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

• **Sensors**
  – Increase RCS

• **Cargo Inspection**
  – Increase Access

• **C3I**
  – Increase Response Time

• **Force Response**
  – Limit Target Mobility
MDP Architecture
Ship/Cargo Inspection System

Suspect Ship

Random Inspections
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
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

- TRAC Monterey
- Network Engineering
- JC4I
- LLNL*
- USCG
- OR
- Defense Analysis (Spec OPS)
- Homeland Defense

Space Systems

= NPS Curriculum

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

Tasking and Current Situation

Requirements Generation

Problem Definition

- Needs Analysis
- Objectives Tree

Decision Making

- Alternative Scoring
- Decision

Design & Analysis

- Alternatives Generation
- Modeling & Analysis

Implementation

- Planning for Action
- Execution
- Assessment & Control

Relevant and Feasible Solution
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

User Needs & Technology Opportunities

Pre-Systems Acquisition
- Concept Refinement
- SEA-7 MDP Study

System Development & Demonstration
- Technology Development
- System Development & Demonstration
- Design Readiness Review

Production & Deployment
- LRIP/IOT&E
- FRP Decision Review

Operations & Support
- Sustainment
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

System Analysis:
- Objectives
- Requirements
- Alternatives
- Modeling
- Optimization
- Results

MDP Problem Definition/Architecture Development

MDP Group
- Needs Analysis

Sensor System

C3I System

Force System

TMIS Group
- Needs Analysis

Land Inspection System

Sea Inspection System

Overarching Integrated Systems Architecture Models

MDP Architecture Performance

MDP Architecture Conclusions & Recommendations

System Analysis:
- Objectives
- Requirements
- Alternatives
- Modeling
- Optimization
- Results
Terrorism and Piracy in the Maritime Domain
Straits of Malacca: Highest Value Chokepoint

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

Source: IMO

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

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
Threat Risk Analysis

**Severity**
- High
- Medium
- Low

**Probability**
- Low
- Medium
- High

- WMD (CBRNE)
- Ship As Weapon (SAW)
- Small Boat Attack (SBA)
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)

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

*Defeat = Less than $100k damage
*Confidence Interval = 95%
<table>
<thead>
<tr>
<th>MDP Top-Level System Objectives</th>
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</thead>
<tbody>
<tr>
<td><strong>Small Boat Attack (SBA)</strong></td>
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<td></td>
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<tr>
<td><strong>Ship As Weapon (SAW)</strong></td>
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<td></td>
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<tr>
<td><strong>WMD</strong></td>
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</tbody>
</table>

- Evaluate System Impact on Commercial Shipping
- Evaluate MDP System Cost
- Evaluate Risk (Expected Attack Damage Cost)
# Current System Capabilities

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Current 10-yr MDP System Cost (FY05$M)</th>
<th>Expected Attack Damage Cost (FY05$B)</th>
<th>Probability of Defeat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Boat Attack</td>
<td>N/A</td>
<td>0.8 – 3.6</td>
<td>~0% 80%</td>
</tr>
<tr>
<td>Ship As Weapon</td>
<td>$38-40</td>
<td>2.5 – 4.9</td>
<td>~80% 90%</td>
</tr>
<tr>
<td>WMD</td>
<td>$638-715</td>
<td>180 - 216</td>
<td>~2% 60%</td>
</tr>
</tbody>
</table>
Environment - CONOPS
Regional High Traffic Density

Strait 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

"Critical Area"
- Narrow straits (≤ 30 nm)
- Highest traffic density
- Restricted maneuvering
- Minimal response time

290nm
Within 300nm of Critical Area
Concept of Operations (CONOPS)

Sensor Coverage

Intelligence on Inbound COIs

Port Inspection/Force Response

Regional C2/Intel Centers
Simulation and Modeling
MDP Modeling Approach

• Individual System Models
  – Modular - No grand behemoth model
  – Best modeling tool
    – EXTEND™
    – Microsoft Excel™
  – “Local” evaluation

• Integrated System Architecture Models
  – Interface requirements
  – Determined performance measures
  – “Global” evaluation
Overall Architecture MOEs

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

- **MOE 2 – Risk (Expected attack damage)**
  - What is the expected attack damage cost for each threat scenario?
Overall Architecture Metrics

- **Metric 1 – Commercial Impact**
  - What is the expected cost to commerce over 10 years (through 2016)?
    - Commercial System Procurement Costs
    - Commercial System Operating & Support Costs
    - Commercial Delay Costs

- **Metric 2 – MDP System Cost**
  - What is the expected MDP system cost over 10 years (through 2016)?
    - MDP System Procurement Costs
    - MDP System Operating & Support Costs

**Total System Cost = Commercial Impact + MDP System Cost**
Overarching Modeling Plan

Performance Models
- Sensors
- C3I
- Force
- Sea Insp
- Land Insp
  - Defeat Distance or \( \text{Pr}(\text{Detect}) \)

