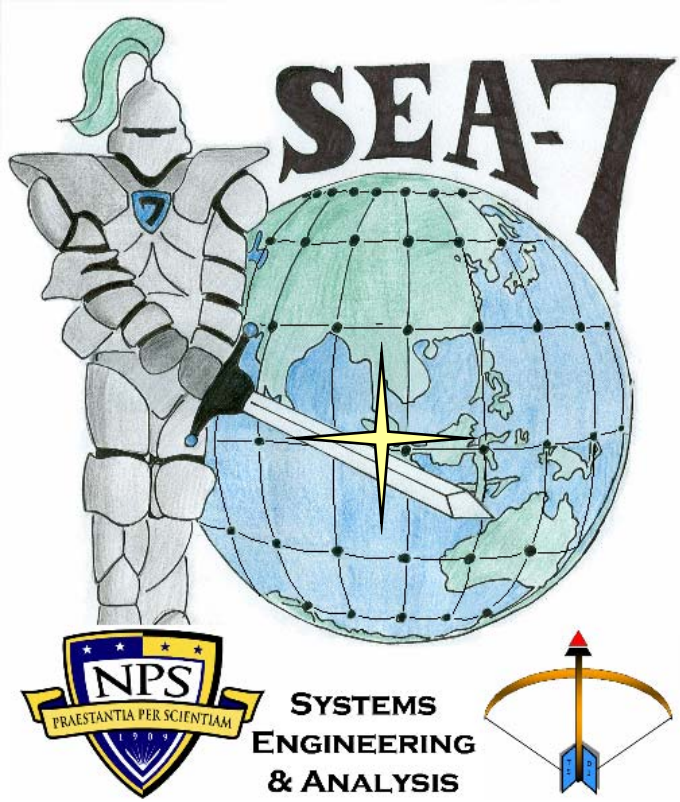
NPS Cross-Campus Integrated Study:

Maritime Domain Protection in the Strait of Malacca



Outbrief 1 June 2005

2-Day Event

Wednesday, 1 JUN 2005

NPS MDP Study Outbrief

Ingersoll Auditorium

0800-1600

Thursday, 2 JUN 2005

Breakout Sessions/Modeling Demo

Bullard Hall Computer Lab

0900-1200

NPS MDP Study
Outbrief Schedule, 1 JUN 2005

0800-0815 Introductions

0815-0915 Background/Results

0930-1015 Cargo Inspection System (Land)

1030-1130 Cargo Inspection System (Sea)

1130-1230 LUNCH

1230-1330 Sensor System

1345-1445 C3I System

1500-1600 Response Force System

Rules of Engagement

- Restrooms
- Cell Phones
- Questions
- Coffee Breaks
- Schedule
- List of Acronyms

NPS MDP Study Background/Results

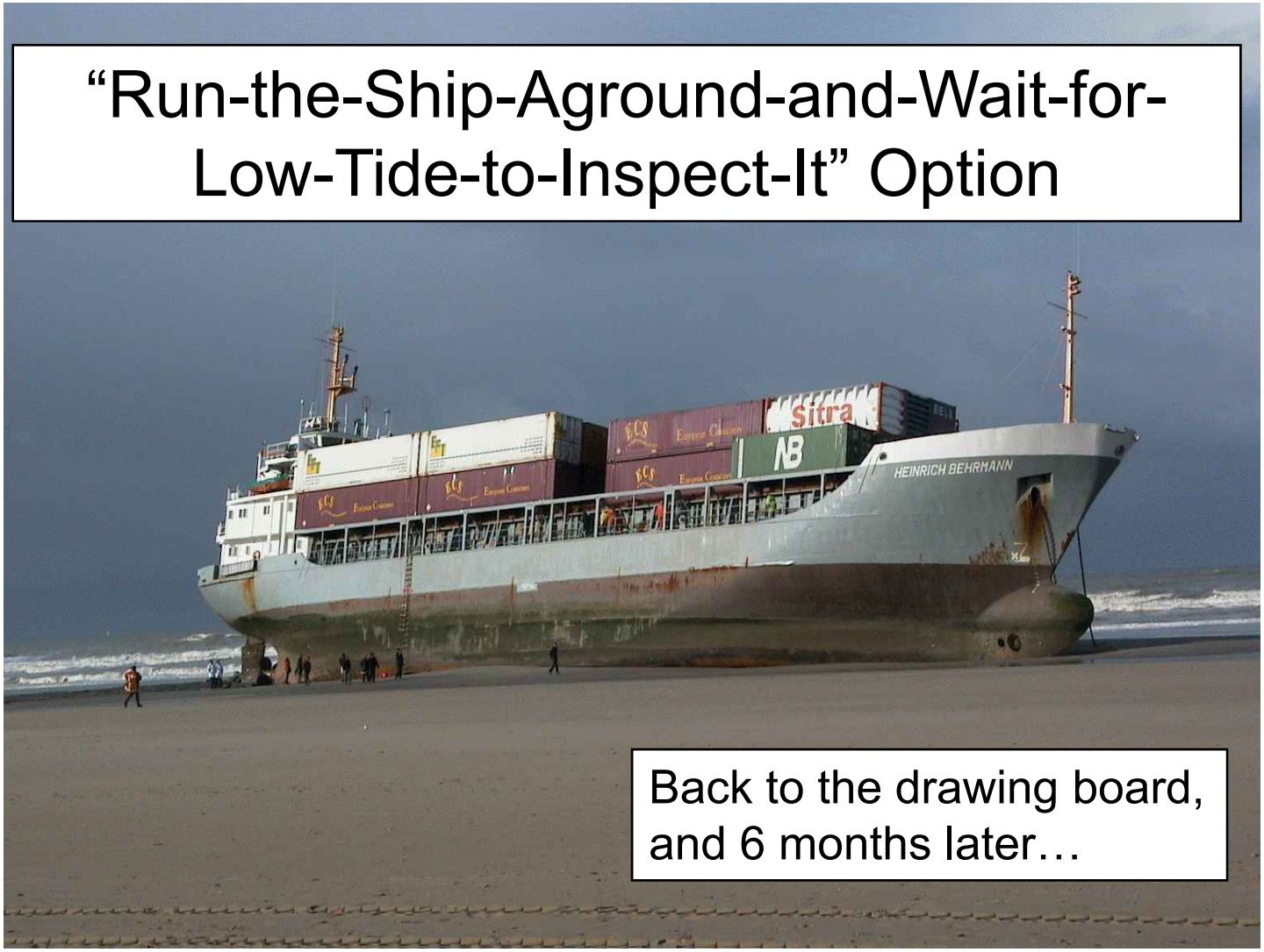
LCDR Chris McCarthy, USN

MDP Architecture
Initial Solution

- <u>Sensors</u>
  - Increase RCS
- <u>Cargo Inspection</u>
  - Increase Access
- <u>C3I</u>
  - Increase Response Time
- <u>Force Response</u>
  - Limit Target Mobility

MDP Architecture
Ship/Cargo Inspection System

RSAWLTII Option
“Real-Salty” Option



“Run-the-Ship-Aground-and-Wait-for-Low-Tide-to-Inspect-It” Option

Back to the drawing board, and 6 months later…

Overall NPS MDP Study Insights

- Systems Engineering approach to MDP is critical
- Land Inspection required to counter WMD threat, but costly
- Current Force Response systems effective against some threats

NPS MDP Study System Insights

Sensors

- Current System is inefficient – better performance available at approximately same cost

C3I

- Common Operating Picture and Data Fusion Centers drive C3I performance

Force Response

- Current Sea Marshal program is effective
- Point defense is key to protecting merchant ships from attack

NPS MDP Study System Insights

Land Cargo Inspection

- Effective Cargo Inspection requires industry cooperation

Sea Cargo Inspection

- Enroute at-sea cargo inspections can be effective using current sensor technology, but effective C3I is required

NPS MDP Study Background/Results

Background

- Goals - Integration - Process
- Tasking - Requirements - Method
- Maritime Terrorism & Piracy
- Threat Scenarios
- Environment - CONOPS
- Simulation & Modeling

MDP Architecture Results

- Conclusions/Insights
- Recommendations

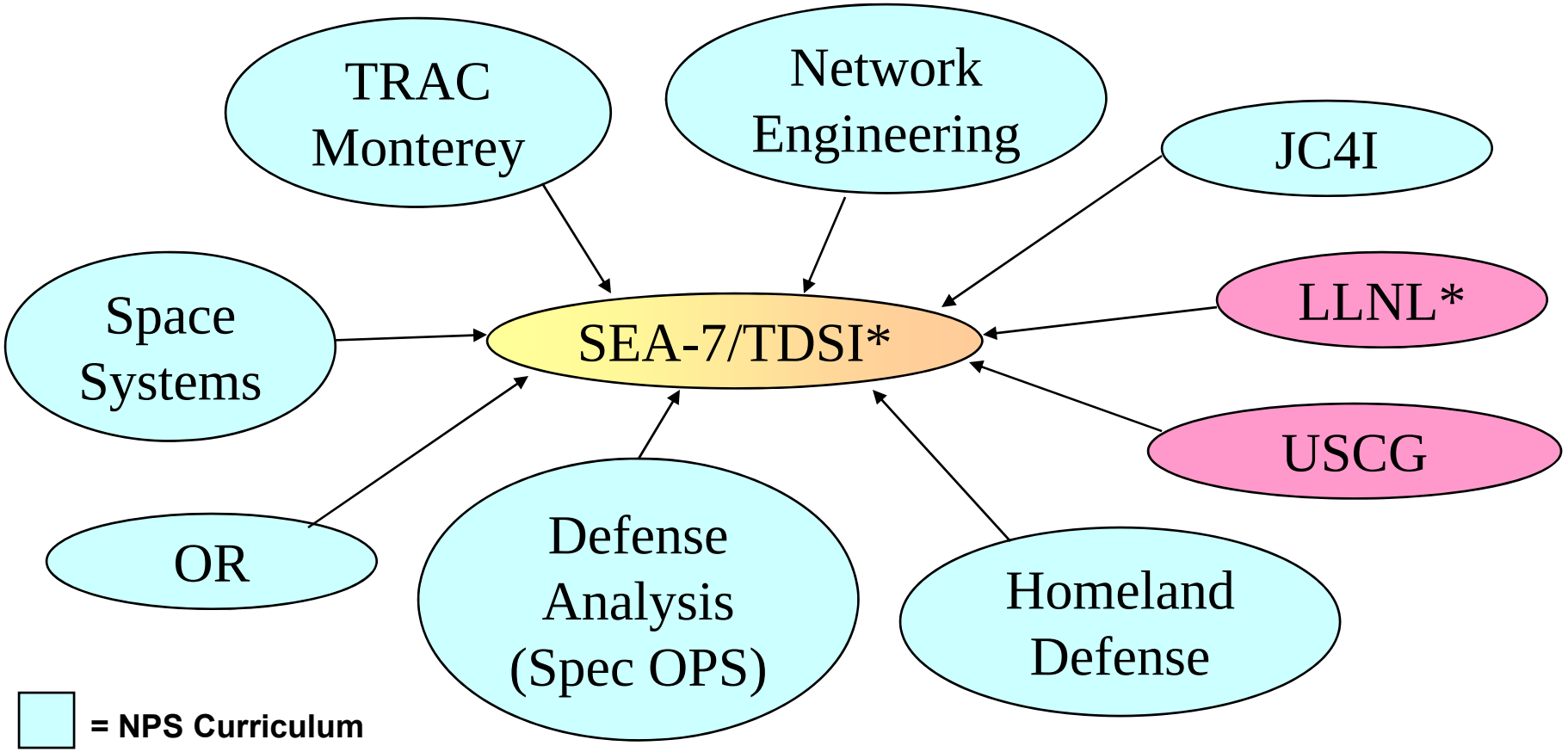
Goals - Integration - Process

NPS MDP Study Goals

- Coordinate NPS cross-campus efforts in an integrated study to analyze and design an integrated architecture for Maritime Domain Protection (MDP) in PACOM.

- "Design a conceptual system of systems to defeat and prevent terrorism in the Maritime Domain." **– Meyer Inst. Memo to SEA-7 Students 9NOV04**

NPS MDP Study Integration

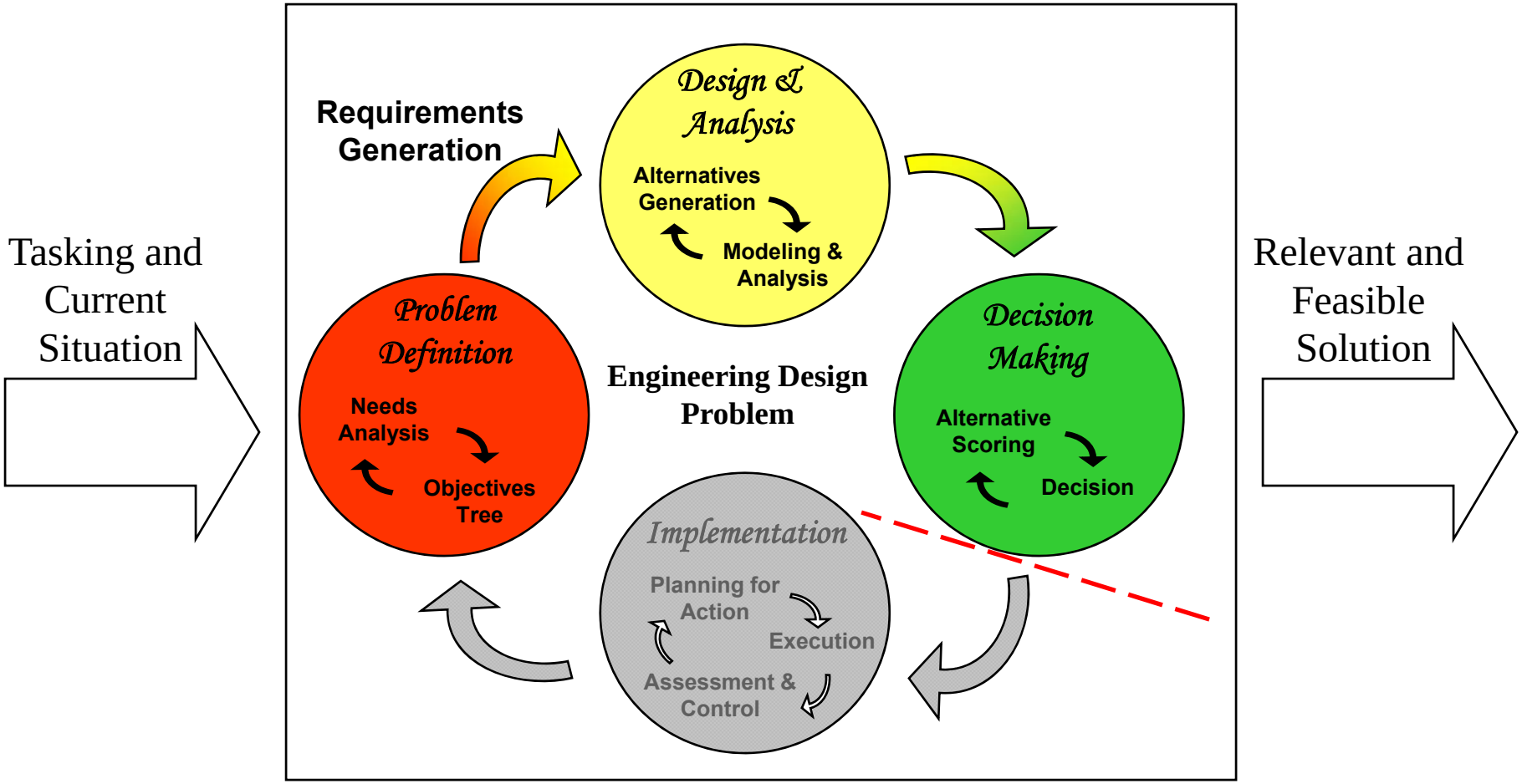


= NPS Curriculum

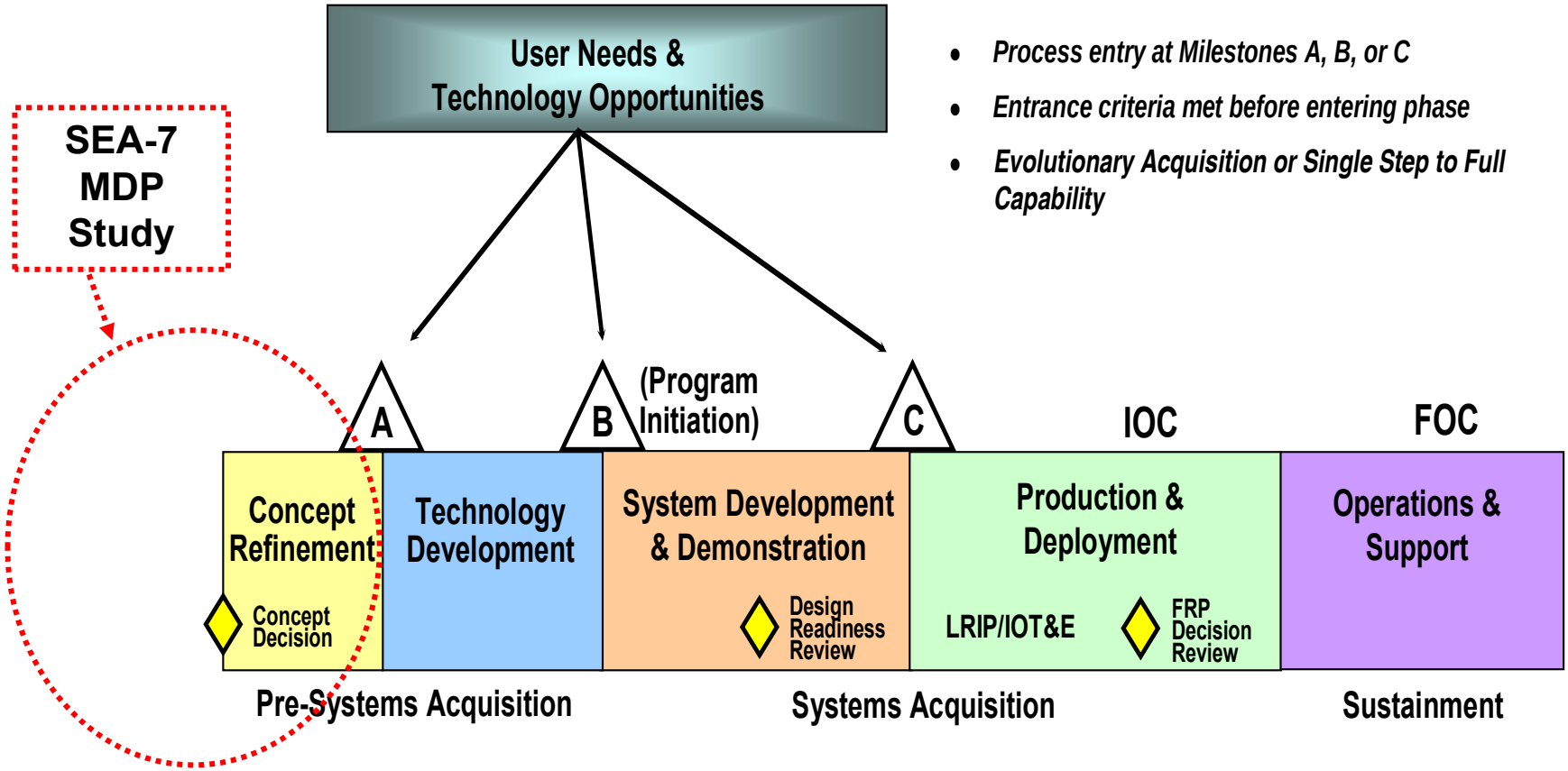
= Off Campus

*TDSI = Temasek Defense Systems Institute (SNP)
*LLNL = Lawrence Livermore National Lab

