Presentation Content

INTRODUCTION
OVERVIEW
THE US DOT GULF COAST STUDY
BAYPORT TERMINAL CLIMATE CHANGE STUDY
CONCLUSIONS AND RECOMMENDATIONS
QUESTIONS AND ANSWERS
South Korea, Norway to Establish New Arctic Shipping Routes

South Korean President Lee Myung-bak is visiting Norway with an aim of establishing new shipping routes over the Arctic which might cut in half the current travelling times and upsurge trade exchange between Europe and Asia. Barents Observer informs.

Arctic sea routes open as ice melts

By Richard Black
Environment correspondent, BBC News

Two major Arctic shipping routes have opened as summer sea ice melts, European satellites have found.

Data recorded by the European Space Agency's ENVISAT shows both Canada's Northwest Passage and Russia's Northern Sea Route simultaneously.

This summer’s melt could break the 2007 for the smallest area of sea ice since observations began in 1799.

Shipping companies are already eying if they remain open regularly.

The two lanes have been used by a rare number of ships.

But the Northern Sea Route has been frantically used for the first time by a number of tankers carrying natural gas from Russia’s Yamal region.

They’re often open at the same time in July and August, you can get through them,” observed Peter Wadhams, a researcher at the University of Cambridge.

Shipping developers eye up route through melting Arctic

While the rate of ice loss in the Arctic has alarmed environmentalists this summer, it has left maritime developers rubbing their hands with glee, as the prospect of a commercially viable Northern Sea Route looks increasingly likely.

By Sébastian SEIBT (text)
Global Average Sea Level is Rising

(Data from NASA)
Vulnerabilities: Ports and Harbors

• Hoboken, New Jersey
  – a Hudson River Marina across New York City

• Staten Island, New York
  – a 168-foot water tanker, sits on the shore in the Stapleton neighborhood
Vulnerabilities: Coastal Infrastructure

• Storm Surge
  – Mirlo Beach, North Carolina
  – Oct. 30, 2012

• Sea Level Rise
  – Jan 2, 2013
  – Houston Chronicle
Vulnerabilities: Supply Chain

Warping Rail lines

• “Heat: train derailment”
  • July 2012, D.C. Metro

• “Extreme Texas Heat Threatens Rail Lines”
  • August 3, 2011

• “The Massachusetts Bay Transportation Authority has had to repair heat kinks”
  • July 7, 2010

• “Virginia Railway Express passengers can expect delays as the extreme heat forces trains to slow down.”
  • July 6, 2010
Vulnerabilities: Airports and Roadways

• “Airplane stuck in heat-softened tarmac”

• “SUV goes airborne after road buckles”
  – Eau Claire, Wis., Jul 3, 2012

• “Heat wave expands, as do signs of the times: buckled roads”

• “Buckled road caused crash”
  – Oklahoma Turnpike Authority July 2011

• “In Minnesota, a state legendary for its cold winters, the heat and humidity is so high this week that highway pavement was buckling in the Minneapolis-St. Paul area.”
  – Jun 7, 2011
Vulnerabilities: Coastal Communities
Before and After

July 17, 2001

August 31, 2005

Hurricane Katrina

September 9, 2008

September 15, 2008

Hurricane Ike

[Images of coastal communities before and after hurricanes Katrina and Ike]
Vulnerabilities: Coastal Communities
Before and After Fire Island, New York
Pea Island National Wildlife Refuge, NC.
Values normalized to 2011 dollars.
Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Phase I

THE GULF COAST STUDY
Highways at risk from a relative SEA LEVEL RISE of 2 ft

(Source: U.S. DOT data; Cambridge Systematics analysis)
Highways at risk from a relative SEA LEVEL RISE of 4 ft

(Source: U.S. DOT data; Cambridge Systematics analysis)
Highways at risk from STORM SURGE at elevations currently below 18 ft

(Source: U.S. DOT data; Cambridge Systematics analysis)
Highways currently at risk from STORM SURGE at elevations currently below 23 ft

(Source: U.S. DOT data; Cambridge Systematics analysis)
Railroad-owned and -served freight facilities at risk due to relative SEA LEVEL RISE 2 and 4 ft

(Source: U.S. DOT data; Cambridge Systematics analysis)
Rail lines at risk due to STORM SURGE of 18 and 23 ft

