Port Security Strategy 2012
SEA-11 Naval Postgraduate School
TDSI National University of Singapore
May 31, 2007
Port Security Strategy 2012

Team

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<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tr>
<td>1300-1310</td>
<td>Introduction</td>
</tr>
<tr>
<td>1310-1330</td>
<td>Terrestrial Threats Group</td>
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<tr>
<td>1330-1335</td>
<td>Question Break #1</td>
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<td>1335-1355</td>
<td>Regional Seaborne Threats Group</td>
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<td>1355-1400</td>
<td>Question Break #2</td>
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<td>1400-1420</td>
<td>Source Seaborne Threats Group</td>
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<td>1420-1425</td>
<td>Question Break #3</td>
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<td>1425-1445</td>
<td>Internal Personnel Threats Group</td>
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<td>1445-1500</td>
<td>Question Break #4</td>
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<tr>
<td>1500-1600</td>
<td>Breakout Session in Bullard 100A</td>
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Tasking Letter
Meyer Institute of SE


- Potential focus areas:
  - Provide individual ship self protection
  - Integrate shipboard protection systems with shore-based systems
  - Integrate Allied and Navy vessels to commercial port security systems
Selected Documents

- National Strategy for Maritime Security
- International Outreach and Coordination Strategy
- International Ship & Port Facility Security Code and SOLAS Amendments 2002
SE Design Process

Definition:
- Stakeholder Analysis
- System Decomposition
- Scope/Bound Problem

Development:
- Alternatives Generation
- Feasibility Screening
- Qual. Func. Deployment

Modeling/Analysis:
- Performance Modeling
- Cost Benefit Analysis
- Scenario Results

Timeline:
2. February – March 2007
Stakeholders Concerns

• Land based
  – Attacks on infrastructure

• Sea based
  – Attack from local waterways
  – Attack via container from foreign ports

• Internal based
  – Attack via employee sabotage
“To protect commercial and Allied shipping by deterring and denying potential terrestrial, seaborne, and internal threats.”
Problem Decomposition

- **Terrestrial Threats Group**
  - Threats from landside port perimeter

- **Source Seaborne Threats Group**
  - Threats from originating port

- **Regional Seaborne Threats Group**
  - Threats from seaside of in-port ship to port boundary

- **Internal Personnel Threats Group**
  - Threats from personnel at port facility
Terrestrial Threats Group

Andrew Cole – Group Lead
Yi Wong – Deputy Lead
MAJ Kim Chuan Chng
MAJ Wei Ting Soh
Mr. Leng Huei Toh
Mr. Lin Kiat Peh
Terminal Operator’s Greatest Concern

• Prevent a vehicle laden with explosives from gaining access to the ports facilities while keeping total life cycle cost and impact on normal port operations to a minimum.
Terrestrial Threats Group
Scenario

• A Container truck laden with explosives attempts to gain access to a terminal in a major U.S. port by speeding past the security guard at the terminal’s entrance.
Fort Lauderdale, FL
Terrestrial Threats Group Alternatives
Key Findings

• Each port terminal needs to assess its vulnerability to a vehicular IED attack
• Perimeter fencing should be hardened before gate security improvements are made
• In our study, an armed guard was not cost effective
• Physical barriers are more effective than armed guards.
• Pop-Up Barriers with staggered concrete blocks before the barrier and at least 300’ between the guardhouse and barrier provide the best effectiveness.
Terrestrial Threats Group Modeling

- The effect of staggered concrete blocks to slow incoming vehicles
  3 levels: No blocks, blocks before guardhouse, and blocks before barrier

- The effect of the distance between the guardhouse and the barrier
  5 levels: 100’, 300’, 500’, 700’, and 900’
### Terrestrial Threats Group Metrics

- **System Effectiveness**

  \[1 - \left( \frac{\text{Number Successful Attacks}}{\text{Number Attempted Attacks}} \right)\]

<table>
<thead>
<tr>
<th>Modeling Tool</th>
<th>Input Parameters</th>
<th>MOEs Obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deny</td>
<td>Arena</td>
<td>1. System Effectiveness</td>
</tr>
<tr>
<td></td>
<td>1. Obstacle Delay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Barrier Delay</td>
<td></td>
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<tr>
<td></td>
<td>3. Security Zone Delay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Report Delay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Reliability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Effectiveness</td>
<td></td>
</tr>
</tbody>
</table>
Terrestrial Threats Group
Modeling Replication Parameters

• Modeled in Arena

• 50 alternative permutations considered

• 34,680 simulated attacks ran against each permutation

(120 days with 289 attempted attacks per day)
Terrestrial Threats Group Model

- Truck Arrives at Gate
  - Concrete Block Delay
  - Security Zone Delay
  - Guard Report Delay
  - Barrier Deploy Delay

- Barrier Deployed Before Truck Arrival?
  - Yes
    - Barrier Reliable?
      - Yes
        - Barrier Effective?
          - Yes
            - Attack Fails
          - No
            - Attack Succeeds
        - No
          - No
  - No
    - No
      - No
        - No
Terrestrial Threats Group
Modeling Results