Systems Engineering Design Process

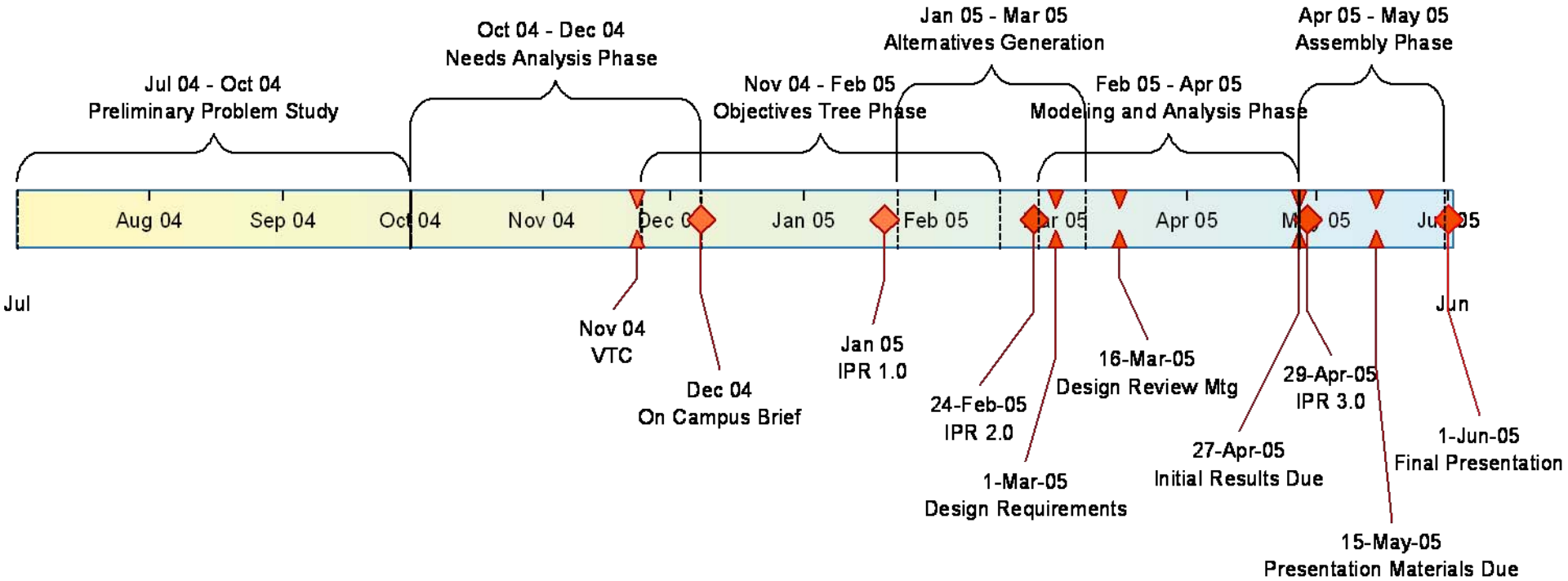


DoD Acquisition Cycle



- *Process entry at Milestones A, B, or C*
- *Entrance criteria met before entering phase*
- *Evolutionary Acquisition or Single Step to Full Capability*

NPS MDP Study Timeline: 6 Months



6 months of focused study

Tasking - Requirements - Method

NPS MDP Study Tasking

MDP Group

"Design and assess integrated alternative architectures…for a coalition of nations, focusing on large ship security…in the Straits of Malacca."

Total Maritime Inspection System (TMIS)

"Design and assess alternative architectures for cargo inspection to include a total ship inspection sub-system…to prevent the use of a large cargo ship as a terrorist vehicle."

NPS MDP Study
No Direct Client/Stakeholder

Disadvantages:

- No answers to focus questions
- No Threat Scenario
- No Operational Concept
- No Mission Needs Analysis
- No Requirements or Performance Measures

Advantages:

- Few constraints = blank slate
- Focus on Approach and Analysis (transferable)
- Allowed focus on multiple threats
- No single-point solution – flexible solution “tool”

NPS MDP Study Requirements

“Hard” Requirements

- Tasking Document only source

Top-Level Requirements & Objectives

- Derived from Tasking Document
- Analysis-based, plausible
- Iterative, amendable (“soft”)

System-Level Requirements & Objectives

- Derived from Top-Level Requirements
- Analysis-based, plausible
- Iterative, amendable (“soft”)

NPS MDP Study Solution

Generic Solution

- Solution capabilities transferable w/modification
- Malacca Straits as “Use Case”

Decision-Making/Assessment Tool

- Approach and analysis valid for any threat/location
- Model suite: Adaptable inputs

Technology Focus

- Detailed, physics-based analysis (e.g. Sensors)
- No Political – No Legal
    - Idealistic – “what could be possible”

NPS MDP Study Considerations

Existing Capabilities

- "As-Is" System

Future Capabilities

- No more than 5 years out from IOC
- At least Technology Readiness Level (TRL) 4:

"Technology component and/or basic technology subsystem validation in laboratory environment."

Conceptual Design

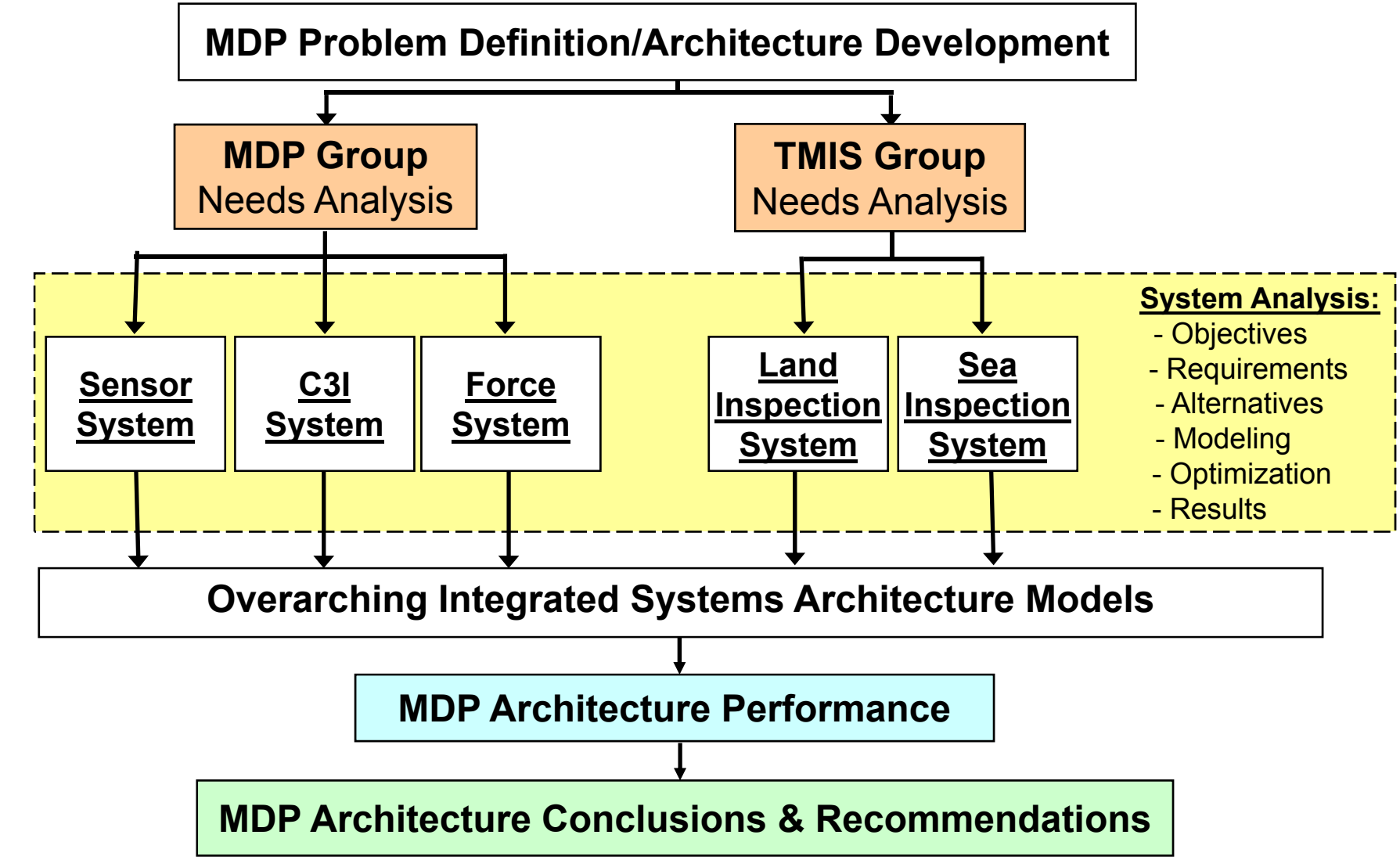
- TDSI detailed design
- NPS thesis

Proposed PACOM Questions

In order to reduce the terrorist threat in the maritime domain:

- What is the most effective use of current resources?
- Where should resources be focused for the most future cost-effectiveness?

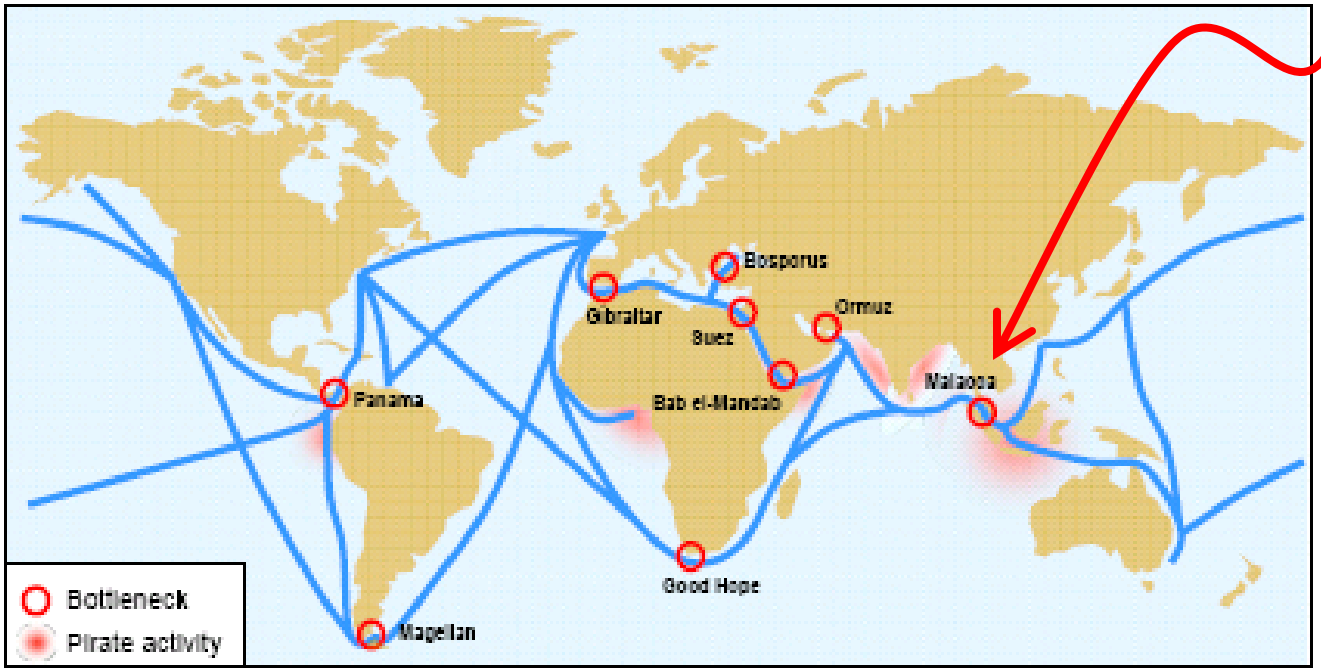
NPS MDP Study: Method



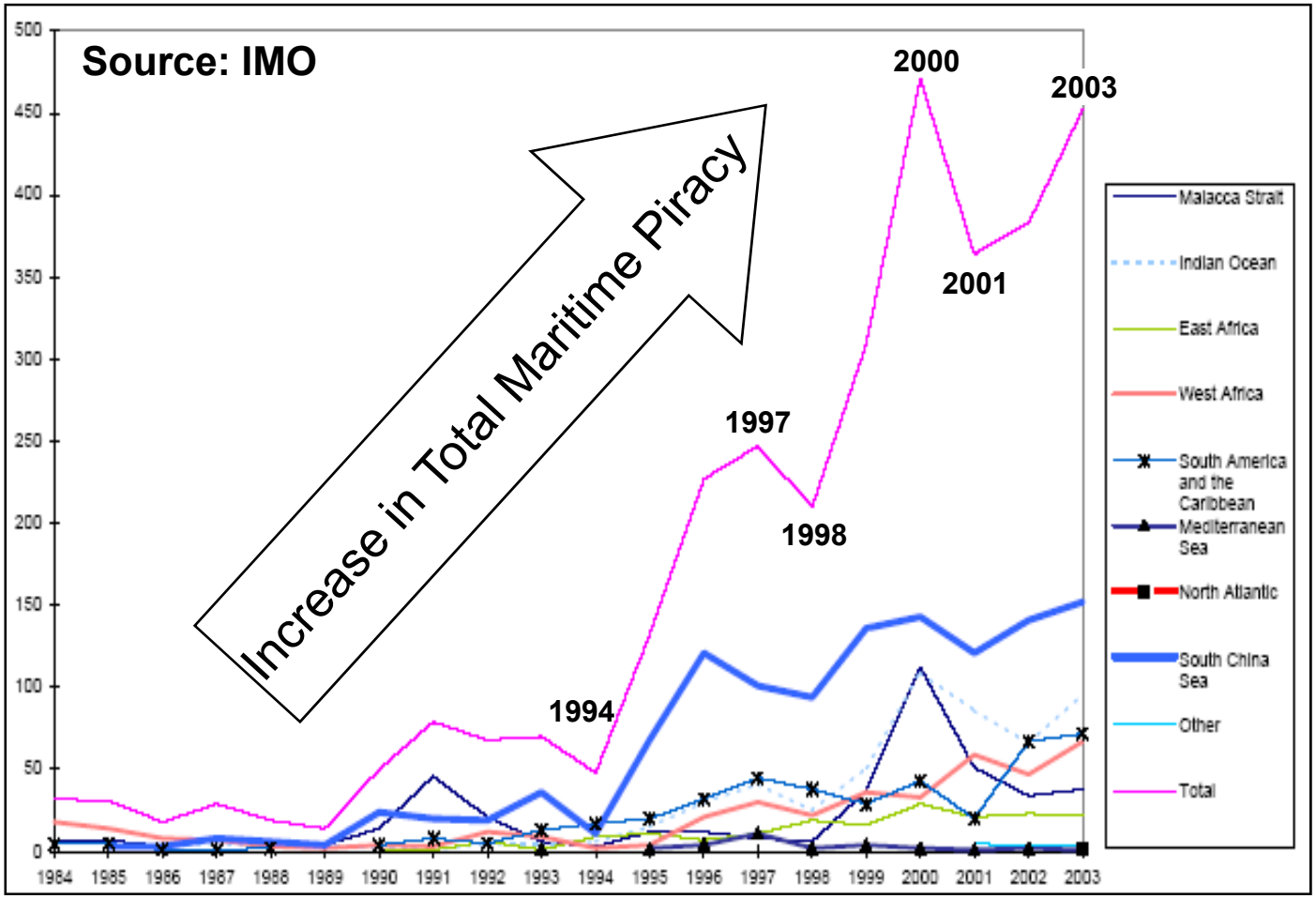
Terrorism and Piracy in the Maritime Domain

Straits of Malacca: Highest Value Chokepoint

Chokepoint/Critical Routes	Traffic (# of Ships/Yr)	Volume (Containers/Yr)	Container/ Bulk Value ($B/Yr) (03$)	Oil (Mbbl/day)	Crude Oil Value ($B/Yr) (03$)	Maritime Shippng Value ($B/Yr) (03$)
Strait of Malacca	**50000**	**30,500,000**	**$331.4**	11	$160.6	**$492.0**
Strait of Hormuz	25455	9,545,455	$103.7	**15**	**$219.0**	$322.7
Bosphorous/Turkish Straits	**50000**	14,625,000	$158.9	3	$43.8	$202.7
Suez Canal	16000	9,900,000	$107.6	3.3	$48.2	$155.7
Panama Canal	13000	9,495,455	$103.2	0.4	$5.8	$109.0
Bab el-Mandab	3920	840,000	$9.1	3.3	$48.2	$57.3
Russian Oil and Gas Export Ports	2545	1,145,455	$12.4	1.2	$17.5	$30.0



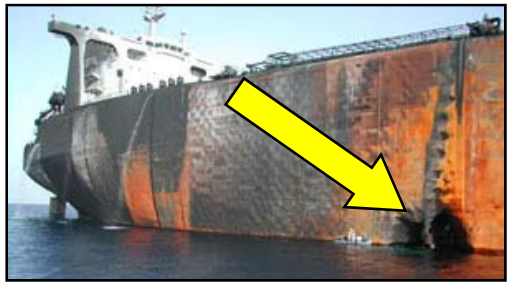
Piracy Increasing Against Commercial Shipping



Terrorism vs. Commercial Shipping

- **OCT 2001- Gioia, Italy – Illegal cargo (stowaway) found**
  - Well-equipped container (bed, toilet, heater, water, laptop, sat-phone)
  - Airport security passes for JFK, Newark, LAX, O'Hare