(Source: U.S. DOT data Cambridge Systematics analysis)
Railroad-owned and -served freight facilities at risk due to STORM SURGE of 18 and 23 ft

(U.S. DOT data; Cambridge Systematics analysis)
Freight handling port facilities at risk from relative SEA LEVEL RISE of 2 and 4 ft

(Source: U.S. Army Corps of Engineers data; Cambridge Systematics analysis)
Freight handling port facilities at risk from STORM SURGE of 18 and 23 ft

(Source: U.S. Army Corps of Engineers data; Cambridge Systematics analysis)
A high level risk and vulnerability assessment of potential climate change impacts
PHA Bayport Terminal: Climate Change Risk and Vulnerability Assessment

- Key objectives of this study:
  - Identify climate change threats
  - Develop inventory of at-risk facilities and operations
  - Prioritize high risk facilities and operations
  - Assess risk and vulnerability for high priority facilities ACCA
  - Evaluate adaptation measures
A Mechanism and Framework for Continuous Evaluation

- Capital infrastructure investments
- Integration with existing risk management activities
- Evaluate the potential business and operational risks
- Develop adaptive measures to reduce risks
- Establish a long term climate change strategy
Systematic Risk Management Approach of Climate Change Impacts
Climate Change Risk Universe

Graph showing the relationship between time (years), increasing facility exposure, and increasing facility vulnerability, with four risk categories: Moderate Risk, Greatest Risk, Low Risk, Significant Risk.
Step 1: Identify Potentially At-Risk Infrastructure and Services
Step 1: Identify Potentially At-Risk Infrastructure and Services

- **Transportation Service Providers:**
  - Vessel/Ship Carriers
  - Terminal Operators
  - Trucking Companies
  - Rail Lines
  - Stevedores/Tug Operators
  - Labor Unions
  - Others

- **Government Agencies:**
  - US CBP
  - United States Coast Guard
  - USACE and other DOD Branches
  - Foreign Government Agencies

- **Port and Local Stakeholders:**
  - Port of Houston Authority (PHA)
  - Utility Providers
  - Emergency Service Providers
  - Lodging/Food Service Providers
  - Members of AMSC
  - Others
### Step 2: Identify Climate Change Threats

<table>
<thead>
<tr>
<th>Hazard/Climate Change Indicator</th>
<th>Historical range and Time period</th>
<th>Range of possible change and Time period</th>
<th>Impact to the region</th>
<th>Impact on the Bayport Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Precipitation and storm frequency</strong></td>
<td>1900-2000: Annual precipitation ranged from 1.76 inches to 109.38 inches with a mean of 37-55 inches</td>
<td>2020: No change in total precipitation but more frequent storms and heavy downpours expected</td>
<td>2050: No change in total precipitation but more frequent storms and heavy downpours expected</td>
<td>Damage to the natural and built environment</td>
</tr>
<tr>
<td><strong>Sea level rise</strong></td>
<td>+0.1 to +0.2 ft</td>
<td>+0.7 to +1.7 ft</td>
<td>+1.0 to 3.0 ft</td>
<td>Decrease in protection to infrastructure from storm surges</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>Rise of 0.4°F to 0.9°F in SE Texas</td>
<td>+1.0°F to +2.0°F</td>
<td>+3.0°F to +4.5°F</td>
<td>Deterioration of infrastructure and the natural environment</td>
</tr>
<tr>
<td>Impacts</td>
<td>Risks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Increased frequency of storms, hurricanes, cyclones and heavy          | • Increased dredging requirements due to changes in siltation patterns caused by sea level rise, wave patterns and storm surge frequency and severity  
| precipitation events                                                  | • Increased timetable delays and, during extreme storm/hurricane conditions, port closure due to reduced berth operability and safety issues                                                                 |
| Rising sea levels and storm surge                                      | • Increased damage to wharf structures, terminal buildings, storage buildings, and containers from flooding and storm damage  Berthing difficulties during high tide |
| Increased summer temperatures, incidences of drought, and frequency/   | • Water shortages and increased water demand for cooling, washing and dust suppression                                                                                                             |
| severity of heat waves                                                 |                                                                                                                                                                                                 |
| Changes to trade patterns, impacts on the supply chain and            | • Increased variability in season-to-season and year-to-year shipping conditions                                                                                                                     |
| interdependencies                                                      |                                                                                                                                                                                                 |
## Step 3: Risk Assessment

