Managing Port Safety and Security Risk Using Dynamic Simulation

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Thesis Statement

• Risk interventions are the tool for making ports safer.
  – Historically aimed at oil spills.
  – Later efforts aimed at passenger safety.
  – Now we must turn our efforts to security.

• Risk management must be sustainable
  – Ensuring the ongoing economic viability of a port or waterway

• Port must be considered as a system
Research in a Nutshell

• “One of the ironies of globalization is that, besides being a potential motivation of attacking America, growing global trade may also provide the delivery mechanism for a devastating attack on the U.S.” [USCG Commandant James Loy (retired)]

• Research objectives:
  – Enable decision-makers to manage security and safety in an economically sustainable manner
  – Simulation models show systemic effects of proposed interventions
  – In a data-sparse environment, eliciting the knowledge of experts is critical to meaningful decision making
Previous Work

- Prince William Sound Risk Assessment
  - Site of the Exxon Valdez Disaster
  - Model used system simulation, data analysis and expert judgment
  - Capable of modeling systemic effects of proposed interventions
  - Multi-million dollar investments made to reduce risk of further oil spills
Previous Work

- Washington State Ferries Risk Assessment
  - Largest ferry system in the United States
  - Simulation/expert judgment model improved based on NRC review of PWS study
  - Legislature approved funding of Safety Management System, training and emergency preparedness exercises
Previous Work

- San Francisco Bay Exposure Assessment
  - California legislature examining the effects of major expansion of ferry services
  - Simulation model tested the impact of proposed expansion on vessel interactions
  - Legislature considering implementing proposed expansions
Previous Work

- **Ports and Waterways Safety Assessment**
  - Federal decisions require examination of numerous ports
  - Multi-attribute model created from expert and stakeholder sessions
  - Model used in resource allocation for new vessel traffic management technology
Accident Event Chain

ORGANIZATIONAL FACTORS
- Vessel type
- Vessel age
- Pilot/officers on bridge
- Individual/team training
- Flag/classification society
- Management type/changes
- Vessel incident/accident history
- Safety management system

SITUATIONAL FACTORS
- Type of waterway
- Traffic situation
- Traffic density
- Visibility
- Wind
- Current
- Time of day

Stage 3 Accident
- E.g. Collisions, Groundings, Founderings, Allisions, Fire/Explosion
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Stage 1
Root Causes
- E.g.
  - Inadequate Skills,
  - Knowledge,
  - Equipment,
  - Maintenance,
  - Management

Stage 2
Incident
- E.g.
  - Propulsion Failure,
  - Steering Failure,
  - Hull Failure,
  - Nav. Aid. Failure,
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Stage 4
Consequence
- E.g. Oil Outflow, Persons in Peril
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Stage 5
Impact
- E.g. Environmental Damage, Loss of Life
**Accident Interventions**

1. **Stage 1: Root Causes**
   - E.g., Inadequate Skills, Knowledge, Equipment, Maintenance, Management

2. **Stage 2: Incident**
   - E.g., Propulsion Failure, Steering Failure, Hull Failure, Nav. Aid. Failure, Human Error

3. **Stage 3: Accident**
   - E.g., Collisions, Groundings, Founderings, Allisions, Fire/Explosion

4. **Stage 4: Consequence**
   - E.g., Oil Outflow, Persons in Peril

5. **Stage 5: Impact**
   - E.g., Environmental Damage, Loss of Life

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**Risk Reduction/Prevention**

1. **Stage 1**
   - 1. Decrease Frequency of Root/Basic Causes
      - E.g., ISM, Training, Better Maintenance

2. **Stage 2**
   - 2. Decrease Hazardous Exposure
      - E.g., Traffic Sep. Scheme, Nav. Aids for Poor Visibility, Work Hour Limits, Drug/Alcohol Tests

3. **Stage 3**
   - 3. Intervene to Prevent Accident if Incident Occurs
      - E.g., Emergency Repair or Assist Tug, Emergency Response Coordination, VTS Watch

4. **Stage 4**
   - 4. Reduce Consequence (Oil Outflow) if Accident Occurs
      - E.g., Double Hull, Double Bottom

5. **Stage 5**
   - 5. Reduce Impact if Oil Outflow Occurs
      - E.g., Pollution Response Vessel, Oil Boom, Pollution Response Coordination

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Attack Event Chain

**Stage 1: Threat Factors**
- E.g. Terrorist Planning combined with Hazardous Cargo Vessels, Terminals Hazmat Storage Areas, Critical Infrastructure such as Bridges

**Stage 2: Attack Attempt**
- E.g. Internal to Vessel (Crew Member?), External to Vessel (Recreational?), on Facility or Infrastructure (Vessel is weapon)