- **OCT 2002 – Gulf of Aden, Yemen – Small Boat Attack**
  - French crude oil tanker Limburg
  - Small fast craft with 2 crew and 2500 lbs TNT
  - Impact pierced both hulls and 8m of cargo hold
  - Lost crude oil from number 4 starboard tank
  - $45M damage cost



- **MAR 2003 – Strait of Malacca – Ship As Weapon(?)**
  - Chemical tanker Dewi Madrim
  - 0300: Boarded by 10 pirates via speedboat
  - Disabled radio, steered vessel, altering speed, for ~1hour
  - Departed with Captain and First Mate (still missing)

Maritime Domain Protection Efforts

- **U.S. Lead Agencies**
  - U.S. Coast Guard (CONUS)
  - U.S. Navy (International)

- **Over 100 Initiatives**
  - U.S. and International
  - Government Agencies
  - National Labs
  - Private Industry
  - Academia

Threat Scenarios

NPS MDP Study
Threat Considerations

Threat Scenarios Used in MDP Study

- Assessed potential threats to shipping
- Identified representative threat scenarios
- Assessed current vulnerabilities to threat scenarios
- Determined potential solution alternatives & costs
- DM Tool:
    - Probabilities of attack not specified (up to DM)
    - If threat materializes, analysis useful
    - Approach and analysis valid for other threats

Potential Threats

Threat to/from Large Ships:

- Small Boat Attack
  - Gun/RPG attack
  - Missile attack
  - Suicide/remote control explosives

#1 "Small Boat Attack" (SBA)

- Hostile Boarding/ Stowaway/Intentional
  - Hostage taking
  - Onload CBRNE weapon
  - Ship as weapon (vs. port or ship)
  - Scuttle ship in port/channel

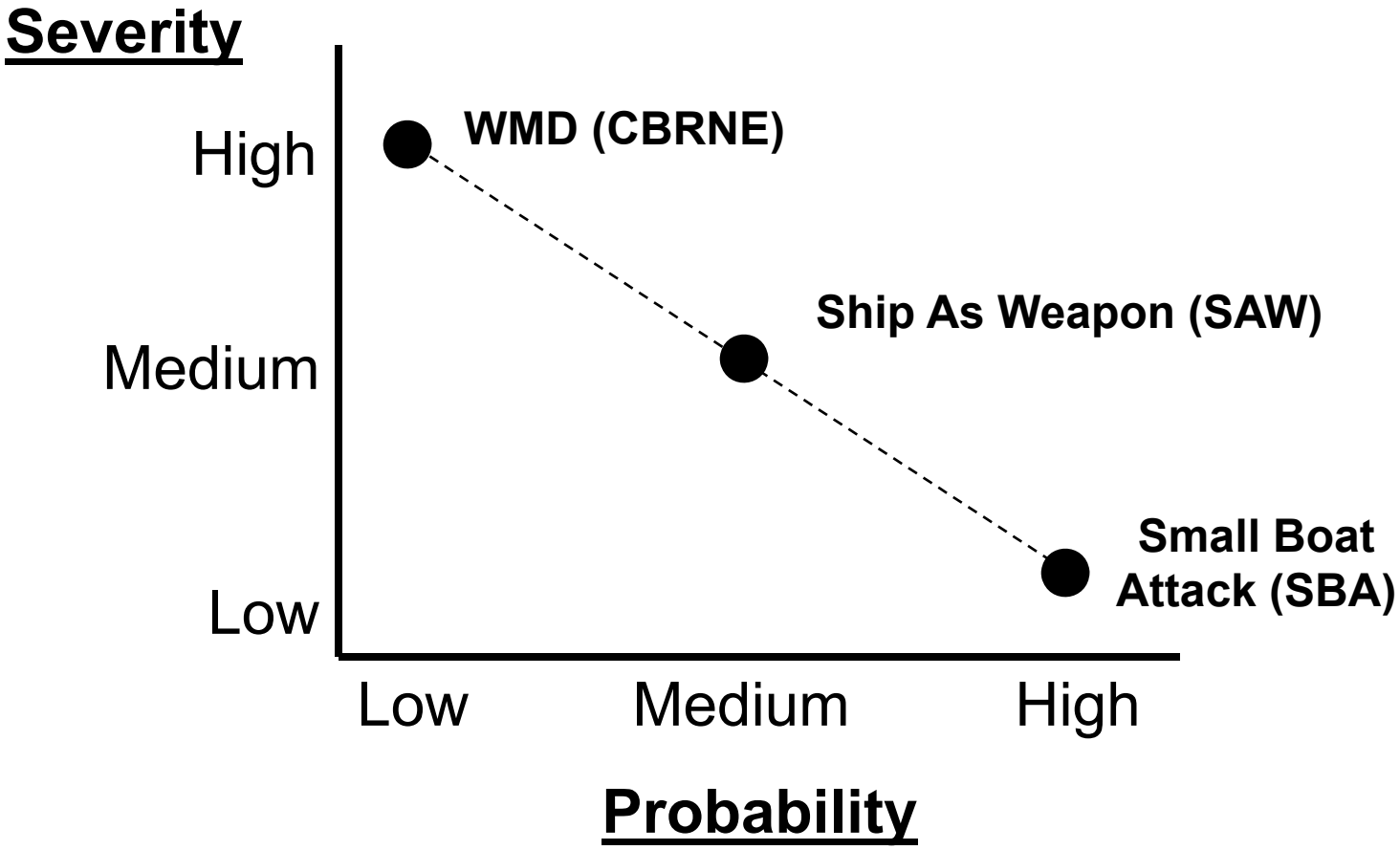
#2 "Ship as Weapon" (SAW)

CBRNE on Large Ship:

- Within Cargo
  - Inside container
  - Outside container
  - In bulk cargo
- Outside of Cargo
  - Inside ship hold
  - Outside hold above waterline
  - Outside hold below waterline

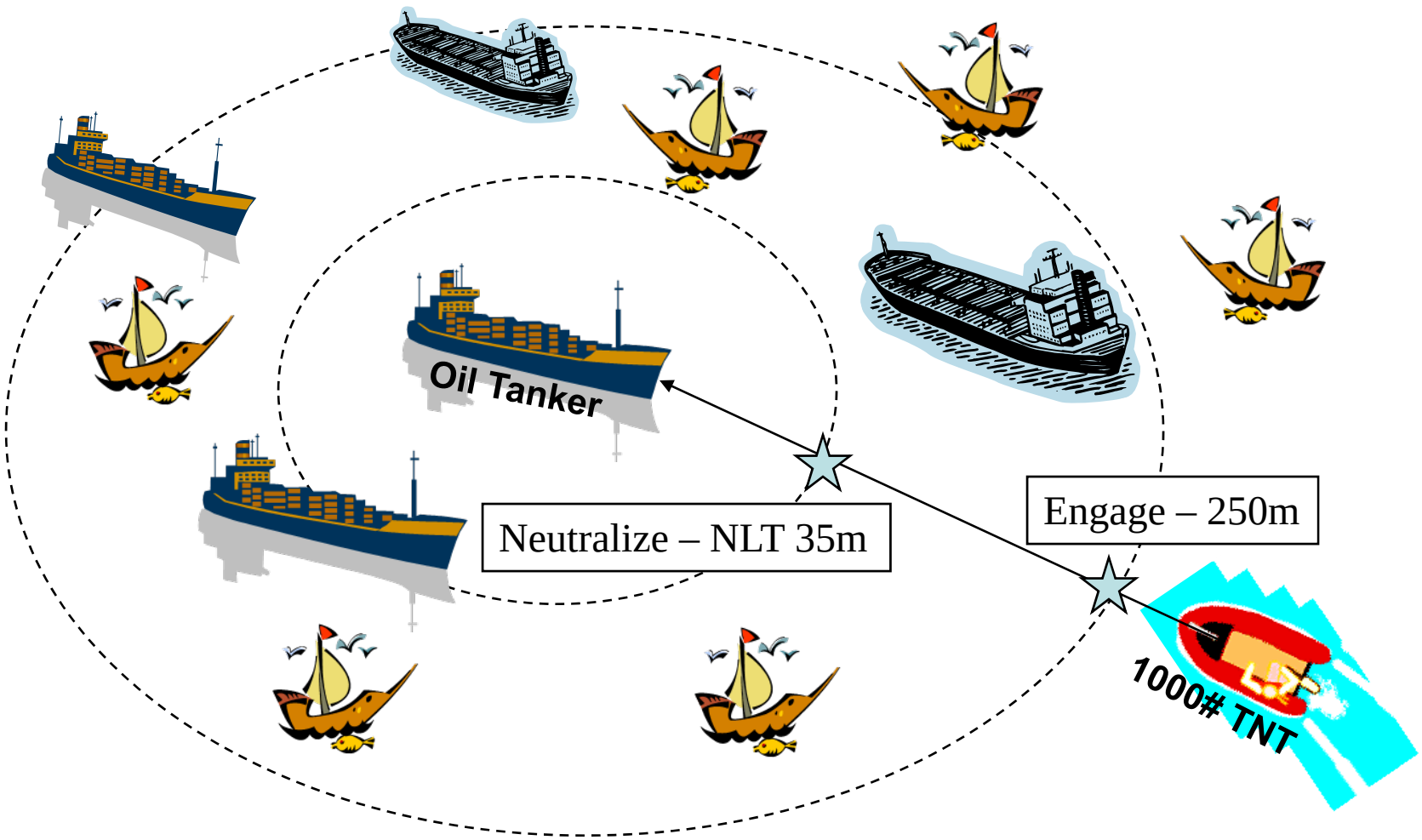
#3 "Weapon of Mass Destruction" (WMD)

Threat Risk Analysis



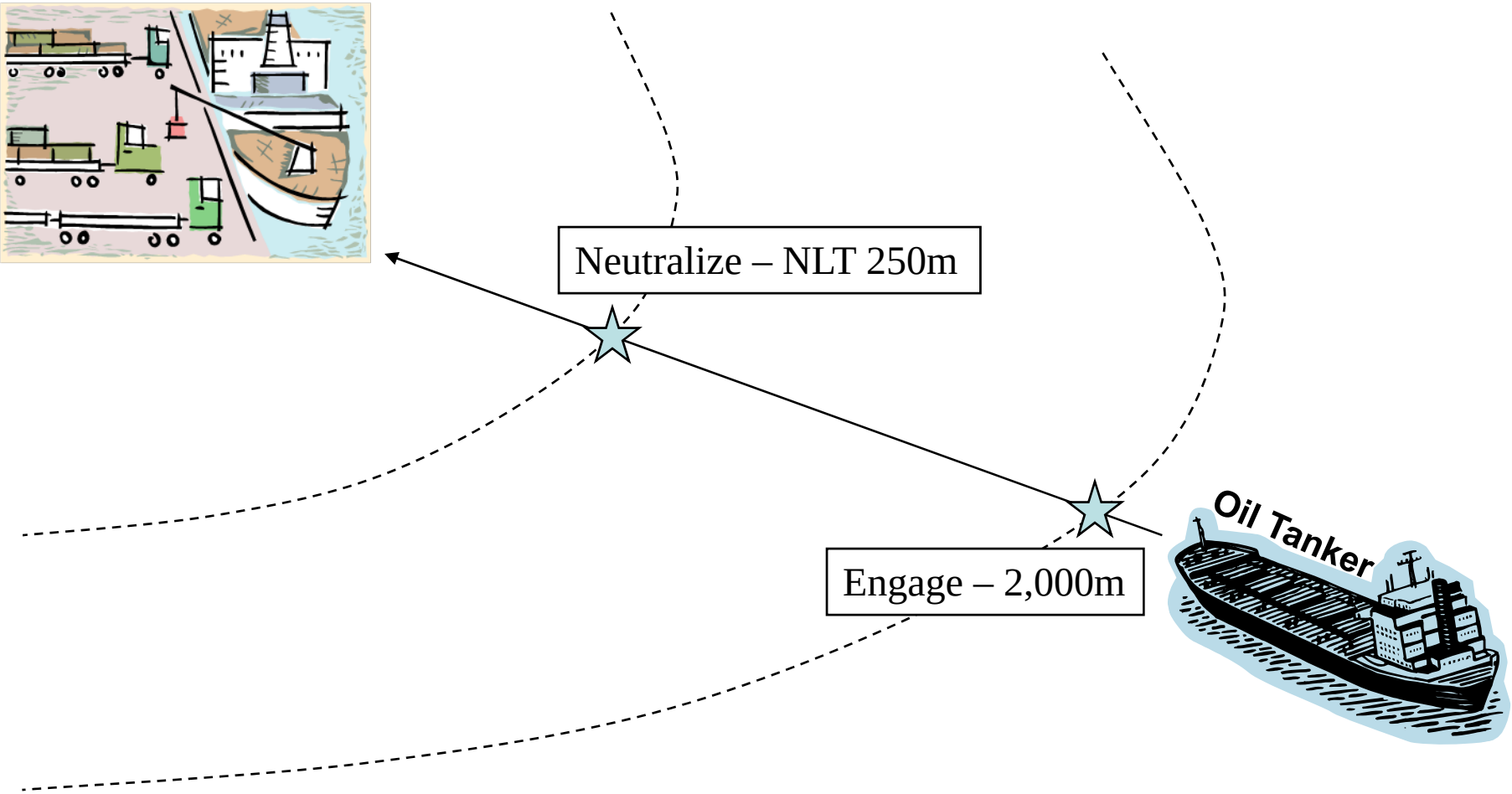
Small Boat Attack Scenario

Objective: Neutralize SBA >65m from Large Ship
Threshold: Neutralize SBA >35m from Large Ship



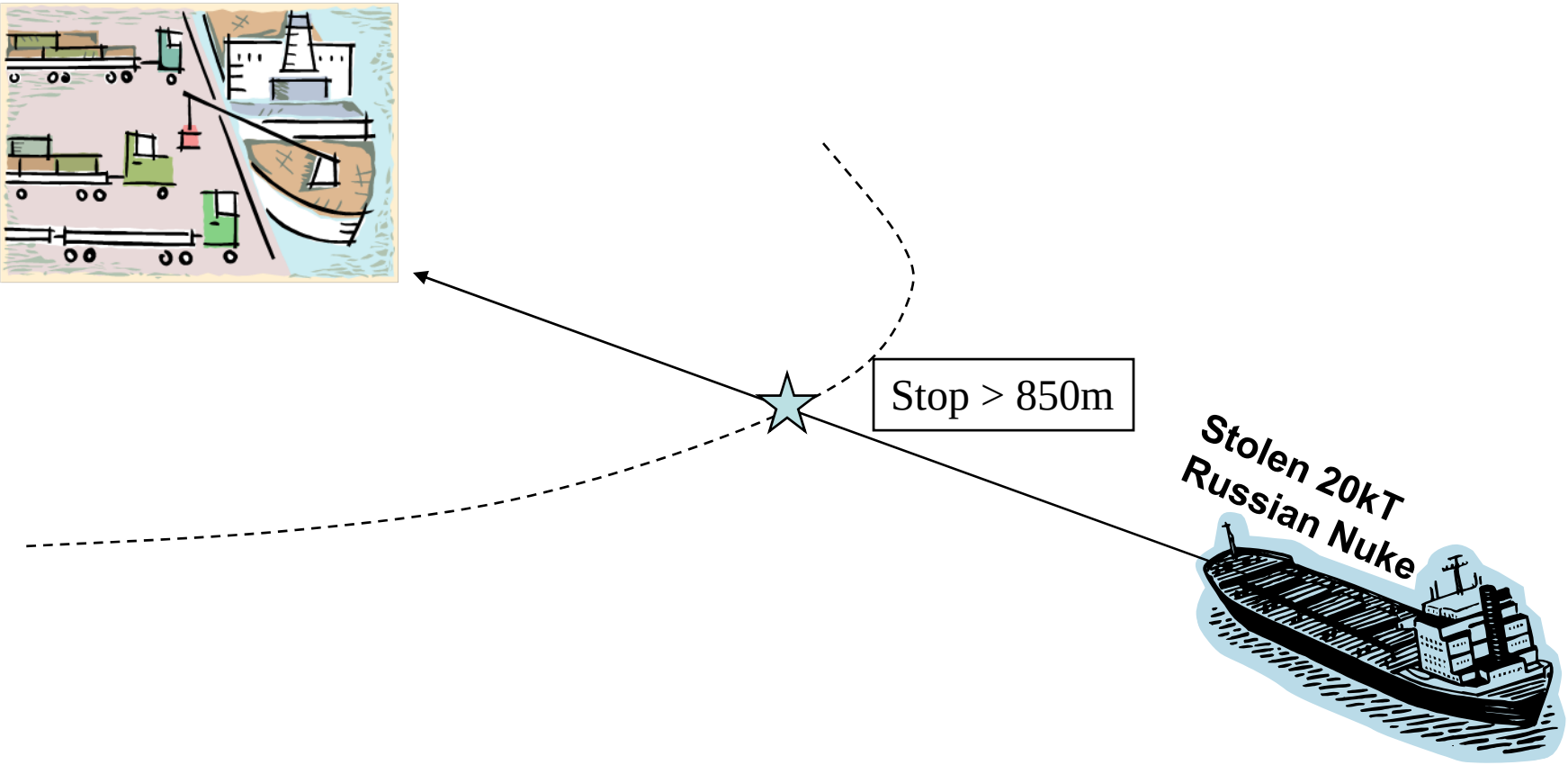
Ship As Weapon Scenario

Objective: Neutralize SAW >500m from pier
Threshold: Neutralize SAW >250m from pier



WMD Scenario

Objective: Stop CBRN material >1000m from port
Threshold: Stop CBRN material >850m from port



MDP Top-Level System Requirements

Small Boat Attack (SBA)

- Probable – Demonstrated
- **Defeat 80%**

Ship As Weapon (SAW)

- Probable – Proven capability
- **Defeat 90%**

WMD - Nuclear

- Remote – Unlikely, but possible
- **Defeat 60%** (MDP Contribution to Counterproliferation Efforts)

***Defeat = Less than $100k damage**
***Confidence Interval = 95%**

Other

- 24/7 – all weather
- System must be interoperable with external systems
- Daily System Operational Availability:
  - 90% Full Mission Capable
  - 99% Partial Mission Capable

MDP Top-Level System Objectives

Small Boat Attack (SBA)	Engage SBA by 250m from target
	Neutralize SBA by 65m from target
Ship As Weapon (SAW)	Engage SAW by 2000m from pier
	Neutralize SAW by 500m from pier
WMD	Detect CBRNE material prior to Critical Area

- **Evaluate System Impact on Commercial Shipping**
- **Evaluate MDP System Cost**
- **Evaluate Risk (Expected Attack Damage Cost)**