<table>
<thead>
<tr>
<th>Risk/ Opportunity</th>
<th>When will it become a ‘Very High’ risk?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased damage to wharf structures, terminal buildings and storage buildings and containers from flooding and storm damage</td>
<td>2050s</td>
</tr>
<tr>
<td>Increased dredging requirements following storms</td>
<td>2050s</td>
</tr>
<tr>
<td>Increased timetabling delays due to extreme weather events</td>
<td>2050s</td>
</tr>
<tr>
<td>Loss and erosion of land from sea level rise and storm surge</td>
<td>2080s</td>
</tr>
<tr>
<td>Water shortages and increased water demand for cooling, washing and dust suppression</td>
<td>2050s</td>
</tr>
<tr>
<td>Infiltration or submersion of storm and sewer drainage systems and pollution risk from overwhelmed drainage</td>
<td>2080s</td>
</tr>
<tr>
<td>Increased variability in season-to-season and year-to-year shipping conditions</td>
<td>2050s</td>
</tr>
<tr>
<td>Failure to secure products and services vital to keeping the terminal operating at the required level (e.g. chemicals and diesel) during extreme weather events</td>
<td>2080s</td>
</tr>
</tbody>
</table>
### Step 3: Risk Assessment (cont.)

<table>
<thead>
<tr>
<th>Infrastructure and Operations Component</th>
<th>Potential Climate Change Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle movements inside the port</td>
<td>- Increased flood risks to port due to sea level rise</td>
</tr>
<tr>
<td>Demand, trade levels and patterns</td>
<td>- Impacts on total trade through PHA's Bayport Terminal</td>
</tr>
<tr>
<td></td>
<td>- Changes in trade flows due to effects on other ports and trade dynamics</td>
</tr>
<tr>
<td>Goods storage</td>
<td>- Impacts of heavier rainfall on the PHA’s Bayport Terminal drainage system, flood risk to storage areas due to sea level rise, water used for the facility, refrigeration impacts due to rising temperatures or power loss and impacts on storage of containers; impacts from high wind</td>
</tr>
<tr>
<td>Environmental performance</td>
<td>- An inundated waste treatment or holding facility could be significant in disturbing the ecological balance</td>
</tr>
<tr>
<td></td>
<td>- Under the scenario of 1.5 meters sea level rise, a total of 33 sites would be impacted or threatened with 16 being wastewater treatment plants and 9 being solid waste sites in the Galveston bay region.</td>
</tr>
<tr>
<td>Navigation and berthing</td>
<td>- Navigation, berthing, and dredging issues associated with sea level rise and increased storm events</td>
</tr>
</tbody>
</table>
Step 3: Risk Assessment (cont.)
Step 4: Potential Adaptation Responses

- Identify critical assets to business continuity, where these are located, and how sensitive they are to extremes of weather
- Undertake regular and on-going programmes of maintenance and repair of all assets under PHA's ownership or responsibility
- Upgrade refrigeration equipment to less temperature sensitive solutions as technology improves
- Increase drainage capacity in line with future design standards
- Consider introducing more flexible working hours and stress test contingency planning during extreme weather events
- Strengthening of infrastructure to protect it from storm surge, flooding and wave damage

Efforts to adapt to climate change should be proportionate to the risks.
CONCLUSIONS AND RECOMMENDATIONS
Conclusions

• There are numerous economic, environmental, social, legal and legislative drivers to adaptation and resilience building

• Climate change impacts will likely impact other PHA terminals and the port sector across the world

• As an inland port, it is possible that the Bayport Terminal may be less vulnerable to the impacts of some of these hazards compared to other ports in the region that are projected to experience greater levels of subsidence

• Risks to the landside supply chain, and the interdependent sectors such as energy, water, and telecommunications/Information Technology, may have greater vulnerabilities and as a result could impact Bayport efficient operations as well
Recommended Future Studies

• A port-wide assessment (all PHA assets)
• A regional assessment (all Houston Shipping Channel assets)
• A detailed assessment for a particular key hazard/threat to include engineering performance analysis
• A detailed assessment of the adaptation strategies (i.e. benefit-cost-analysis, feasibility study of strategies)
• Periodic updates to the studies/plans as science and operating conditions change