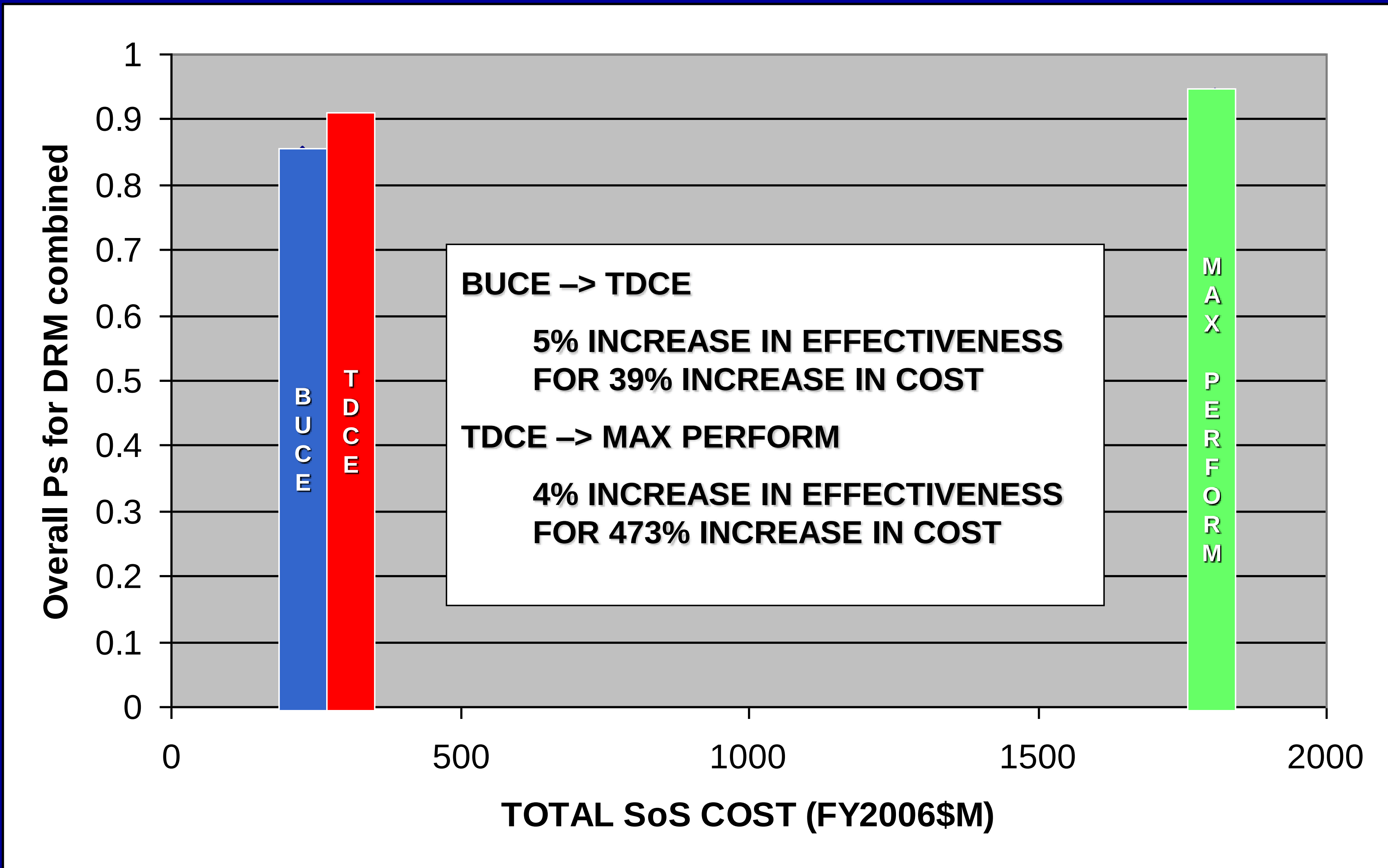
SoS Effectiveness Results



Cost Estimation Results



SoS Cost-Effectiveness Results



Top-Down Cost Effective (TDCE) SoS Architecture

LCS AND WMSL

Prepare the Battlespace

Finish

SURGE ESCORT / RECAPTURE

Finish

LINEAR RADIATION MONITOR AND FISSION METER

Find/Fix

Find/Fix

LOCAL CONTROL / OBJECTIVE-ORIENTED

Prepare the Battlespace

Finish

SMALL BOATS ONLY

ORGANIC WEAPONS, USV, AND ARMED HELIOCOPTERS

Find/Fix

VISUAL DETECTION WITH RADAR SUPPORT

TDCE Performance

MTR Mission Type	TDCE System Ps (%)	Raw Damage Cost from Attack ($M)	Relative Probability of Occurrence	Expected Damage without TDCE System ($M)	Expected Damage with TDCE System ($M)
WMD	99	500,000	0.001	1,000	10
SAW	99	2,500	1.0	500	5
SBA	72	1,000	2.0	400	112

Overall Key Findings

- Specific intelligence is a necessary, but not sufficient, component of reliable and effective responses to terrorist threats
- Minimizing impact on commerce causes shifts away from traditional solutions and Concepts of Operations
- Inter-agency cooperation and coordination is critical to success
- Rules of Engagement and Concepts of Operations must enable independent action by forces without consulting HQ

Counter WMD Key Findings

- Surging National Fleet (USN and USCG) assets to meet incoming container ships affords search times of 100 – 200 hours per ship given intelligence latency of less than 180 hours
- Time available to search affords opportunities to spend tens of minutes per container and tens of hours per cargo hold

Counter SAW Key Findings

- SAW threat can be countered through employment of 10-man "Sea Marshall" teams with Harbor Pilots, but time is critical and a reliable method of disabling the ship must be immediately available
- Surging in response to SAW threat affords more time and options, but at significantly increased cost in resources
- Many key points impacting results are estimates of likely terrorist courses of action

Counter SBA Key Findings

- Close escort is more effective than barrier patrol in San Francisco Bay
- Prohibiting recreational boat traffic is critical to mission success
- Static infrastructure needs to be protected as well as commercial boat traffic
- Medium escort ships are effective but costly
- Unmanned Surface Vehicles (USV) were cheap and effective

Recommendations

- All proposed architectures showed need for a Standing Joint Inter-agency Task Force (JIATF) for Counter-Terrorism and Homeland Security Operations
  - Could leverage off of SJFHQ-N and JTF-N
- Operational testing of different sensor technologies against actual devices in realistic operational conditions should be conducted to make knowledgeable decisions regarding procurement as well as to develop CONOPs for employment by various agencies

Acknowledgements

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Questions?