Current System Capabilities

Scenario	Current 10-yr MDP System Cost (FY05$M)	Expected Attack Damage Cost (FY05$B)	Probability of Defeat	
			Current	Desired
Small Boat Attack	N/A	0.8 – 3.6	~0%	80%
Ship As Weapon	$38-40	2.5 – 4.9	~80%	90%
WMD	$638-715	180 - 216	~2%	60%

Environment - CONOPS

Regional High Traffic Density

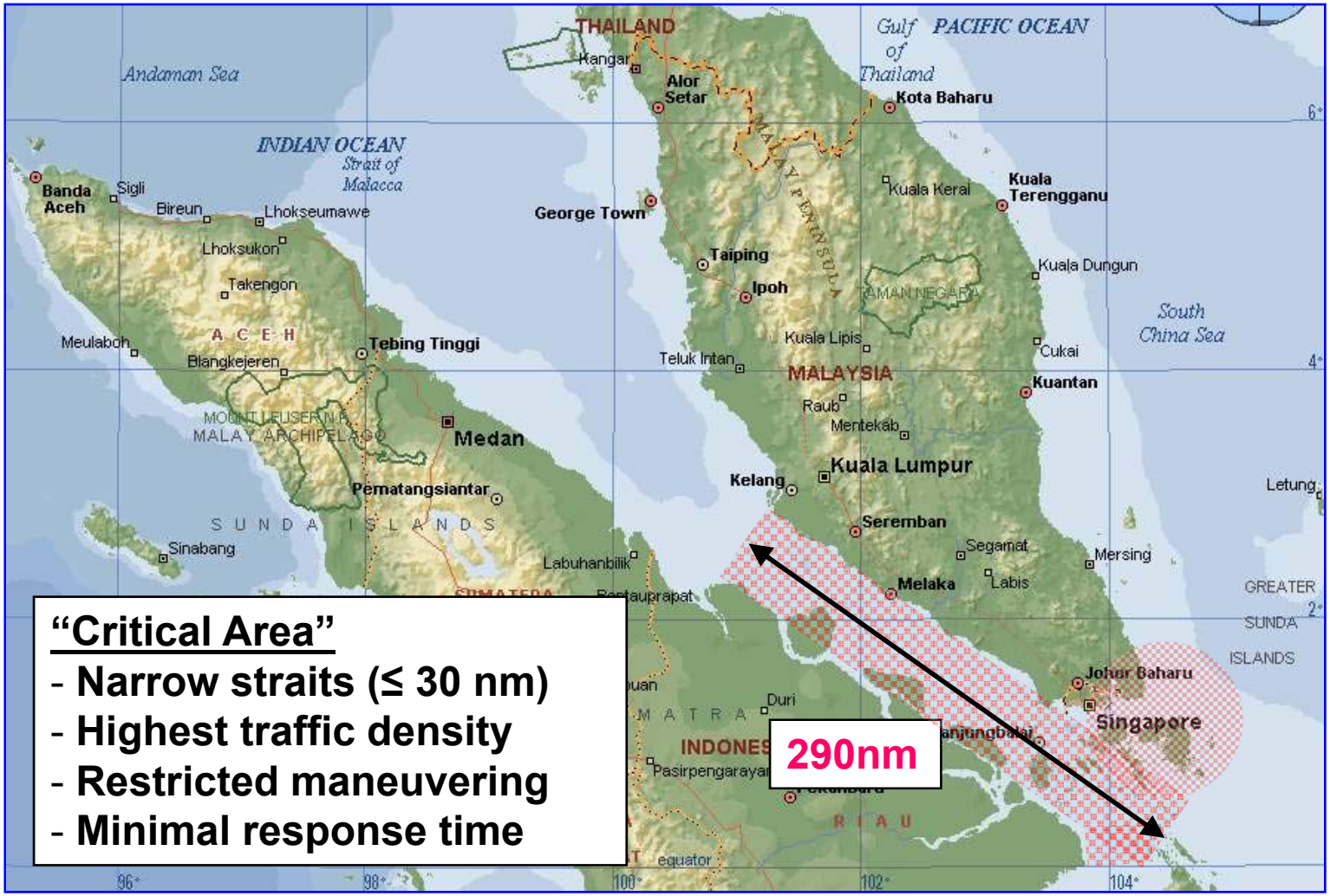
Straits of Malacca

- 59,314 Ships per year (2001)
  - 20,665 Tankers
  - 3,086 LNG tankers
  - Average 162 ships per day
- 30% of World trade
  - $1.3 billion USD per day (2003)

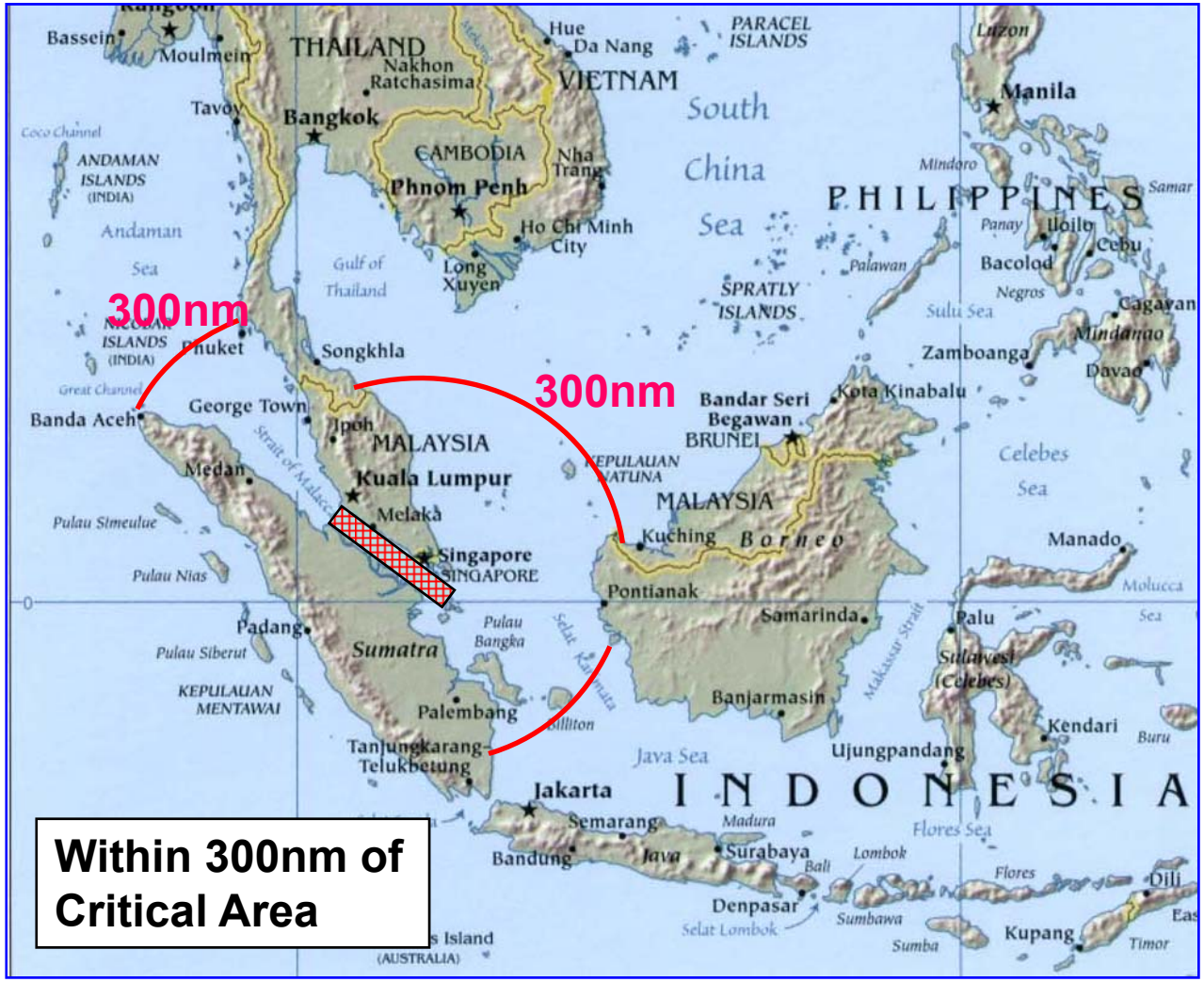
Port of Singapore

- 133,385 ship arrivals per year (2004)

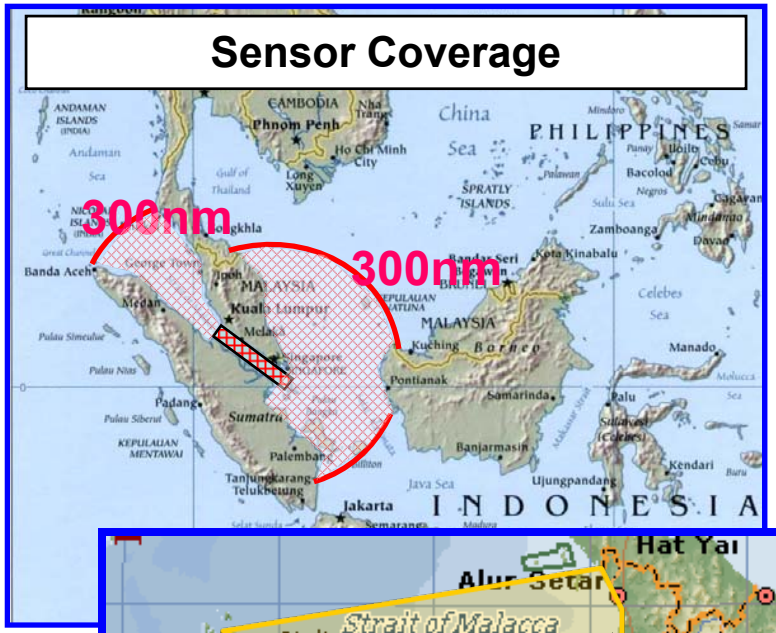
Critical Area - Most Vulnerable to Terrorist Attack



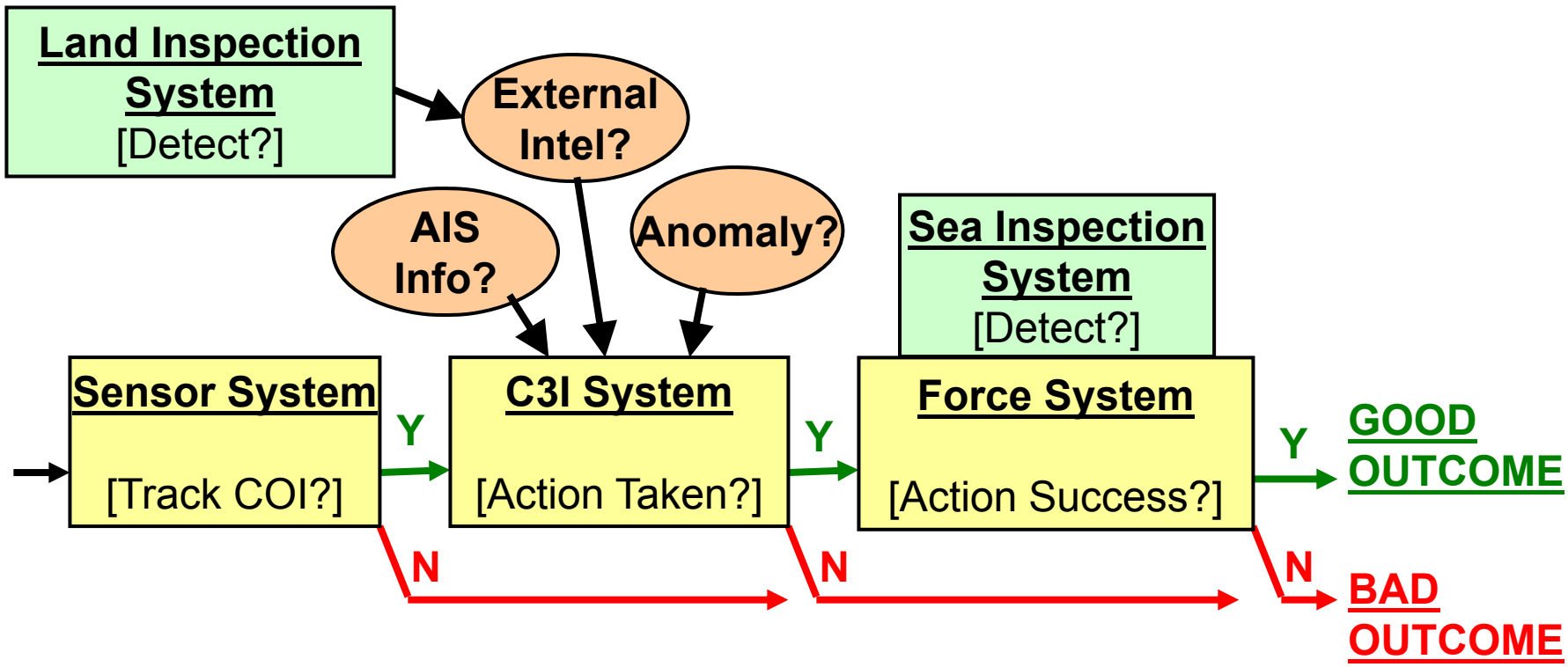
“Maritime Domain” Area of Regard (AOR)



Concept of Operations (CONOPS)


Sensor Coverage
300nm
300nm
Banda Aceh
Medan
Kuala Lumpur
Melaka
Singapore
Pontianak
Palembang
Jakarta
Kuching
Kota Kinabalu
Manado
Palu
Kendari
Ujungpandang
Banjarmasin
Samarinda
Padang
Sumatra
Borneo
Celebes Sea
Java Sea
Phnom Penh
Ho Chi Minh City
Long Xuyen
Hat Yai
Bangkok
Bacolod
Zamboanga
Davao
Cebu
Iloilo
Cagayan
Mindanao
Palawan
Negros
Sulu Sea
Mindoro
Samar
Pulau Simeulue
Pulau Nias
Pulau Siberut
KEPULAUAN MENTAWAI
Tanjungkarang Telukbetung
Palembang
Great Channel
Gulf of Thailand
Andaman Sea
ANDAMAN ISLANDS (INDIA)
CAMBODIA
China Sea
PHILIPPINES
SPRATLY ISLANDS
MALAYSIA
INDONESIA
Pulau Bangka
Selat Sunda
Madura
Makassar Strait
Molucca Sea
Buru
Sulawesi (Celebes)
Palu
Kendari
Ujungpandang
Banjarmasin
Samarinda
Java Sea
Jakarta
Semarang
George Town
Ipoh
Kuala Lumpur
Melaka
Singapore
SINGAPORE
Kuching
Pontianak
Medan
Padang
Palembang
Tanjungkarang Telukbetung
Jakarta
Semarang
Madura
Selat Sunda
Pulau Bangka
Pulau Simeulue
Pulau Nias
Pulau Siberut
KEPULAUAN MENTAWAI
Great Channel
Gulf of Thailand
Andaman Sea
ANDAMAN ISLANDS (INDIA)
CAMBODIA
Phnom Penh
Ho Chi Minh City
Long Xuyen
Hat Yai
Bangkok
Bacolod
Zamboanga
Davao
Cebu
Iloilo
Cagayan
Mindanao
Palawan
Negros
Sulu Sea
Mindoro
Samar
China Sea
PHILIPPINES
SPRATLY ISLANDS
MALAYSIA
INDONESIA
Celebes Sea
Java Sea
Makassar Strait
Molucca Sea
Buru
Sulawesi (Celebes)
Palu
Kendari
Ujungpandang
Banjarmasin
Samarinda
Manado

MDP System
Operational Architecture



Simulation and Modeling

MDP Modeling Approach

- Individual System Models
  - Modular - No grand behemoth model
  - Best modeling tool
    - EXTEND™
    - Microsoft Excel™
    - MANA
    - TAWS/AREPS
  - “Local” evaluation
- Integrated System Architecture Models
  - Interface requirements
  - Determined performance measures
  - “Global” evaluation

Overall Architecture MOEs

- **<u>MOE 1 – Performance</u>**
  - Does the system architecture defeat each attack with the required probability?

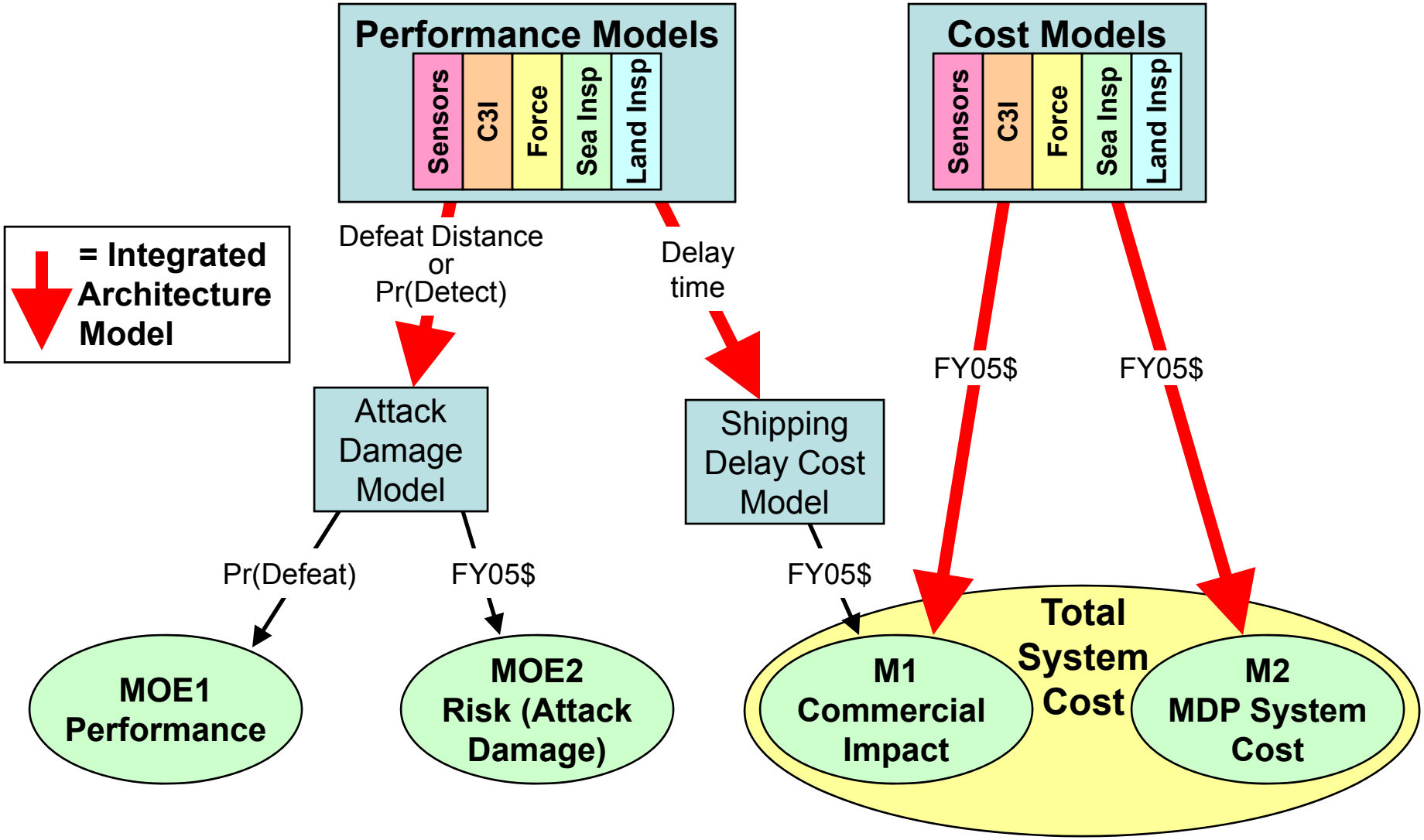
- **<u>MOE 2 – Risk (Expected attack damage)</u>**
  - What is the expected attack damage cost for each threat scenario?