Simulation Results Based On Distance

Effectiveness

Configurations

Status Quo  Pop-Up Barriers  Spike Strips  Armed Guard
### Terrestrial Threats Group Modeling Results

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Maximum Effectiveness</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Quo</td>
<td>0%</td>
<td>N/A</td>
</tr>
<tr>
<td>Pop-Up Barriers</td>
<td>95%</td>
<td>300', Blocks Before Barrier</td>
</tr>
<tr>
<td>Spike Strips</td>
<td>47%</td>
<td>900', Blocks Before Guardhouse</td>
</tr>
<tr>
<td>Armed Guard</td>
<td>16%</td>
<td>500', Blocks Before Guard</td>
</tr>
</tbody>
</table>
Terrestrial Threats Group
Cost Estimation

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Anticipated Annual Lifecycle Cost (FY07$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Quo</td>
<td>0</td>
</tr>
<tr>
<td>Pop-Up Barriers</td>
<td>37,100</td>
</tr>
<tr>
<td>Spike Strips</td>
<td>15,656</td>
</tr>
<tr>
<td>Armed Guard</td>
<td>36,365</td>
</tr>
</tbody>
</table>
Terrestrial Threats Group
Cost Benefit Analysis

Overall Cost V Effectiveness

- Pop-Up Barrier, Blocks at Barrier, 300'+
- Spike Strips, Blocks before Guardhouse, 900'
- Armed Guard, Blocks at Barrier, 500'
- Status Quo
Terrestrial Threats Group Dominance

Overall Cost vs Effectiveness

- Pop-Up Barrier, Blocks at Barrier, 300'+
- Spike Strips, Blocks before Guardhouse, 900'
- Armed Guard, Blocks at Barrier, 500'
- Status Quo

Annual Lifecycle Cost (FY07$)

Effectiveness

0 0.2 0.4 0.6 0.8 1

0 10000 20000 30000 40000
Terrestrial Threats Group
Conclusions

• Each port terminal needs to assess its vulnerability to a vehicular IED attack

• Perimeter fencing should be hardened before gate security improvements are made
Conclusions

- Pop-Up Barriers with staggered concrete blocks before the barrier and at least 300’ between the guardhouse and barrier provide the best effectiveness.

- In our study, an armed guard was not cost effective.
At gate screening for incoming vehicles. Study the effectiveness at preventing vehicular IEDs and the impact that additional screening would have on commerce.

Additional screening for imported containers. Study the effectiveness for different screening methods and the impact that the screening would have on commerce. Possible collaboration with Sandia National Laboratories.
Regional Seaborne Threats Group

LT Morgan Ames – Group Lead
Mr. Thiow Yong Lim - Deputy Lead
Mr. Chee Wai Ng
Mr. Chee Wan Ng
Mr. Kim Leng Koh
Mr. Chun Man Chan
Pier-side Ships’ Greatest Concerns

• To *increase port waterside readiness* prior to terrorist attack while carrying on day to day port operations by *detecting*, tracking and employing appropriate courses of action.
Regional Seaborne Group Modeling Scenario

Options:
- Small boat attacks (SWARM)
- Large ship collision
- Swimmer attack
- RPG attack

Stakeholders’ Conclusion: Small boat attack scenario

Scenario:
Multiple small boats attack container terminal from different threat axis to inflict the most damage to moored ships and to the terminal. Desire of the terrorist is to inflict physiological damage and render the port facilities inoperable for a period of time.
Regional Seaborne Group
Alternatives Generation

• Current “As Is” configuration:
  – 1 Helo
  – 4 Patrol craft
  – 1 Radar

• Increase detection capability by adding:
  – Shore based Assets:
    • Radars, EO/IR Sensors, Sonars and Buoys
      – E.g. Thermo Vision Sentry II
  – Mobile Assets:
    • USV
# Regional Seaborne Group Alternatives Configuration

<table>
<thead>
<tr>
<th>Type of Sensor Platform</th>
<th>(A) Current</th>
<th>(B) (A) + USV</th>
<th>(C) (B) + 1 Radar</th>
<th>(D) (B) + 2 Radars</th>
<th>(E) (D) + SentryII</th>
<th>(F) (E) + Sentinel</th>
<th>(G) (F) + Buoys + Sonars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x Helo</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>4 x Patrol Craft</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>1 x Radar Configuration (Existing)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>2 x Radar Configuration</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>3 x Radar Configuration</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
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<tr>
<td>2 x Unmanned Surface Vessels (USV)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>2 x ThermoVisionSentryII</td>
<td></td>
<td></td>
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<td>✔</td>
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<tr>
<td>5 x ThermoVisionSentinel</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
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<tr>
<td>2 x Networked Sensor (Buoys)</td>
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<tr>
<td>5 x Active OmniDirectional Sonar</td>
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<td>✔</td>
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<tr>
<td>4 x High Frequency Tactical Sonar</td>
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<td>✔</td>
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</table>
Regional Seaborne Group
Key Findings

• Most Effective: 1 x Helicopter
  4 x Patrol Craft
  1 x Radar
  2 x Radar
  2 x USV
  2 x Thermo Vision Sentry II