**Stage 3: Attack**
- E.g. Hazmat Cargo Explosion near Populated Area, Cargo Explosion To Disable Infrastructure (E.g. Bridges)

**Stage 4: Consequence**
- E.g. Persons in Peril, Fatalities, Vessel Damage, Port Damage, Other Infrastructure Damage

**Stage 5: Impact**
- E.g. Terror, Loss of Life, Environmental Damage, Economic Downturn

**ORGANIZATIONAL SUB SYSTEM FACTORS**
Two Markets, Industrial Trade of Vessels, Owned Chartered by Oil Companies, spot market trade vessels, Tankers often escorted, Maritime Routes Not Designed with Security in Mind

**SITUATIONAL FACTORS**
Closeness of Explosion to Population Area, Chemical Facilities or Infrastructure (e.g. Port Assets, Bridges). Traffic Density, Time of Day, Weather Conditions
**Attack Interventions**

**Petrochemical Subsystem: Interventions and Organizational Responsibilities**

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Examples of Organizational Responsibility for Interventions</th>
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</thead>
<tbody>
<tr>
<td><strong>1. Reduce Threat Factors</strong></td>
<td>U.S. Coast Guard</td>
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<tr>
<td>e.g.</td>
<td>Oil Companies</td>
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<tr>
<td>Disrupt Terrorist Activities</td>
<td>MARAD</td>
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<tr>
<td>Identify Owner and Crew List</td>
<td>Pilots</td>
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<tr>
<td>Locate Chem. Plants away from population areas,</td>
<td>DOD</td>
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<tr>
<td>Trusted Vessels Program</td>
<td>VTS/VTIS</td>
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<td><strong>2. Reduce Likelihood of Attack Attempt</strong></td>
<td>State/Local Law Enf.</td>
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<td>e.g.</td>
<td>TSA</td>
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<tr>
<td>Arm Vessels,</td>
<td>Acute Medical Care</td>
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<tr>
<td>Board Vessels at Port of Entry,</td>
<td>EPA</td>
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<tr>
<td>Improved Intelligence and Detection,</td>
<td>FEMA</td>
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<td>Escort Vessels</td>
<td>Acute Medical Care</td>
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<td><strong>3. Reduce Likelihood of Attack Success</strong></td>
<td>Local Fire/Rescue</td>
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<td>Escort Vessels,</td>
<td>Oil Companies</td>
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<tr>
<td>Ship Riders,</td>
<td>TSA</td>
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<tr>
<td>Improve Terminal Security</td>
<td>Acute Medical Care</td>
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<td><strong>4. Reduce Immediate Consequences</strong></td>
<td>EPA</td>
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<td>On Board Fire Suppression,</td>
<td>Acute Medical Care</td>
</tr>
<tr>
<td>Escort Vessel Fire,</td>
<td>Port Contingency Plans &amp; Experience.</td>
</tr>
<tr>
<td>Facility Fire,</td>
<td>Port Contingency Plans &amp; Experience.</td>
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<td>Resp. Resp.</td>
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<td><strong>5. Reduce Delayed Consequences</strong></td>
<td>Acute Medical Care</td>
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<td>Pollution Response,</td>
<td>FEMA</td>
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<tr>
<td>Mass Casualty Response.</td>
<td>Acute Medical Care</td>
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<tr>
<td>Port Contingency Plans &amp; Experience.</td>
<td>Acute Medical Care</td>
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**Examples**

- PETROCHEMICAL SYSTEM: Interventions and Organizational Responsibilities

- **Merrick, Harrald, van Dorp (GWU)**

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Modeling Approach

• Port Simulation
• Definition of Critical Infrastructure at Risk
• Exposure Counting Model
• Multi-attribute Security Vessel Risk Model
  – Owner/Operator, Type of charter, Cargo Broker, Officers/crew id, Nationality, Background, Crew agent, Flag State, Agent, Last Port, Voyage Route, Unique voyage or routine route, Loading Facility.
Benefit to Defense and Homeland Security

• Base model outputs:
  – Geographic Profile of Security Risk
  – Geographic Profile of Safety Risk

• Model proposed security interventions:
  – Systemic impact on security risk
  – Systemic impact on safety risk
  – Impact on efficiency and economics of port operations
Research Sponsors

- Prince William Sound Shipping Companies.
- Prince William Sound Regional Citizens’ Advisory Council
- United States Coast Guard
- Washington State Ferries
- Washington State Transportation Commission
- San Francisco Bay Water Transit Authority
- National Science Foundation

See NSF Project Web-Site for Journal Papers, Technical Reports and Simulation Movies:
http://www.seas.gwu.edu/~dorpjr/tab3/NSFProject_GWU_VCU/NSFMain.html
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