Overall Architecture Metrics

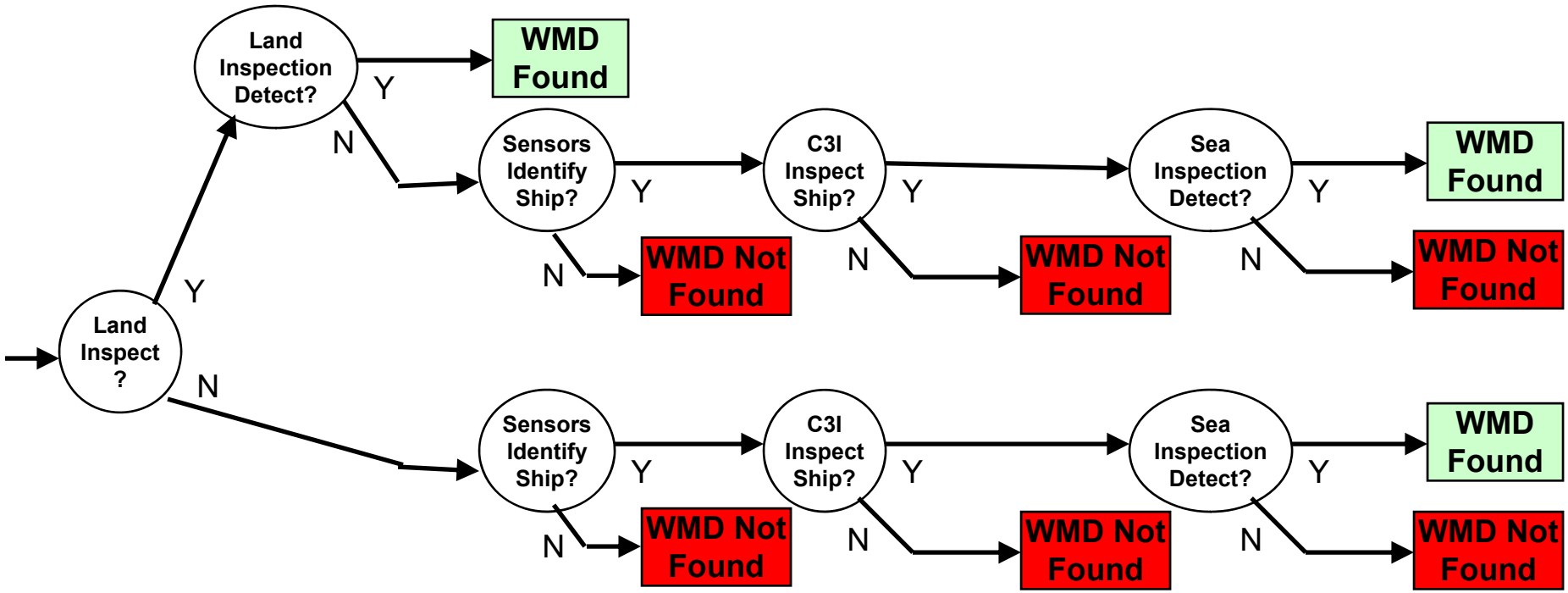
- **<u>Metric 1 – Commercial Impact</u>**
  - What is the expected cost to commerce over 10 years (through 2016)?
    - Commercial System Procurement Costs
    - Commercial System Operating & Support Costs
    - Commercial Delay Costs
- **<u>Metric 2 – MDP System Cost</u>**
  - What is the expected MDP system cost over 10 years (through 2016)?
    - MDP System Procurement Costs
    - MDP System Operating & Support Costs

Total System Cost = Comm'l Impact + MDP Sys Cost

Overarching Modeling Plan



Integrated Architecture Model
WMD Scenario – Performance and Risk

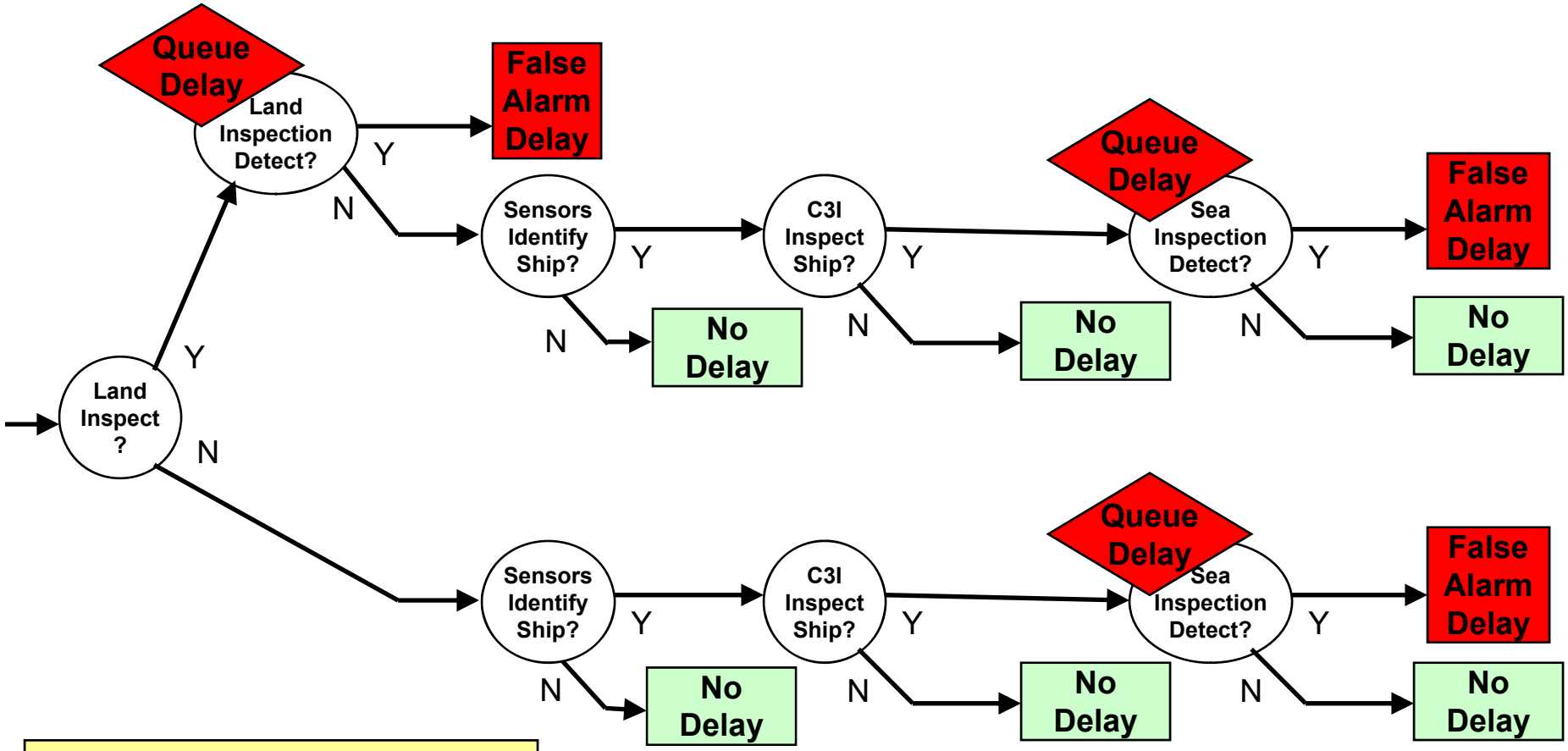


Given: WMD Present

Performance = Pr(WMD Found)

Risk (Attack Damage) = Pr(WMD Not Found) x Attack Damage Cost

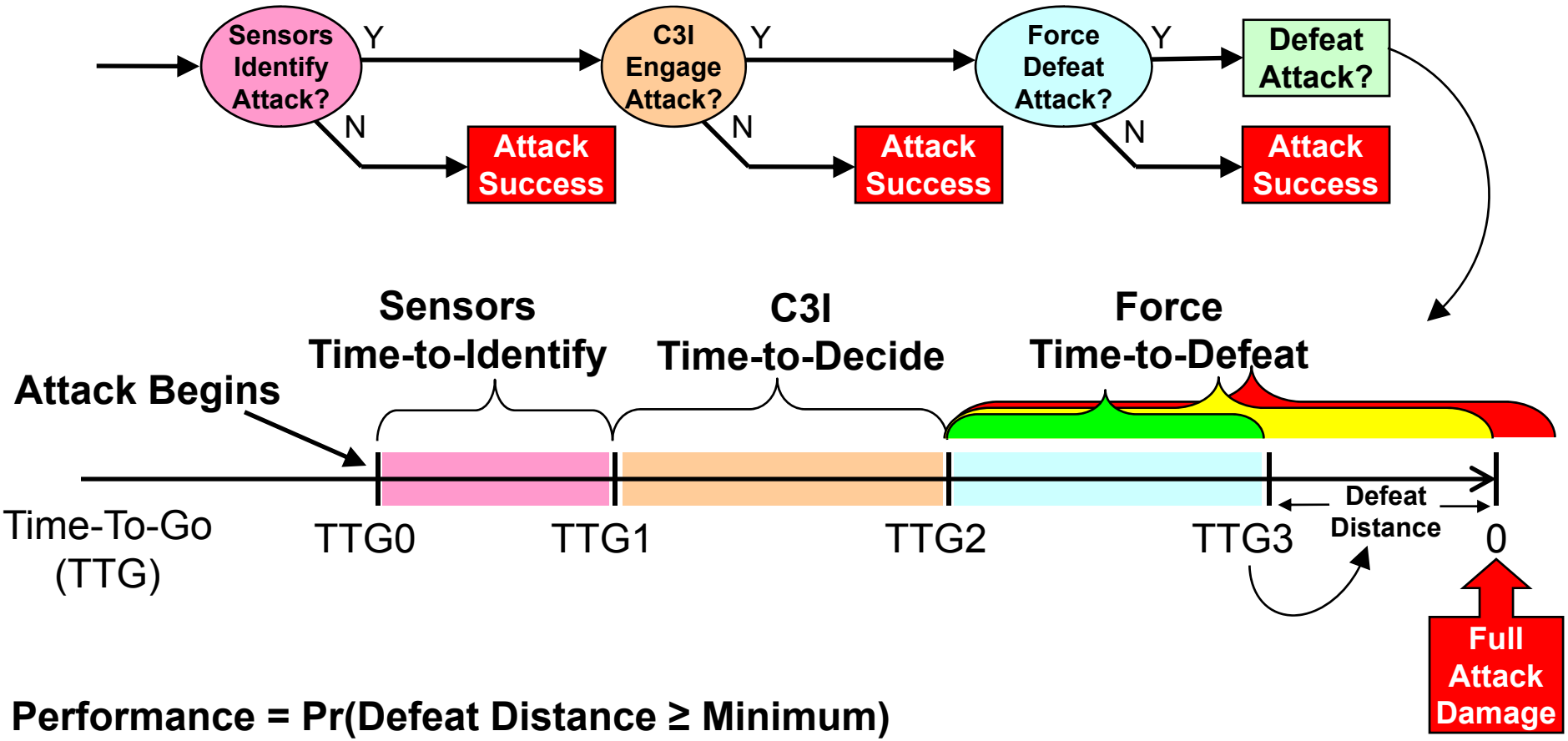
Integrated Architecture Model
WMD Scenario – Commercial Delay



Given: WMD Not Present

Commercial Impact (Delay Cost) = Total Delay Time x Cost per Delay Time

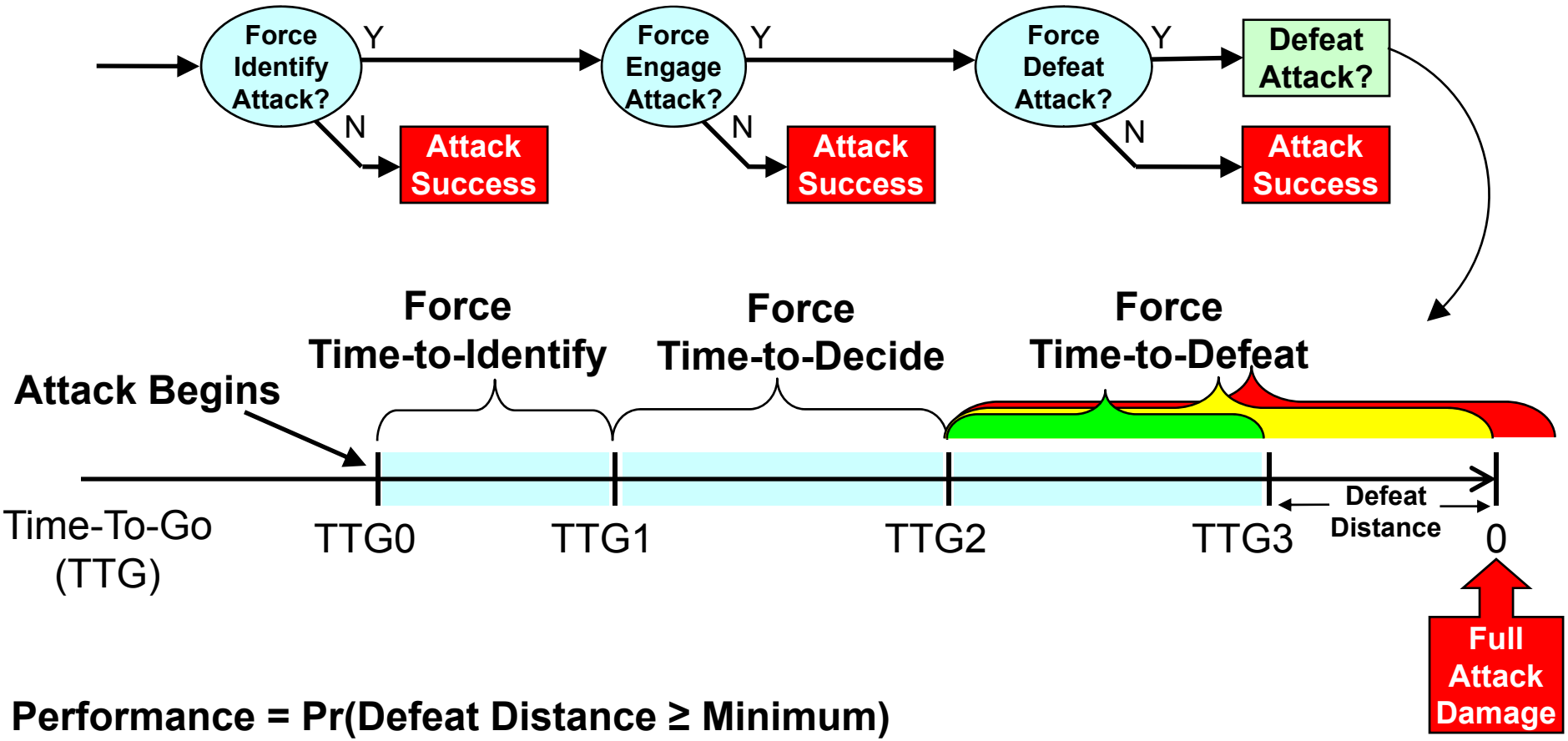
Integrated Architecture Model
SAW Scenario – Performance & Risk



Performance = Pr(Defeat Distance ≥ Minimum)

Risk (Attack Damage) = Defeat Distance x Attack Damage Cost @ Defeat Distance

Integrated Architecture Model
SBA Scenario – Performance & Risk



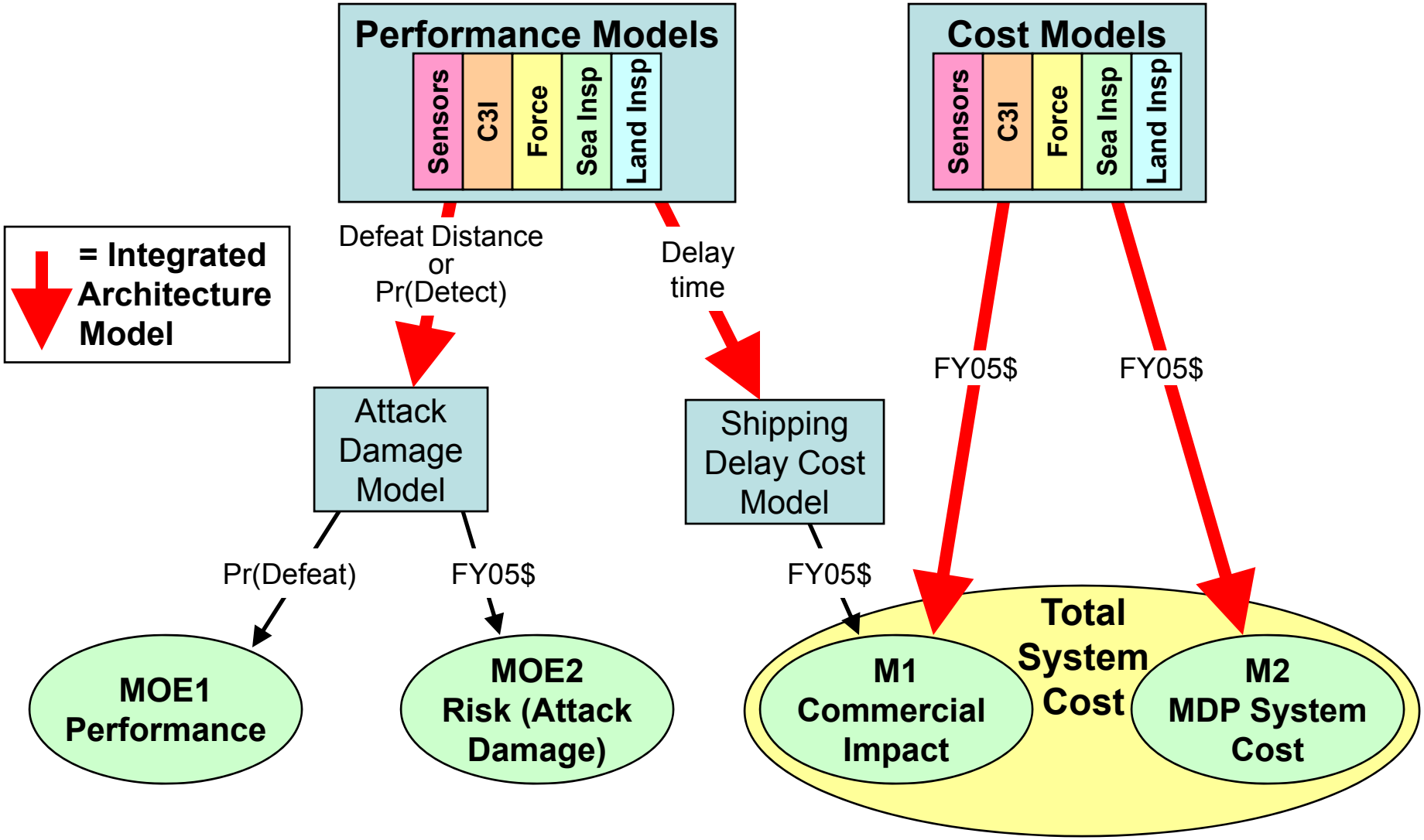
Performance = Pr(Defeat Distance ≥ Minimum)