• Cost: $21,312,000

• There needs to be:
  - network of sensors for port security
  - data fusion center

• Provide increased AWARENESS, increased port security
Regional Seaborne Group
Modeling Metrics

• **MOE:** Terrorist Infiltration
  – MOP: Infiltration rate

• **MOE:** Target Detection
  – MOP: Detection rate

<table>
<thead>
<tr>
<th>Modeling Tool</th>
<th>Input Parameters</th>
<th>MOEs Obtained</th>
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<tbody>
<tr>
<td>Protect</td>
<td>Simkit</td>
<td>1. Target Detection</td>
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<td>2. Terrorist Infiltration</td>
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<tr>
<td></td>
<td>1. Number and type of sensors</td>
<td></td>
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<tr>
<td></td>
<td>2. Number of terrorists</td>
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</table>
Regional Seaborne Group
Modeling Tools

• Discrete Event Simulation
  – Event driven paradigm
  – Modeling of complex dynamic system
  – MOVES Simkit
  – Maneuvering Models
  – Sensor Models
    • Cookie-cutter
    • With detection and not detection
Regional Seaborne Group
Model Design and Implementation

• Port Security Local Waterside Simulation Application
  – Create Threats behavior
  – Create Sensor (basic) behavior
  – Create Scenario for different alternatives
  – Collection of results
  – Analysis of results
  – Recommendation of Alternatives
Regional Seaborne Group
Flow Chart

Port Security - Local Waterside - Small Boat Procedure Flow Chart

Search for small boats

Detect (Locate Boat)

Classify (Type of Boat)

Recognise (Features of Boat)

Identify (Owner of Boat)

Monitor Intent

Is Threat

Monitor Intent

Loss of Intent? (Surrender)

Danger

Yes

Engage (non-lethal)

Neutralised? (Stopped and Unarmed)

End Engagement

No

Yes

Engage (Lethal)

Is Lethal Threat? (Speed or Armed)

Is Threat

Opportunity? (breach of proximity to installations and portside ships)

Intent? (Speed)

Capability? (Armed)

Intent? (IFF - Unknown)

Neutralised? (Stopped and Unarmed)

End Engagement

Yes

Engage (non-lethal)

Neutralised? (Stopped and Unarmed)

End Engagement

Yes

Engage (Lethal)

Is Lethal Threat? (Speed or Armed)

Is Threat

Opportunity? (breach of proximity to installations and portside ships)

Intent? (Speed)

Capability? (Armed)

Intent? (IFF - Unknown)
Regional Seaborne Group
Discrete Events

- Maintains a list of Threats that exist:
  - List of Red (Hostile & Unknown) Movers
  - List of Blue (Rdr, IR, Patrol) Sensors

`NeutralThreat Component`

- Start Track
- Check Compliance
- Set Threat
- Check Speed
- Check Breach
- Set Threat
- Check IFF Code
- Set Threat
- Check Armed
- Check Intent
- Monitor
- Deter (curPos)
Neutral Threat Behaviour

CreateNeutralThreat

Arrival

{  NeutralMover Mv = new NeutralMover  
   ( <Name>, PosStart,  
   PosEnd, Speed );  
   WayPoint[] Route = GetWayPoint( );  
   NeutralMvMgr MvMgr = new NeutralMvMgr( Mv, Route );  
}

Deter( curPos)

{  WayPoint[] DeterRoute = GetWayPoint( curPos, PosStart );  
   MvMgr.removeWayPoints( );  
   MvMgr.addWayPoints( DeterRoute );  
}

NeutralArrival

NeutralMoverManager

NeutralMover
Regional Seaborne Group Model Inputs
Regional Seaborne Group
Modeling Assumptions

• Homeland security level
  – Normal

• Focus is on small boat attacks
  – Threats come from within the San Francisco Bay, and originate from designated areas
  – Small boats travel at 30kts
  – Not considering air threats or threats from swimmers

• Sensor Assets
  – Placement of static sensors
  – Routes for mobile sensors
  – Search pattern follows detect-classify-recognize-identify algorithm
  – False Alarm Rate not modeled
Regional Seaborne Group Model Area

- 5 nautical miles Boundaries & Low Depth areas

- Red lines – Outbound merchant vessel
- Yellow Line- Inbound merchant vessel
- Green circles – Marinas where terrorist might come from!
Regional Seaborne Group Routes

Possible routes from far bank marinas
Regional Seaborne Group
Sensor Placement
Regional Seaborne Group
Limitations of the Model

• Model focuses on the detection of terrorist small boats. A successful detection means
  – Terrorist fails in mission
  – Terrorist is deterred

• Sensor Characteristics
  – Sensors follow a detect-classify-recognize-identify algorithm that takes 3 mins for each stage of the process (in Simulation time)
  – Sensors can only perform target detection-classification for a single platform at any one time.