Attack Damage Model
- \( \text{Pr}(\text{Defeat}) \)
- FY05$

MOE1 Performance

MOE2 Risk (Attack Damage)

Cost Models
- Sensors
- C3I
- Force
- Sea Insp
- Land Insp
  - Delay time

Shipping Delay Cost Model
- FY05$
- FY05$

Total System Cost
- M1 Commercial Impact
- M2 MDP System Cost
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
Performance = $\Pr(\text{Defeat Distance} \geq \text{Minimum})$

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

Performance Models

- Sensors
- C3I
- Force
- Sea Insp
- Land Insp

Attack Damage Model

Defeat Distance or Pr(Detect)

MOE1 Performance

MOE2 Risk (Attack Damage)

Cost Models

- Sensors
- C3I
- Force
- Sea Insp
- Land Insp

Shipping Delay Cost Model

Delay time

Pr(Defeat) FY05$

Total System Cost

M1 Commercial Impact

M2 MDP System Cost

FY05$ FY05$

= Integrated Architecture Model
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

Matching performance and cost for each combination gives 109 data points
**MDP Overall Results**

**WMD Scenario**

**Risk (Expected Damage) vs. Total System Cost**

![Graph showing Risk vs. Total System Cost]

- **Current System**

- **Desired**

**WMD Scenario Pr(Defeat) vs. Total System Cost**

- **Adding Land Inspection System gives biggest gain**
- **Improving C3I gives further gain**
- **Improving Sensors and Adding Sea Inspection System gives minor gain**
- **Land Inspection gives required performance, but at significant cost**

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

**Current System**

- **Low-cost gain from adding Sea Inspection and improving Sensors & C3I**

- **Land Inspection Alternative 2**
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

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

Starting point:
- Land Inspection Alt 2 - has Land Inspection system installed in 16 ports
- Sea Inspection Alt 1
- Sensors Alt 1
- C3I Alt 2
MDP Overall Results
Ship As Weapon (SAW) Scenario

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

Current System provides effective solution to SAW

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)
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

- Improving Sensors gives big increase in available response time
- Improving C3I very costly, minimal gain
- Better Sensors: Sensor "As-Is" → Sensor Alt 1 → Sensor Alt 2
- Better C3I: C3I "As-Is" → C3I Alt 1 → C3I Alt 2
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

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

WMD Scenario
- 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

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

Small Boat Attack Scenario
• 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?

WMD Scenario
• Develop Land Inspection system for major ports
• Develop “Trusted Agent” shipping company certification process

Ship As Weapon Scenario
• Develop sensors to track large ships in AOR
• Extend rapid response force range

Small Boat Attack Scenario
• 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

### High Relative Humidity
- Mean: 84%
- Diurnal range: high 90’s to 60%
- During prolonged heavy rain: 100%

### Uniform Pressure
- Diurnal pressure variation: 4 hPa
- Extremes: 1002.0 hPa and 1016.9 hPa

### Abundant Rainfall
- Average annual rainfall: 92.8”
  (Reference: South Florida 56”)
- No distinct wet or dry season.

### Prevailing Winds
- DEC to APR: from SE
- JUN to OCT: from NW

### 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

- User Requirements
  - Environment
  - Threat
  - CONOPS
  - Scenarios

- Needs Analysis
  - System ("Design To") Requirements

- Design

- Implementation
  - "Build To" Specifications
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

C2 Center

Intel

Command & Control

External Sensors

Internal Sensors

Cargo Inspection

Reaction Forces

Forces
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

Prevent Terrorist Attack

Sensor
- FCN 1
- FCN 2

VSD / Detailed Model

C3I
- FCN 1
- FCN 2

VSD / Detailed Model

Force
- FCN 1
- FCN 2

VSD / Detailed Model

Overarching Model
WMD Performance & Risk

Given: WMD Present

Performance = Pr(WMD Found)
Risk (Attack Damage) = Pr(Attack Success) x Attack Damage Cost
WMD Commercial Impact

Given: WMD Not Present

Land Inspection Detect?

Pr(L.I. False Alarm)

Y

False Alarm Delay

Pr(Land Inspect) 1 - Pr(L.I. False Alarm)

N

Queue Delay

Sensors Identify Ship?

Pr(Identify)

Y

C3I Inspect Ship?

Pr(Sea Inspect)

Y

Sea Inspection Detect?

Pr(S.I. False Alarm)

Y

False Alarm Delay

N

Queue Delay

No Delay

1 - Pr(Sea Inspect)

N

No Delay

1 - Pr(S.I. False Alarm)

Y

Queue Delay

No Delay

1 - Pr(Sea Inspect)

N

No Delay

1 - Pr(S.I. False Alarm)

Pr(Land Inspect)

1 - Pr(Land Inspect)

No

Queue Delay

No Delay

1 - Pr(Sea Inspect)

N

No Delay

1 - Pr(S.I. False Alarm)

Queue Delay

No Delay

1 - Pr(Sea Inspect)

N

No Delay

1 - Pr(S.I. False Alarm)

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