Risk (Attack Damage) = Defeat Distance x Attack Damage Cost @ Defeat Distance

Integrated Systems Architecture Modeling Results

*Individual System Results in follow-on briefs

Overarching Modeling Plan



Integrated Systems Architecture Model Results & Analysis

WMD Model

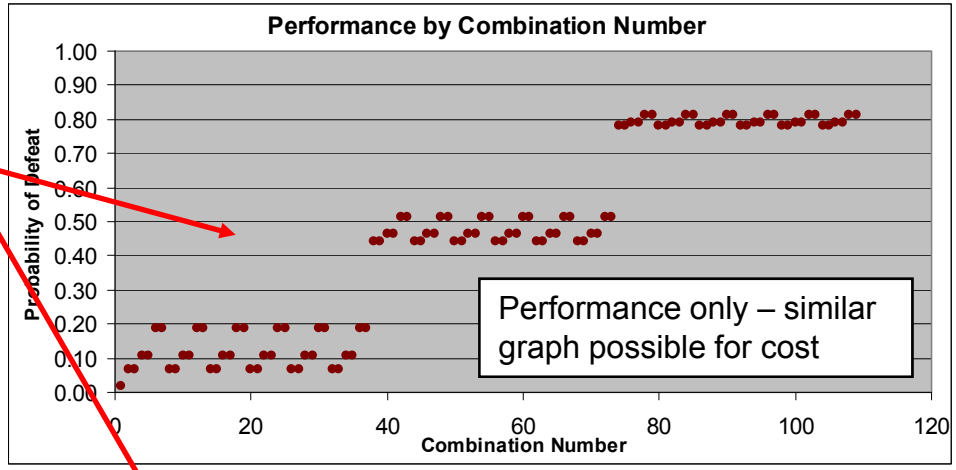
- 109 Combinations (incl. As-Is):
  - 3 Land Inspection options
  - 2 Sea Inspection options
  - 3 Sensor options
  - 3 C3I options
  - 2 Force options

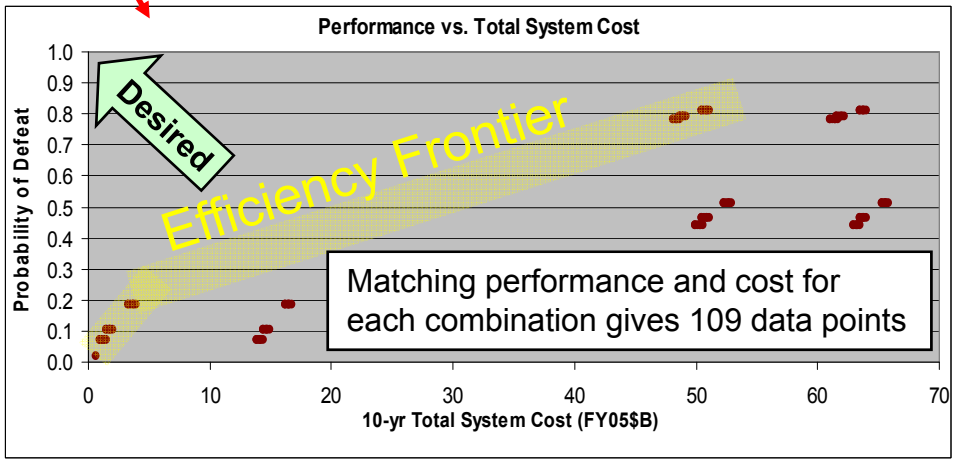
Ship As Weapon Model

- 11 Combinations

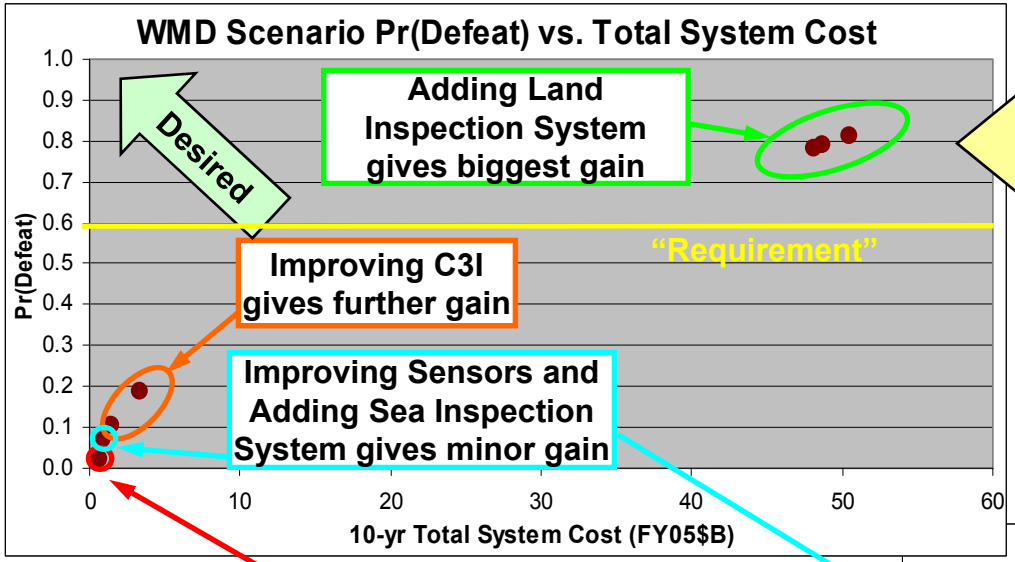
Small Boat Attack Model

- 3 Combinations





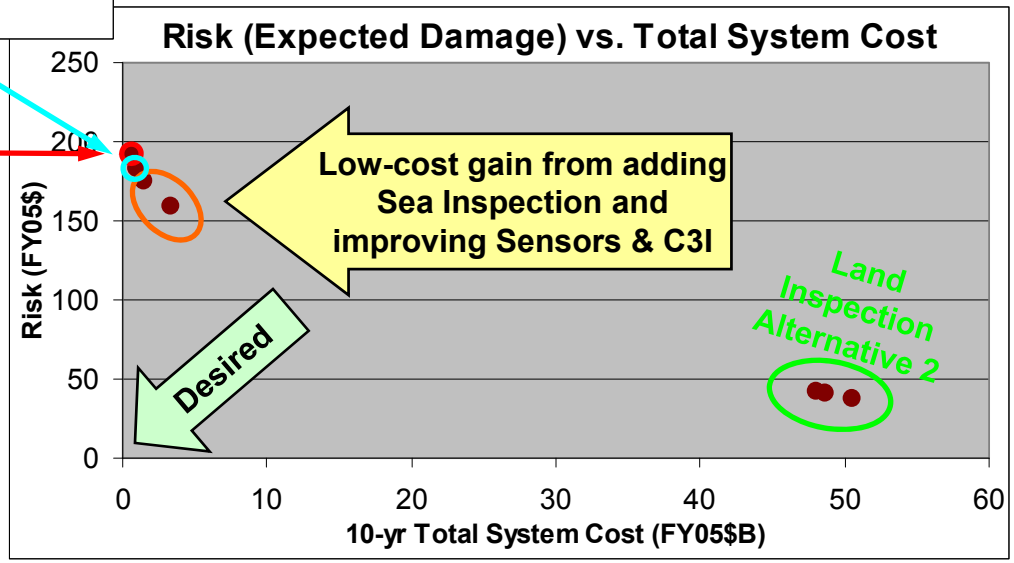
MDP Overall Results
WMD Scenario



Land Inspection gives required performance, but at significant cost

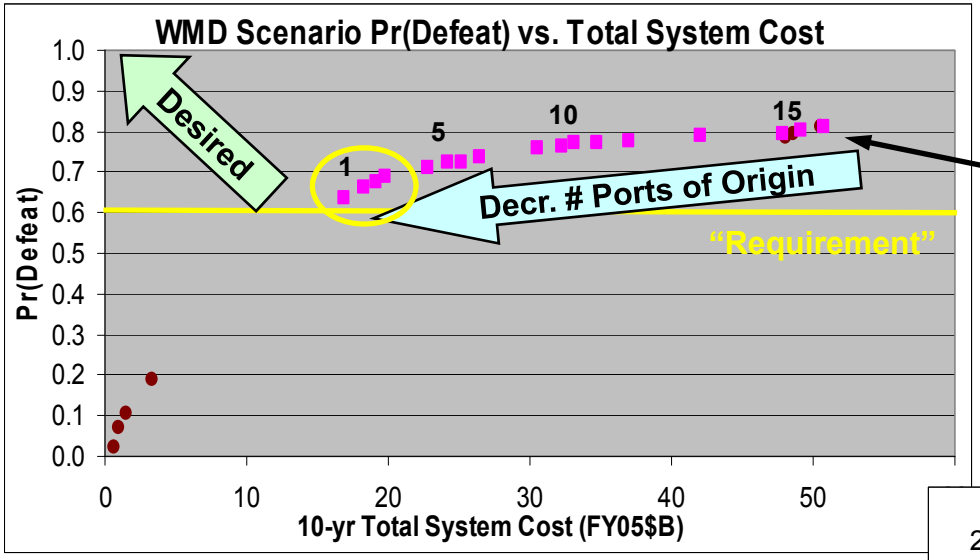
*Total System Cost = MDP & Commercial System Costs + Commercial Delay Costs

Current System



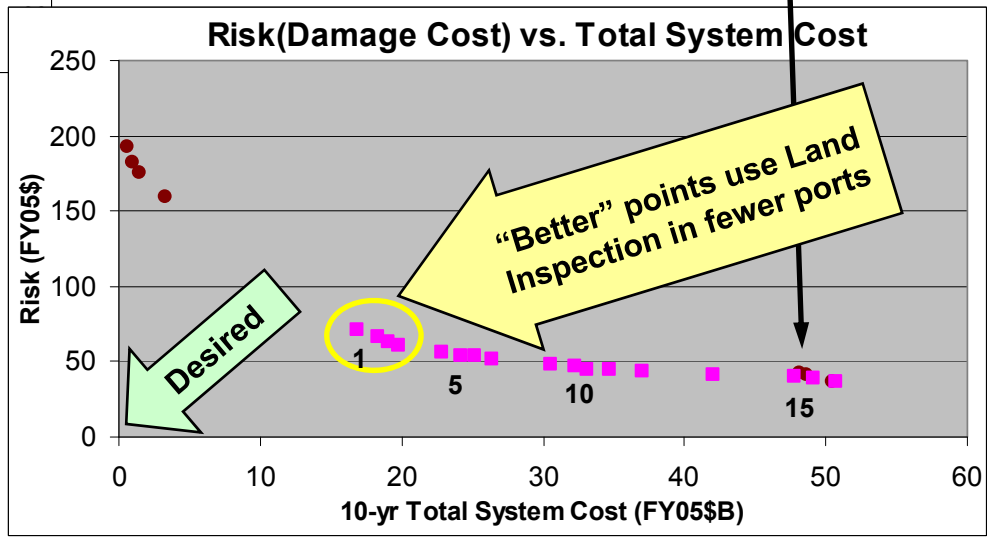
MDP Overall Results – WMD Scenario

Combined Effects Show That Decreasing the Number of Ports of Origin with Land Inspection System Installed Decreases Cost Without Large Performance Penalty



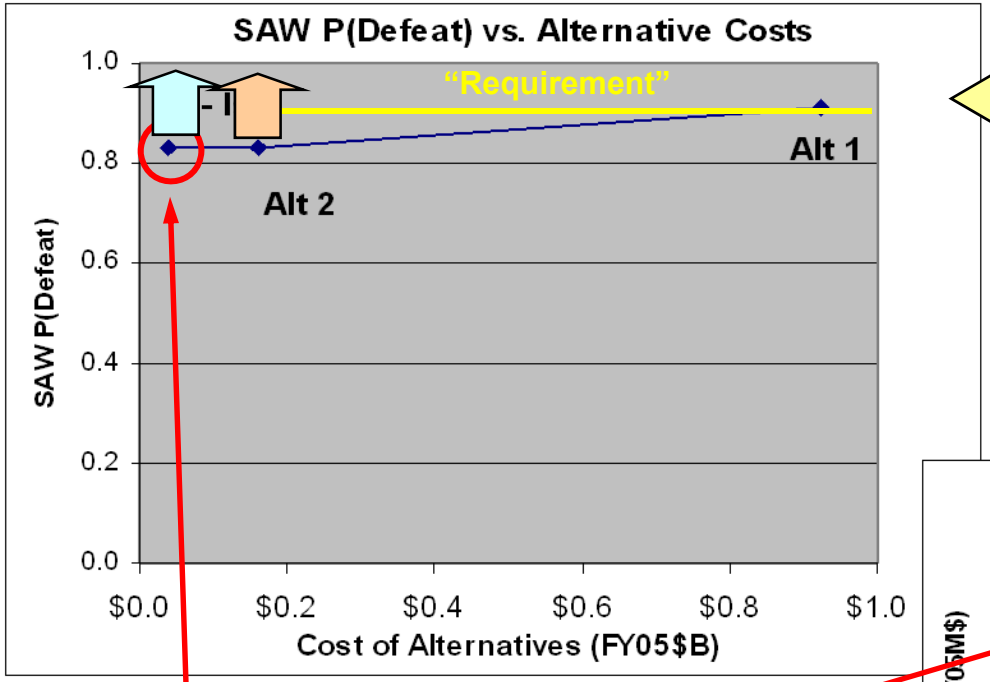
Starting point:

- Land Inspection Alt 2 - has Land Inspection system installed in 16 ports
- Sea Inspection Alt 1
- Sensors Alt 1
- C3I Alt 2



- Decreasing Highest-Volume ports of origin using Land Inspection System reduces cost but performance stays above requirement
- "Intelligent" adversary not considered

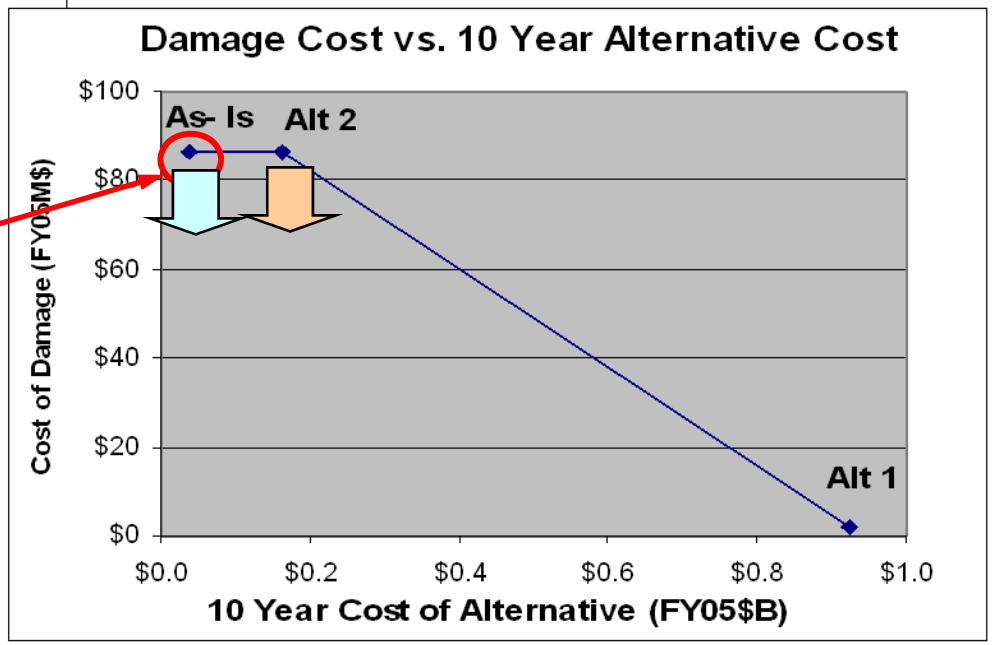
MDP Overall Results
Ship As Weapon (SAW) Scenario



Alt 1 meets requirement, but costly

= Improvement possible on As-Is (e.g. better training/armament)

= Improvement when not constrained by scenario (e.g. 10-nm notification)