• SimKit only implements type Point2D
  – Subsurface detection, e.g. sonars may not be modeled accurately.
  – Diskit, which is able to implement Point3D, has stability issues, hence not used.
Regional Seaborne Group Results

Terrorist Infiltration-Detection Rate

F + Buoys + Sonar

Infiltration/Detection Rate for (G) Configuration
Regional Seaborne Group
Results of the Modeling

Terrorist Detection Rate

Percentage

# of Terrorist Small Boats

Config (A)
Config (B)
Config (C)
Config (D)
Config (E)
Config (F)
Config (G)
## Regional Seaborne Group Cost Estimation

<table>
<thead>
<tr>
<th>Configuration</th>
<th>$FY07M Cost</th>
<th>$FY18M Cost</th>
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<tbody>
<tr>
<td>A</td>
<td>4.14</td>
<td>41.4</td>
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<tr>
<td>B</td>
<td>14.64</td>
<td>76.4</td>
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<tr>
<td>C</td>
<td>17.89</td>
<td>83.9</td>
</tr>
<tr>
<td>D</td>
<td>21.14</td>
<td>91.4</td>
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<tr>
<td>E</td>
<td>21.31</td>
<td>91.48</td>
</tr>
<tr>
<td>F</td>
<td>21.45</td>
<td>91.96</td>
</tr>
<tr>
<td>G</td>
<td>46.65</td>
<td>133.96</td>
</tr>
</tbody>
</table>

**PROTECTOR USV used cost FY07 $3.5 million**
Regional Seaborne Group
Cost Benefit Analysis

Cost vs Detection

Detection %
110.00%
90.00%
70.00%
50.00%
30.00%
10.00%

$0
$10,000,000
$20,000,000
$30,000,000
$40,000,000

Cost ($ FY07)

1 terrorist
3 terrorists
5 terrorists
9 terrorists
Regional Seaborne Group
Cost Benefit Analysis

Cost Vs Detection

- 2 terrorists
- 4 terrorists
- 6 terrorists
- 12 terrorists
RSTG Recommendation Revisited

• Most Effective:
  1 x Helicopter
  4 x Patrol Craft
  1 x Radar
  2 x Radar
  2 x USV
  2 x Thermo Vision Sentry II

• Cost: $21,312,000
• Without USVs: $11,312,000
Regional Seaborne Group
Conclusions

• Layered sensors are the most sure way to prevent a terrorist attack
• Implementation of a Data fusion center.
• Sharing of information and awareness are key attributes for port security
• Products exist such as: Hawkeye, Project Athena, and HarborGuard. Provides sensors as well as C2 platform for fusion center.
Regional Seaborne Group
Recommended Future Study

- Since RSTG examined the prevent aspect the engagement problem still remains
- Did not look into a single sensor having the ability to track multiple crafts
- Examine and implement the air threats and intelligence aspects into Port security
- Address the false alarm issue
Source Seaborne Threats Group

LCDR Dale Johnson - Group Lead
Ms. Pei Tze Oh – Deputy Lead
Mr. Horng Lim
ENS Alan Marsh
ENS Laura Okruhlik
Source Seaborne Group
Effective Need

• Design a system to detect and deny all containers holding undesired cargoes from loading onto a container ship.
  – Undesired cargoes are defined as:
    • chemical agents
    • biological agents
    • radiological material
    • explosives
    • conventional weapons
    • weapon system parts
    • human cargo
  – Containers enter the source port via:
    • railway
    • vehicle (trucks)
    • transshipment (berthed ships)
Source Seaborne Group
Scenario Objectives

• Good guys
  – Detect and deny all WMD at the source port

• Bad guys
  – Get at least one container with WMD to each destination port
Source Seaborne Group
Detection Capability Metrics

• Analysis Questions of Interest
  – Comparison of Alternatives
  – Optimal Sensor Mix to maximize Pd

• MOE: Accuracy
  – MOP: Probability of Detection
  – MOP: Missed Detection
  – MOP: False Alarm Rate

• MOE: Timeliness
  – MOP: Productivity
  – MOP: Average inspection time per container

<table>
<thead>
<tr>
<th>Modeling Tool</th>
<th>Input Parameters</th>
<th>MOEs Obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deny</td>
<td>Extend</td>
<td>1. Accuracy</td>
</tr>
<tr>
<td></td>
<td>1. Container Traffic</td>
<td></td>
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<td>2. Sensor Performance</td>
<td>2. Timeliness</td>
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# Source Seaborne Group Alternatives Generation