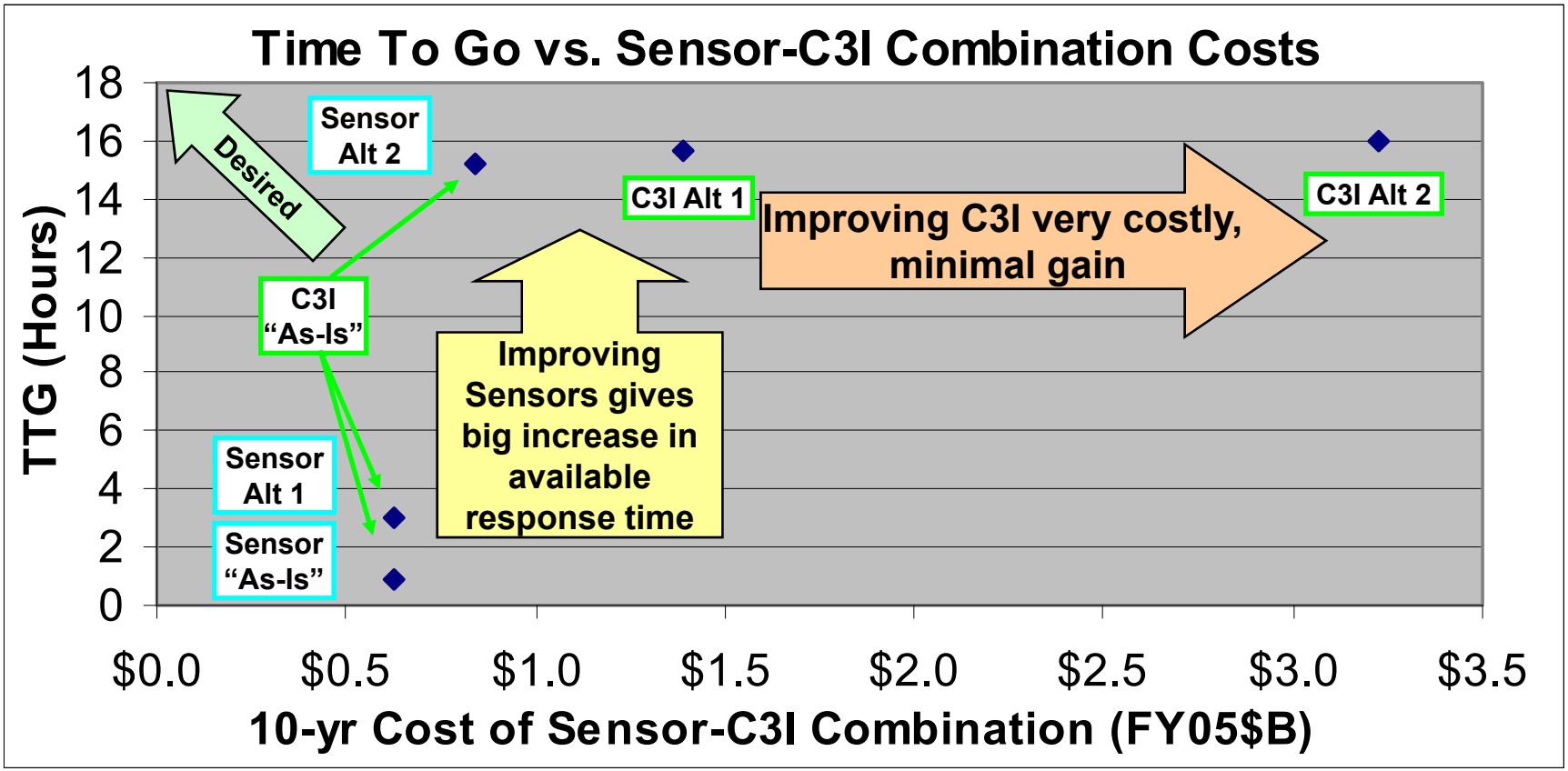


Current System provides effective solution to SAW

Alt 2 performance constrained by scenario – 5 nm notification of SAW attack

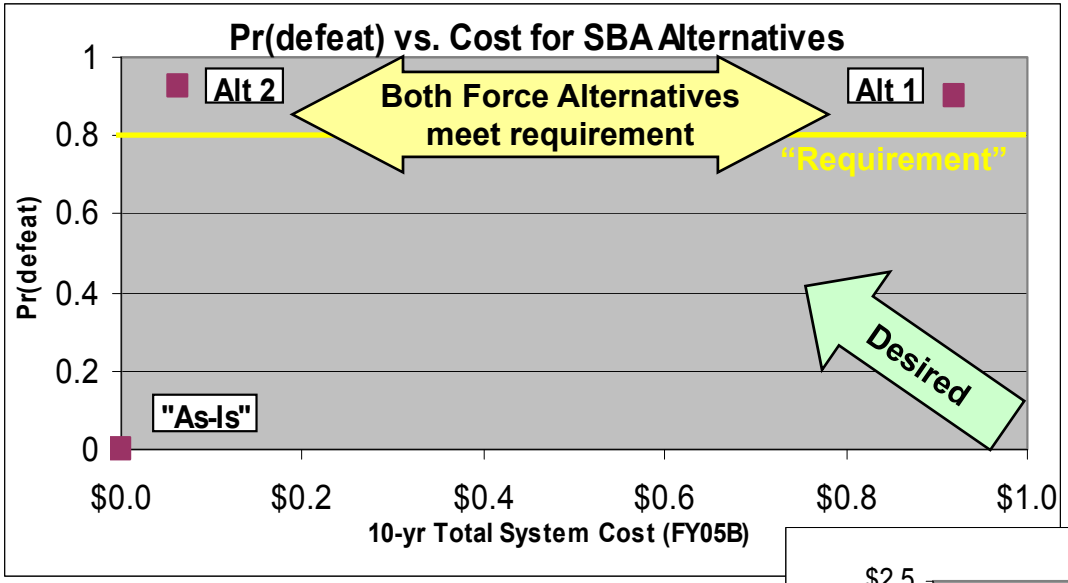
MDP Overall Results - Ship As Weapon (SAW) Scenario:

Increasing Time Remaining After Sensing and Deciding on an Inbound COI is Primarily Achieved with Better Sensors Instead of Better C3I

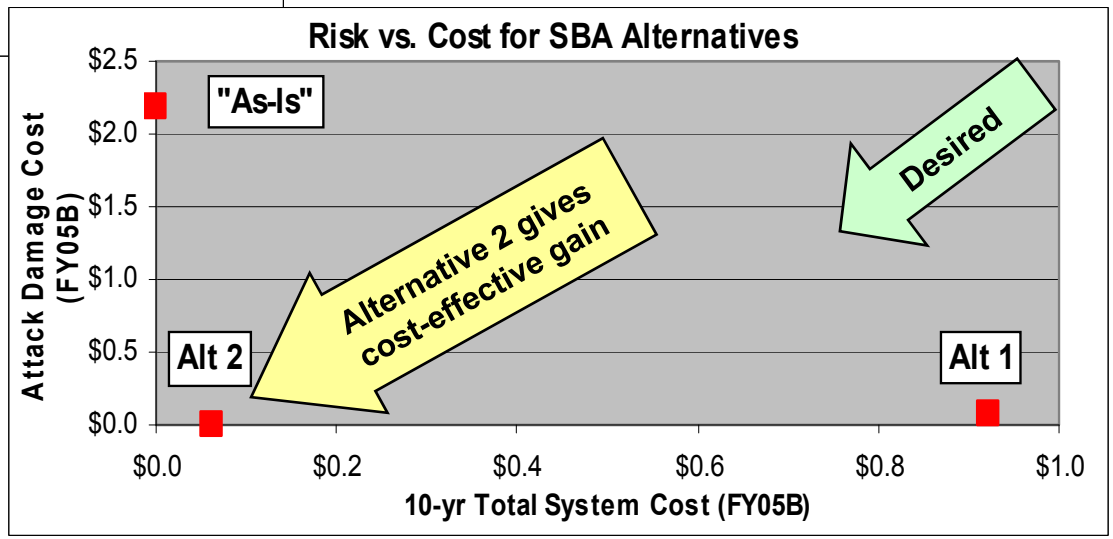


MDP Overall Results - Small Boat Attack (SBA) Scenario:

Low-Cost Alternatives Exist to Defeat SBA Attack With Desired Probability



*Total System Cost = MDP & Commercial System Costs + Commercial Delay Costs



NPS MDP Study Overall Insights

<u>MDP</u>

- Wide-ranging, extremely difficult, highly interconnected problem
- Systems Engineering approach critical
- No single solution – evolving threats & capabilities

<u>WMD Scenario</u>

- Adding Sea Inspection and improving Sensors & C3I capabilities give low-cost benefit
- Land Inspection required for large benefit, but costly

NPS MDP Study Overall Insights

<u>Ship As Weapon Scenario</u>

- “As-Is” system (Sea Marshals) effective
- Improving Sensor range (not C3I capability) gives low-cost increase in response time

<u>Small Boat Attack Scenario</u>

- Feasible cost-effective solutions exist
- Hardened Target required:
  - Active point defense
  - Passive protection (double-hull, hull coating)

MDP Overall Recommendations

Most effective use of current resources?:

WMD Scenario

- Focus on Sensors, C3I (all threats) and an enroute (minimum delay) Sea Inspection capability

Ship As Weapon Scenario

- Increase Sea Marshal training/armament
- Maintain rapid-response deployment force
- Implement procedure to determine COI hostile intent at or before 10nm

Small Boat Attack Scenario

- Minimal investment
- Randomly on load armed Sea Marshal escorts to repel (or capture?) pirates and deter terrorists

MDP Overall Recommendations

Resource focus for future cost-effectiveness?:

<u>WMD Scenario</u>

- Develop Land Inspection system for major ports
- Develop “Trusted Agent” shipping company certification process

<u>Ship As Weapon Scenario</u>

- Develop sensors to track large ships in AOR
- Extend rapid response force range

<u>Small Boat Attack Scenario</u>

- Sensors to track small boats in Critical Area
- HUMINT

Questions?

Backup Slides

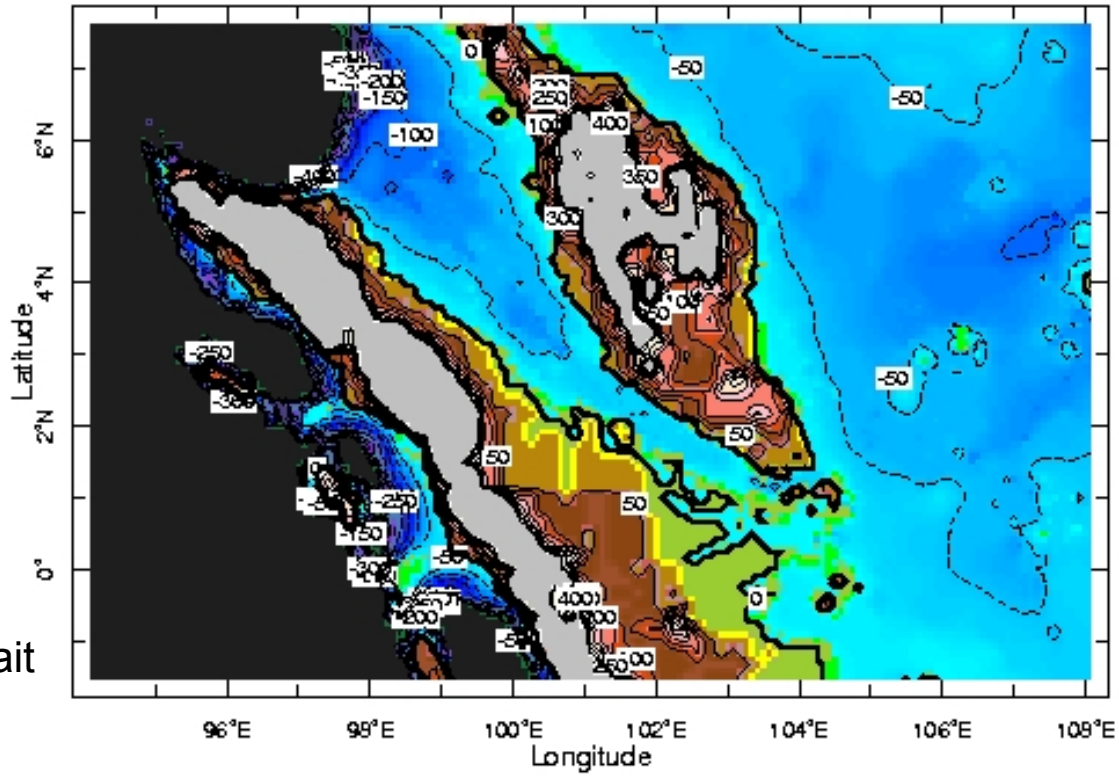
Straits of Malacca
Benign Maritime Characteristics

Sea State
- Malacca Strait: 1 to 2, max 3
- South China Sea: 1 to 5
- Andaman Sea: 1 to 5

Water Temperature
- Isothermal
- Day: 88 deg F
- Night: 79 deg F

Shallow Depth
- Continental shelf
- Typically 40 to 60m
- Restricted maneuvering in Strait

Light Currents
- Fairly constant
- Average 1/3 to 2 knots
- Both directions, with winds



Straits of Malacca
Stable Meteorological Conditions

Uniform Temperature

- Average maximum: 88 to 93 deg F
- Average minimum: 73 to 79 deg F
- Extremes: 67 and 101 deg F

Uniform Pressure

- Diurnal pressure variation: 4 hPa
- Extremes: 1002.0 hPa and 1016.9 hPa

Prevailing Winds

- DEC to APR: from SE
- JUN to OCT: from NW

High Relative Humidity

- Mean: 84%
- Diurnal range: high 90's to 60%
- During prolonged heavy rain: 100%

Abundant Rainfall

- Average annual rainfall: 92.8" (Reference: South Florida 56")
- No distinct wet or dry season.

Ducting (RF prop. >3GHz)

- Surface based ducting: 15-20% of time
- Evaporation ducting: Continuous

Scenario Definitions

“Large Ship”

- 50m and up (COLREGS)

“Small Boat”

- 7m to 49m (COLREGS)
- 0 – 50 kts
- 30 kts for suicide vehicle (1000 lbs explosives)

Coalition of Nations

- Singapore
- Malaysia
- Indonesia
- U.S. (PACOM)

Threat Scenario 1 - Small Boat Attack

- **Threat:**
  - 7m inflatable boat with 75hp outboard motor
  - 1,000 lb of TNT with a remote detonator.
- **Environment:**
  - Daytime (≈1300hrs)
  - Sea State 2 with 3-5 ft waves and winds less than 20 kts
  - Temp 90°F with 98% Humidity
- **Setting:**
  - Small boat exits from the cove near Pulau Assan and rapidly approaches the Sea Lanes.
  - There are currently seven large ships and 34 small ships in the immediate vicinity (<2nm).
  - The small boat is maintains a high rate of speed (30 kts) toward the largest ships, and is unresponsive to VHF hails.

Threat Scenario 2 – Ship As Weapon

- **Threat:**
  - “Ghost ship” loaded with crude oil
  - Approaches Singapore with the intent of ramming pier

- **Environment:**
  - Nighttime with a pier side arrival time of 0200 hrs
  - Sea State 2 with 3-5 ft waves and winds less than 20 kts
  - Temp 82°F with 90% humidity

- **Setting:**
  - Manifest in order, responsive to hails, accepts pilot onboard at normal pilot pickup point
  - Follows all standard navigation restrictions for initial entry into Singapore
  - Accelerates at breakwater
  - Does not follow pilot advice, Harbor Control loses communications with pilot

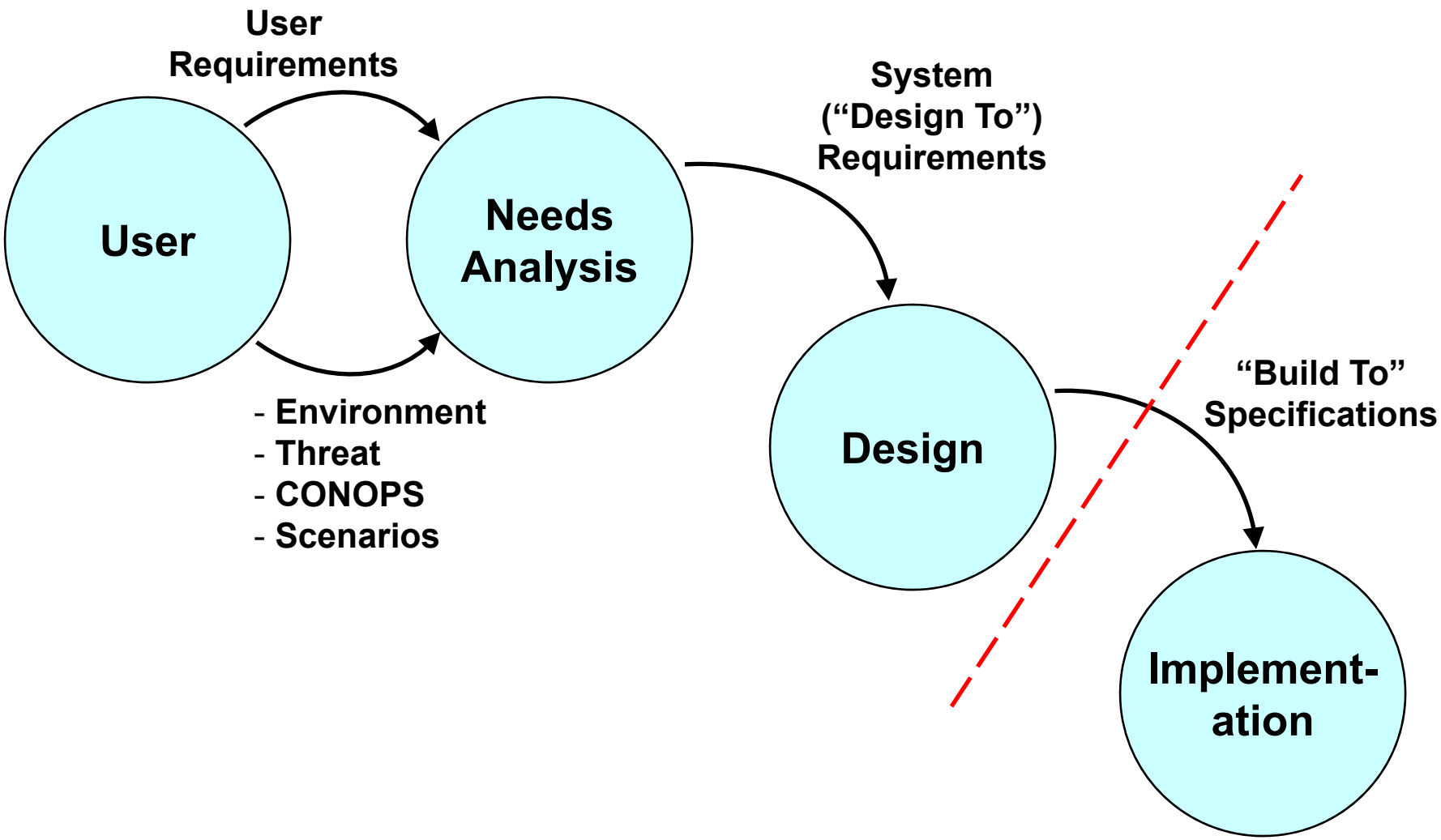
Threat Scenario 3 - WMD

- **Threat:**
  - MAERSK Shipping vessel Dawn Treader is transporting a 20-kT Russian-made nuclear device through the Straits of Malacca to a final destination of Singapore.

- **Environment:**
  - Daytime (~0800 hrs)
  - Sea State 3 with 6-10 ft waves and winds less than 25 kts
  - Temp 87°F with 92% humidity

- **Setting**:
  - The Dawn Treader unknowingly loaded the illicit cargo at the port of Shanghais, China in a shipment of thirty-two 40’ shipping containers carrying Apple Ipods to Singapore.
  - All ship’s paperwork (including manifests) are legitimate, and in order.

Generic Design Process

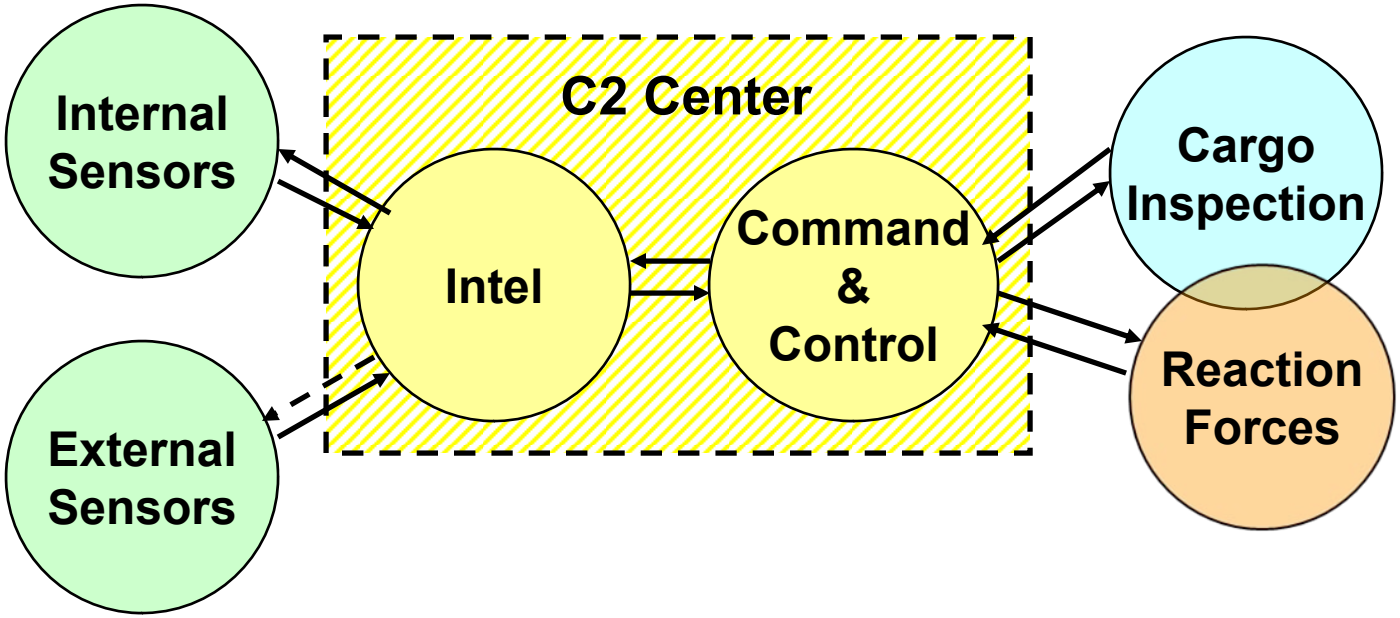


Effective Need Statement

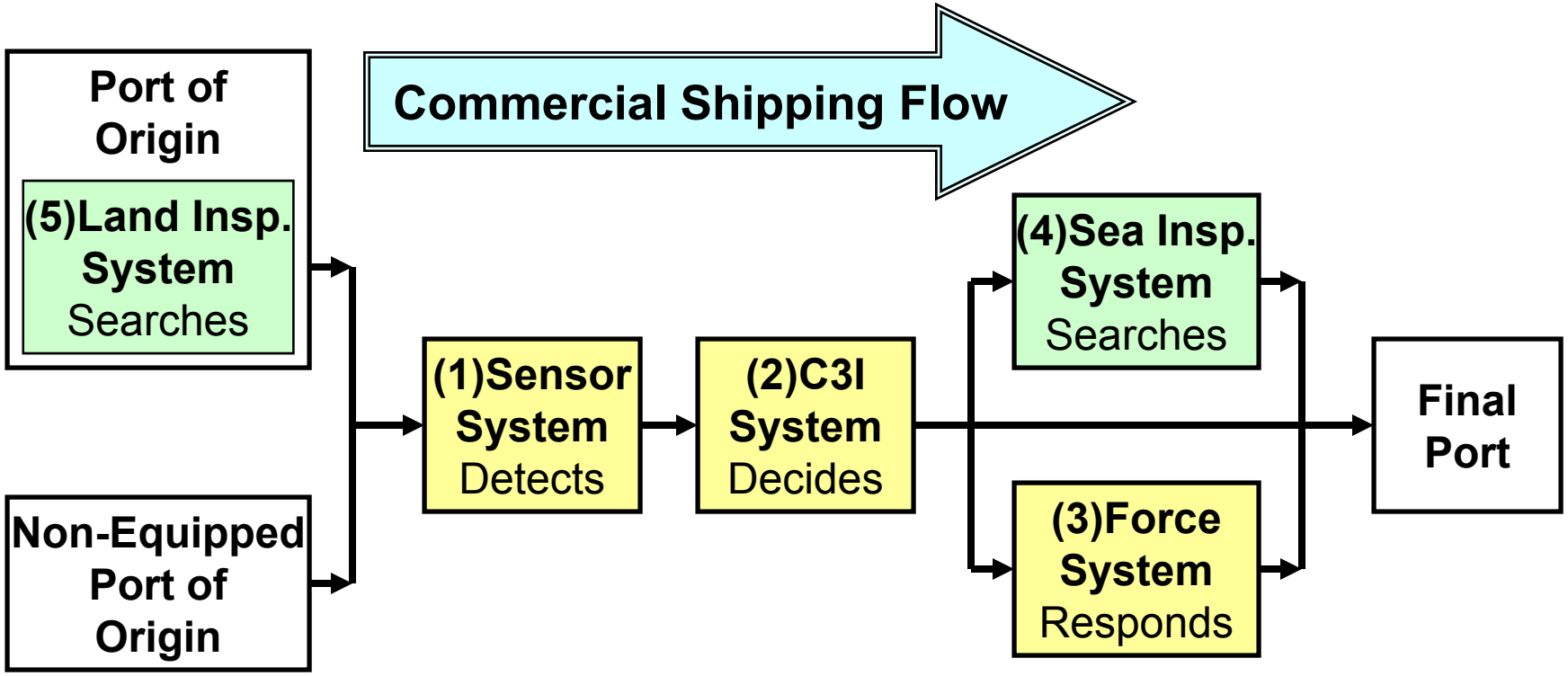
"An adaptable, integrated systems architecture that neutralizes the threat of terrorism from the sea in the Malacca Strait by providing large ship security and detecting hazardous materials in the maritime environment."

- Objectives include evaluating impact on commerce and evaluating system cost.

Conceptual Flow



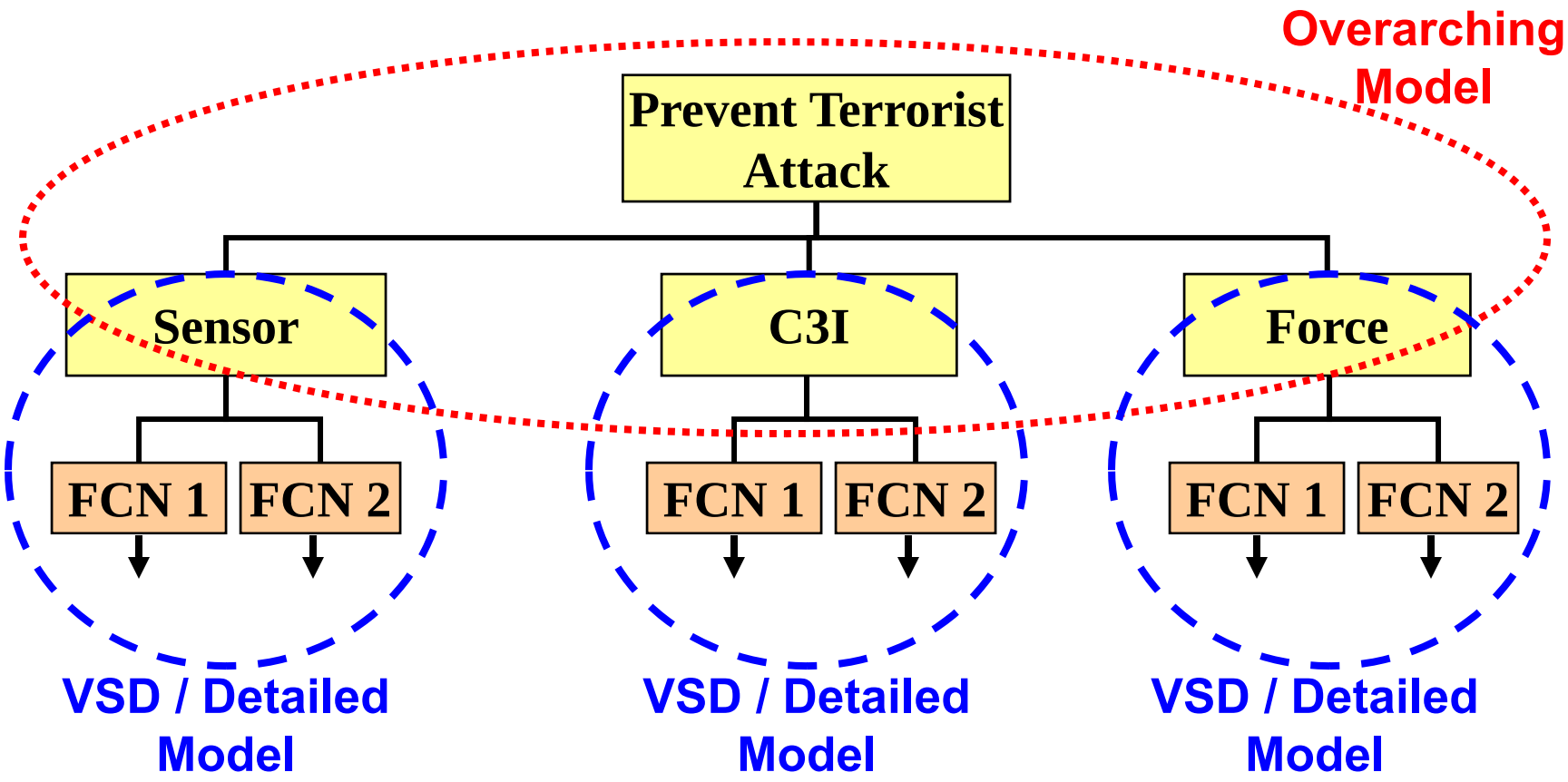
MDP Integrated Architecture: 5 Components



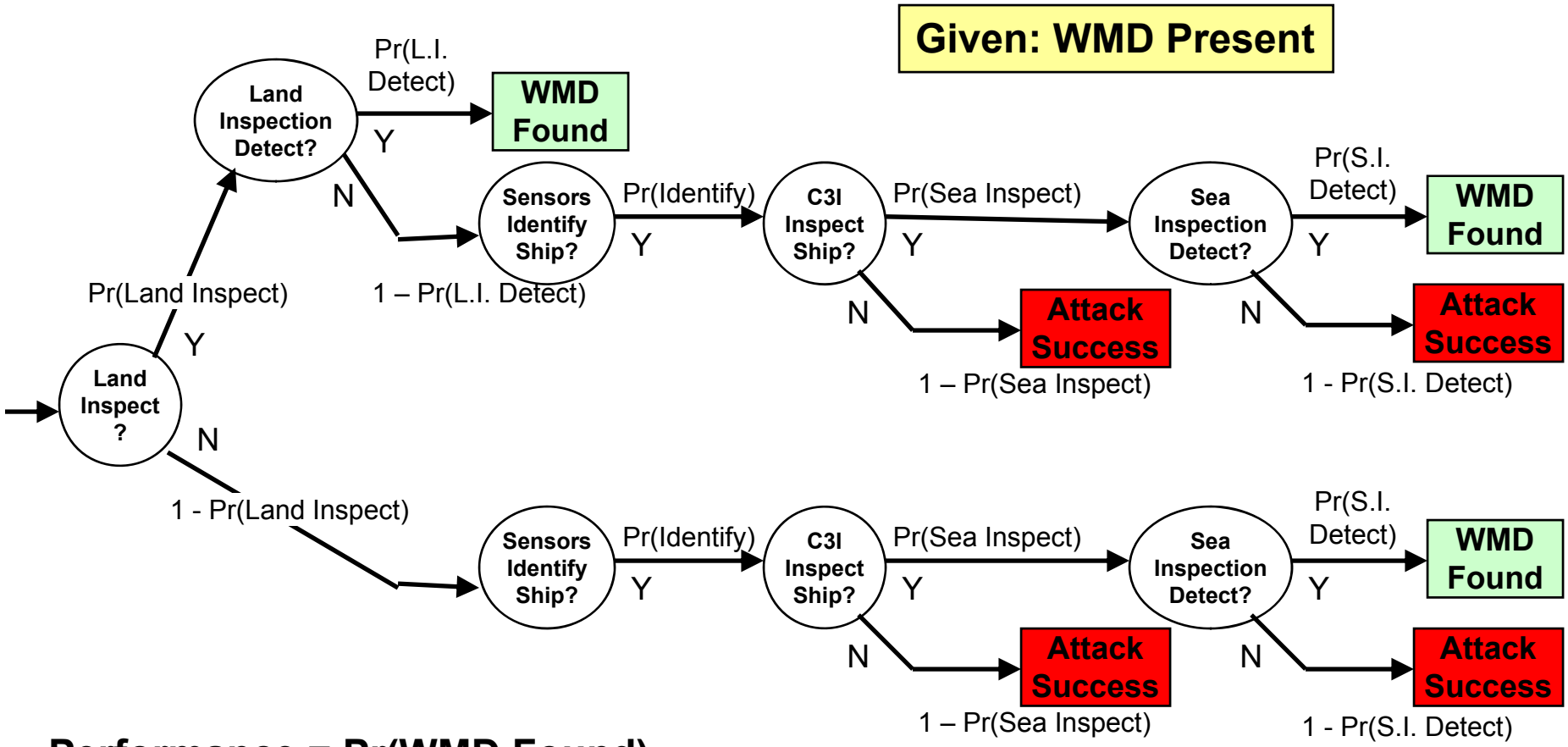
Integrated Architecture Components:

1) Sensor System
2) C3I System
3) Force Response System
4) Sea Inspection System
5) Land Inspection System

Modeling Approach



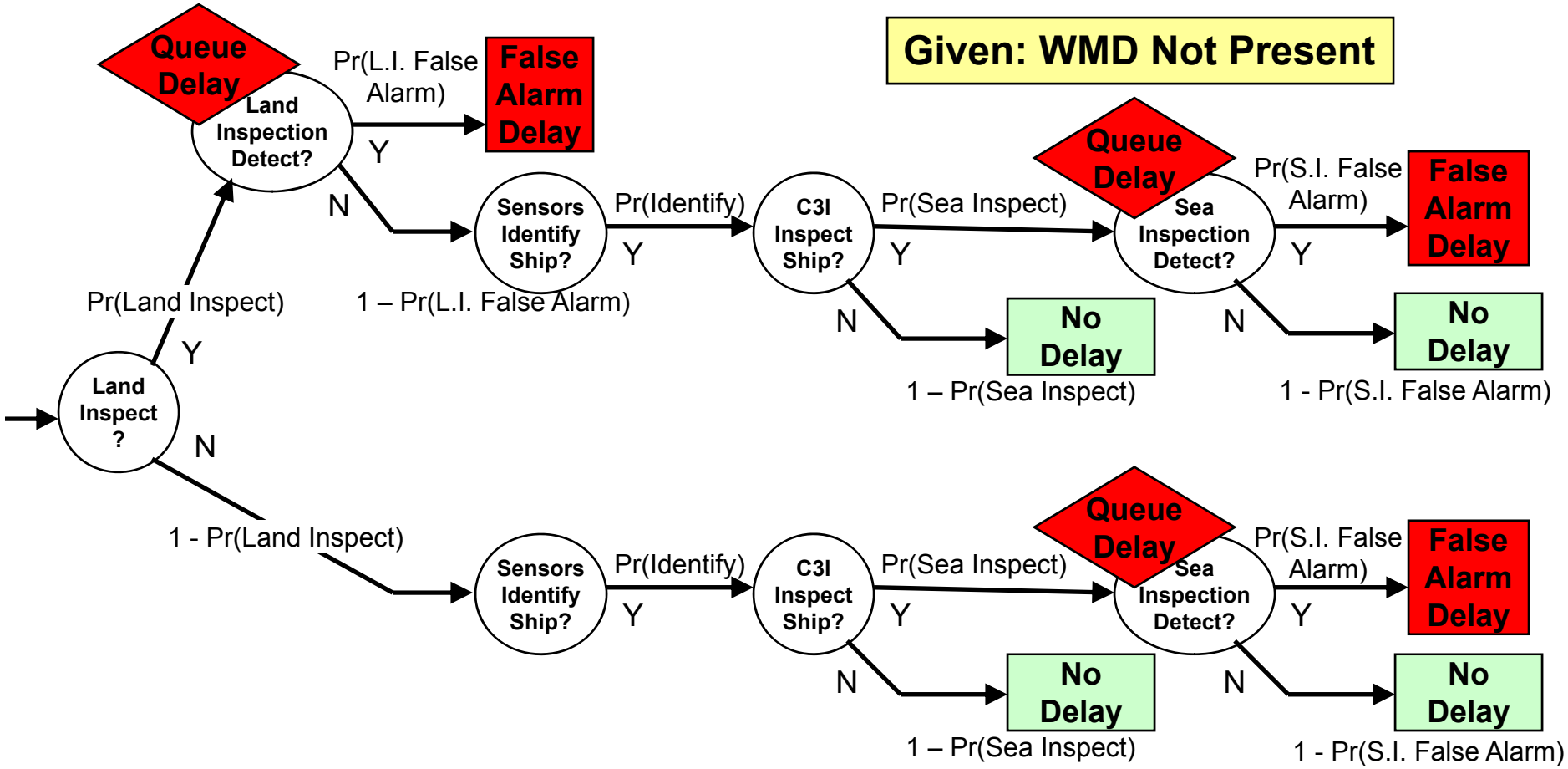
WMD Performance & Risk



Performance = Pr(WMD Found)

Risk (Attack Damage) = Pr(Attack Success) x Attack Damage Cost

WMD Commercial Impact



Commercial Impact (Delay Cost) = Total Delay Time x Cost per Delay Time