<table>
<thead>
<tr>
<th>System</th>
<th>Manifest Screening</th>
<th>Scanning Location</th>
<th>Non-Intrusive Container Screening</th>
<th>% Screening</th>
<th>Intrusive Container Screening</th>
<th>Screening requirements</th>
<th>Data Sharing</th>
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</thead>
<tbody>
<tr>
<td>Reference System</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>0%</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>0% inspection</td>
<td>ATS (status quo)</td>
<td>Mobile system</td>
<td>Gamma ray scanners</td>
<td>5%</td>
<td>Human</td>
<td>Containers that don’t pass the non-intrusive inspection</td>
<td>Smart Tags</td>
</tr>
<tr>
<td>100% Inspection (100% of containers)</td>
<td>ATS+ (shippers submit manifests to ATS system 24 hours before ship loading)</td>
<td>On crane spreaders</td>
<td>X-ray scanners</td>
<td>25%</td>
<td>Animals</td>
<td>Random (fixed percentage)</td>
<td>Upload container screening data to destination port</td>
</tr>
<tr>
<td>Improved loading search</td>
<td>Fixed entry point with truck drive-through</td>
<td>Fixed entry point with truck drive-through</td>
<td>Operator experience</td>
<td>50%</td>
<td>Portable Radiation Detectors</td>
<td>Containers tagged high risk by manifest screening</td>
<td></td>
</tr>
<tr>
<td>Minimize port operations disruption</td>
<td>Trained animals</td>
<td>Radiation detectors</td>
<td>100%</td>
<td></td>
<td></td>
<td>Remotely-operated inspection robots</td>
<td>100%</td>
</tr>
<tr>
<td>High Performance</td>
<td></td>
<td></td>
<td>Scales</td>
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<tr>
<td>100% Intrusive Inspection</td>
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# Source Seaborne Group

## Alternatives Generation

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## Table: Screening Alternatives

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Key Findings

- **Best alternative – High Performance**
  - Automatic Targeting System (Improved)
  - Gamma scanner and HAZMAT detector at container holding and loading areas
  - Fully equipped inspection station
  - US 2007 $82.67 million

- **Optimal sensor mix to maximize Pd**
  - Gamma scanner at port of entry
  - Radiation detector, gamma scanner at holding area
  - Scales, gamma scanner at loading area
  - Gamma scanner, HAZMAT detector, and trained animals at intrusive inspection station
Modeling & Simulation

All models are wrong, but some models are useful.

George Box
Source Seaborne Group
What the Model…

IS…

• A tool to compare relative performance of alternatives
• A high level abstraction of many factors that could drive MOPs
• An experiment to identify the most significant factors

IS NOT…

• A detailed simulation of actual port processes
• A prediction of real life performance of various inspection configurations
Source Seaborne Group
Extend Model

- **Port of Entry**
  - Container delivered by truck are expected to drop the container at the loading bay after security clearance. No temporary storage for these containers. JIT delivery.
  - If container targeted by ATS, send to Inspection Team otherwise randomly select container for intrusive inspection.

- **Customs Inspection Team**
  - Exit 106 Detained
  - Exit 1732 Loadship

- **Loading Bay**

- **Holding Area**
  - Transshipment container temporarily placed at the Holding Area

- **Source Seaborne Group**

**Extend Model**
Source Seaborne Group
Derivation of Port Statistics

- Based on traffic data of world’s biggest transhipment hub, PSA Singapore

- Annual Container Traffic
  - 22.3m TEUs transhipment
  - 23.2m TEUs total

- Daily vessel traffic
  - 60 ships

- Facilities
  - 4 terminals, 41 berths, 131 quay cranes
Source Seaborne Group
Design Of Experiments

• Analysis of Alternatives
  – 6 different alternative configurations

• Optimal Sensor Mix
  – 17 different sensor configuration parameters
  – Full factorial testing requires $2^{17}$ runs = 131072 runs
  – Extended Nearly Orthogonal Latin Hypercube
    • Efficient space filling properties: Cover total experiment space with minimum sample points
    • Reduce total runs from 131072 runs to 65 runs
Analysis of Alternatives
# Source Seaborne Group Raw Score of Alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Prob of Detection</th>
<th>Missed Detection Rate</th>
<th>False Alarm Rate</th>
<th>Good Productivity [Containers per hour]</th>
<th>Change in Productivity Relative to Status Quo [%]</th>
<th>Avg Insp Time Per Container [min]</th>
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<tr>
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<td>13.9%</td>
<td>86.1%</td>
<td>0.3%</td>
<td>159</td>
<td>NA</td>
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<td>1.4%</td>
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<td>83.8%</td>
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## Utility Ranking & Cost Estimation

<table>
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<th>Cost (US 2007 $ million)</th>
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Source Seaborne Group
Cost Benefit Analysis

Cost vs Utility Score of Alternatives

System Life-Cycle Cost (million 2007$)
Utility Score
Efficient Frontier
100% Intrusive Inspection
High Performance
Min Port Operation Disruption
Improved Loading Search
Reference System
100% Vol Inspection
Optimal Sensor Mix for Pd

Regression Analysis
Source Seaborne Group

Logistic Regression Model

• Purpose of Logistic Regression Model
  – Determine significant factors that influence Pd
  – Predict Pd for sensor configurations that were not modeled

• Pd converted to binary response variable
  – Dirty Container detected = 1
  – Dirty Container not detected = 0

• Logistic regression model with logit link function used to fit data.
  – Saturated Model assumes all factors are significant in influencing Pd
**Source Seaborne Group Logistic Regression Model**

**Legend**
- **e**: Land Entry Point
- **h**: Transhipment Holding Area
- **i**: Intrusive Inspection Team
- **c**: Crane (Loading)

**Analysis Method**
- Significance of Regressors
- Type III Sums of Squares

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<th>Df</th>
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<th>Mean Sq</th>
<th>F Value</th>
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<td>Entry Scan %</td>
<td>1</td>
<td>0.20</td>
<td>0.20</td>
<td>6.40</td>
<td>0.0114</td>
<td>Yes</td>
</tr>
<tr>
<td>Intrusive Insp Random Selection %</td>
<td>1</td>
<td>0.05</td>
<td>0.05</td>
<td>1.70</td>
<td>0.1927</td>
<td>No</td>
</tr>
</tbody>
</table>
Source Seaborne Group
Logistic Regression Model

• Subset Model Selection
  – stepAIC
    • Backwards elimination algorithm for finding best subset model
  – Mallow’s Cp
    • Criteria for “best” subset model selection

• Factors NOT important to determining Pd
  – Land Entry Point: Scales, trained Animals, radiation detector
  – Crane: Radiation detector
  – Random selection percentage for intrusive inspection
Source Seaborne Group
Logistic Regression Model

- Gamma scanners most Significant contribution to Pd

Legend
- e: Land Entry Point
- h: Transhipment Holding Area
- i: Intrusive Inspection Team
- c: Crane (Loading)

- 0: Sensor OFF
- 1: Sensor ON
Optimal Sensor Mix for Pd

Partition Analysis
Source Seaborne Group
Partition Tree: Pd

Legend
• e: Land Entry Point
• h: Transhipment Holding Area
• i: Intrusive Inspection Team
• c: Crane (Loading)
• 0: Sensor OFF
• 1: Sensor ON
Source Seaborne Group
Partition Tree: Pd

- **Most Significant Factors for minimum Pd**
  - Mean 31.4%
  - Crane Gamma scanner (off)
  - Holding area Gamma scanner (off)

- **Most Significant Factors for maximum Pd**
  - Mean 95.4%
  - Crane Gamma scanner (on)
  - Intrusive Insp Team Gamma Scanner (on)
  - Intrusive Insp Team Trained Animals (on)
Partition Tree: Pd

• Most Significant Factors
  – Gamma scanners at various locations
  – Locations in descending preference
    • Crane, holding area and intrusive inspection team
  – Trained Animals a good supplement to increase Pd
Source Seaborne Group
Partition Tree: False Alarm Rate (FAR)

• Most Significant Factors for minimum FAR
  – Mean 0.22%
  – Intrusive Insp Team Gamma Scanner (off)
  – Intrusive Insp Team Chemical Detector (off)
  – Intrusive Insp Team Biological Detector (off)

• Most Significant Factors for maximum FAR
  – Mean 0.43%
  – Intrusive Insp Team Gamma Scanner (on)
  – ATS Current, ATS Improved
  – Crane Scales (on)
Source Seaborne Group
Partition Tree: Productivity

• Most Significant Factors for **minimum** Productivity
  – Mean 151 containers per hour
  – Intrusive Insp Team Random selection percentage >= 8%
  – ATS Current, ATS Improved
  – Crane Scales (on)

• Most Significant Factors for **maximum** Productivity
  – Mean 163 containers per hour
  – Intrusive Insp Team Random selection percentage < 8%
  – Intrusive Insp Team Gamma Scanner (off)
Source Seaborne Group
Partition Tree: Avg Inspection Time

• Most Significant Factors for **minimum** Avg Inspection Time
  – Mean 29.6min
  – No ATS
  – Holding Area Gamma Scanner (off)

• Most Significant Factors for **maximum** Avg Inspection Time
  – Mean 44.9min
  – ATS Current, ATS Improved
  – Intrusive Insp Team Random selection percentage >= 0.07
  – Crane Gamma scanner (on)
Source Seaborne Group
Partitioning Analysis Recommendations

• Recommended Sensor Suite to optimize multiple MOPs
  – Gamma detectors
    • Crane, holding area, intrusive inspection teams
    • Trained animals complementary
  – No ATS risk profiling
  – Intrusive inspection random selection < 8%
  – Not deploying crane scales

• Estimated Performance
  – Average probability of detection of 90%
  – Average false alarm rate of 2.77%
  – Average productivity of 161 containers per hour
  – Average inspection time per container of 32.6 minutes
Conclusions and Recommendations
Source Seaborne Group
Conclusions

• Source port and transit security is still in the infancy stage and providing an adequate security solution is a global problem.

• Large transshipment hubs pose additional security risks from cargo arriving by ship from less secure ports.

• False alarm rate is directly proportional to number of sensors in system and can negatively impact port operations and productivity.

• The number of inspection teams should be sufficient to handle the false alarms and volume of containers randomly selected for inspection.
Source Seaborne Group Recommendations

• Best alternative – High Performance
  – Automatic Targeting System+
  – Gamma scanner and HAZMAT detector at container holding and loading areas
  – Fully equipped inspection station
  – US 2007 $82.67 million
Source Seaborne Group
Recommended Future Study

• Conduct detailed analysis on manifest screening and random selection percentages on port operations and ability to detect undesired cargos
• Review security vulnerabilities in transshipment process
• Improve accuracy in modeling port operations and sensors

• Scenarios of interest
  – UAV attack on container ship in transit close to source or destination port
  – Sinking of large container ship over Hampton Roads Bay Bridge tunnel, while 4 carriers are in port
Internal Personnel Threats Group

Mr. Henry Nguyen – Group Lead
LT Claude McRoberts – Deputy Lead
MAJ Chee Leong Tan
Mr. Min Yew Ng
Mr. Kar Leong Ong
MAJ Kiah Wen Kwai
Internal Personnel Group
Effective Need

To prevent insiders from committing or supporting terrorist acts within/through port facilities

By:
1. Minimizing impact to current operations
2. Deterrence
3. Control access to information and to physical locations
4. Respond if necessary
Internal Personnel Group
Scenario

**Concept 1**: A disgruntled port terminal employee attempt to smuggle in explosives to cause damage to terminal infrastructures and prevent port operation.

**Concept 2**: Port terminal employee gain unauthorized access to electronics data to be used in support of planning and executing terrorist attacks.
Key Findings

• Combined scenarios with involving data access control, physical access control, and response implementing maximum alternative solutions were able to achieve an 18% improvement.

• By implementing metal detector, bag scanner, improved training, random searches, and improved communications can improve physical security by 194%.

• Additionally, if a mid-terminal fence is added and the gates are triggered shut upon intruder detection a total physical security improvement of 441% can be achieved.
Internal Personnel Group
Alternatives for Modeling

• Deterrence
• Physical Access Control
  • Status Quo
  • Random searches
  • Metal detector & bag scanner
  • Training for guards
  • Mid-terminal fence (gate open/shut)
• Data Access Control
  • Two-factor authentication
• Response
  • Improved communication
<table>
<thead>
<tr>
<th>MOEs</th>
<th>Input Parameters</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deter</strong></td>
<td>1. Probability of deterrence</td>
<td>Mathematical model of psychological deterrence (Excel)</td>
</tr>
<tr>
<td></td>
<td>2. Severity of consequences for offenders</td>
<td></td>
</tr>
<tr>
<td><strong>Physical Access</strong></td>
<td>1. Probability of detection</td>
<td>Queuing theory (Extend)</td>
</tr>
<tr>
<td></td>
<td>2. Mean delay time</td>
<td></td>
</tr>
<tr>
<td><strong>Data Access</strong></td>
<td>1. Probability of detection</td>
<td>Probabilistic model (Excel)</td>
</tr>
<tr>
<td></td>
<td>2. Probability of detection at various points of data access</td>
<td></td>
</tr>
<tr>
<td><strong>Response</strong></td>
<td>1. Probability of interdiction</td>
<td>Agent based model (MANA)</td>
</tr>
<tr>
<td></td>
<td>2. Quality of communications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Existence of internal fence</td>
<td></td>
</tr>
</tbody>
</table>
The Model - Combining

• Goal: $P(\text{Successful Interdiction})$

• How?
  – Each model produces probabilities
    • Data Access – Independent
    • Physical Access – Independent
    • Response – Dependent on Physical Access
    • Deterrence – Dependent on all 3 above
  – Link them all together
  – Get $P(\text{Successful Interdiction})$ for all possible combinations and compare
Internal Personnel Group
Data Access Modeling – System Level

- Model the intruder strategy at system level
- Nodes represent barriers that an intruder must penetrate
- Overall probability of success computed by considering the probability of success of all nodes

Diagram:
- Intrusion Entry Nodes
  - Office Access
  - Data Center Access

- Attack Tool Nodes
  - Network Access thru Client PC

- Protection Nodes
  - Network Security Controls (eg. FW)
  - Server Security Controls (eg. Rack, ACL)

- Data Nodes
  - Data Access
  - Undetected Exit
Internal Personnel Group
Data Access Model –
Random Test Case

• Probabilistic Model
• Based on Bayes Rule

Results

• Min (Single Authentication and with IDS)
  – 79% effective
• Max (2 Factors Authentication and IDS)
  – 89% effective

Box 1. Bayes Rule.
\[
\eta_1 = \frac{P(\text{intrusion}|\text{signal}) P(\text{signal}|\text{intrusion}) P(\text{intrusion})}{P(\text{signal}|\text{intrusion}) P(\text{intrusion}) + P(\text{signal}|\text{no-intrusion}) P(\text{no-intrusion})}
\]
and
\[
\eta_2 = \frac{P(\text{intrusion}|\text{no-signal}) P(\text{no-signal}|\text{intrusion}) P(\text{intrusion})}{P(\text{no-signal}|\text{intrusion}) P(\text{intrusion}) + P(\text{no-signal}|\text{no-intrusion}) P(\text{no-intrusion})}
\]
Internal Personnel Group
Physical Access Model

Alternatives modeled by EXTEND

1. Status Quo - Turnstiles
2. Untrained Guard - Alternative 1 + Random Search with handheld Metal detector
3. Trained Guard - Alternative 2 + Training given to identify suspicious behavior
4. Maximum Control - Alternative 3 + Metal gate detector with bag scanner
Internal movement models

1. Without internal fence – rely only on watchmen for detection
2. With internal fence – Watchmen + guard at internal fence
Internal Personnel Group
Physical Access Modeling Results

Recommended:
Max Control with internal fence

<table>
<thead>
<tr>
<th>$P_{Detection}$</th>
<th>Without Internal Fence</th>
<th>With Internal Fence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Quo</td>
<td>.343</td>
<td>.669</td>
</tr>
<tr>
<td>Untrained Guards</td>
<td>.392</td>
<td>.694</td>
</tr>
<tr>
<td>Trained Guards</td>
<td>.497</td>
<td>.747</td>
</tr>
<tr>
<td>Max Control</td>
<td>.681</td>
<td>.839</td>
</tr>
</tbody>
</table>
Internal Personnel Group
Response Model

Alternatives modeled in MANA

1. Poor Communications vs Good Communications
2. Mid-Terminal Fence w/ Gate Open vs w/ Gate Closed vs No Fence
3. Perpetrator starting at mid-field gate with good comms vs poor comms
### SCENARIO | \( P(\text{Successful Interdiction}) \)
--- | ---
No Fence, Bad Comms | 0.32
No Fence, Good Comms | 0.52
Fence w/ Open Gate, Bad Comms | 0.63
Fence w/ Open Gate, Good Comms | 0.77
Fence w/ Closed Gate, Bad Comms | 0.48
Fence w/ Closed Gate, Good Comms | **0.87**
Mid-Terminal Start w/ Bad Comms | 0.39
Mid-Terminal Start w/ Good Comms | 0.54
Deterrence Model – System Level

• Model based on research done by Robert Anthony (Institute for Defense Analysis) that appears in his paper “Deterrence and the 9-11 Terrorists”

• Involves both qualitative and quantitative analysis

• Provides quantitative value for psychological deterrence based on **probability of interdiction**

• The model also accounts for ‘severity of **consequences**’ from the perpetrator perspective.
Deterrence Model – Results

**Equation:**

\[
P_D = 1 - (1 - P_I) \left( \frac{P_I}{P_O} \right)^x
\]

**Results**

- **Status Quo**
  - 0.904*
- **Max Physical Access and Max Response**
  - 0.935*
- An increase of 3.4%

*Note: these results are for the combined Physical Access Control and Response model results.*
Internal Personnel Group
Combined Model Results
(with Data Access Results)

• Status Quo
  • 0.815
• Status Quo PA/Response with 2 factor authentication
  • 0.903
• Max PA/ Response with 1 factor authentication
  • 0.927
• Max PA/ Response with 2 factor authentication
  • 0.962
# Internal Personnel Group

**Physical Access - Response**

## Combined Model Results

<table>
<thead>
<tr>
<th>Status Quo</th>
<th>Untrained Guards</th>
<th>Trained Guards</th>
<th>Max Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Internal Fence</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bad Comm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.1210</td>
<td>.1359</td>
<td>.1677</td>
<td>.2334</td>
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<tr>
<td>Good Comm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.1816</td>
<td>.2068</td>
<td>.2609</td>
<td>.3557</td>
</tr>
<tr>
<td>With Internal Fence</td>
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<tr>
<td>Closed</td>
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<tr>
<td>Bad Comm</td>
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<td>.6542</td>
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</table>
Internal Personnel Group
Cost Benefit Analysis

Cost/Benefits Analysis

Total Life Cycle (10 yrs) cost

Probability of interdiction

Max PA, no fence
Max PA w/ fence shut
Status Quo
Internal Personnel Group
Cost Benefit Analysis

Cost vs. Benefits

- Total Life Cycle (10 yrs) cost vs. Probability of interdiction
- Status Quo
- Most Cost Efficient
- Max PA, no fence
- Max PA w/ fence shut
- Max Performance

Costs:
- $0
- $500,000
- $1,000,000
- $1,500,000
- $2,000,000
- $2,500,000
- $3,000,000
- $3,500,000
- $4,000,000
- $4,500,000

Probabilities:
- 0.121
- 0.1677
- 0.2068
- 0.2609
- 0.2933
- 0.3256
- 0.3557
- 0.3828
- 0.4243
- 0.4579
- 0.491
- 0.5934
Internal Personnel Group
Conclusions

• With current port security infrastructure, incremental improvements in procedural changes and hardware modifications can increase the security effectiveness against internal threats from 12% to 36%.

• With substantial investment in manpower, procedural changes, and additional technologies implementation, the security effectiveness can be increased further to 65%.

• Given the difficulty of addressing internal threats and the potential impacts this has on the port operation, recommend making the investment for the higher performance gain.
Internal Personnel Group
Recommended Future Study

• Preventive mechanisms to monitor suspicious activity and act upon them before they become threats
  – Pattern analysis for identification of abnormal behaviors

• Data mining techniques for misuse and anomaly detection
  – Statistical modeling
  – Temporal sequence learning
  – Neural network
  – Genetic algorithms
Summary

- Different agencies, whose efforts collectively provide port security, have different jurisdictions, organizational structures, and funding.
- A coordination problem exists amongst different agencies.
- The information received from the agencies must be rapidly received, displayed, interpreted and responded to in order for many of the modeled alternatives to be effective.
- From conducting this study, PSS12 recognized that the fusion of data is a critical issue that needs to be addressed.
Questions