Port Corpus Christi Ship Channel and Waterways Planning and Design using Simulation

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• Industry Trends
• Case Study
  • Data Needs
  • Analysis Techniques
  • Results
• Benefits of simulation modeling

VESSEL NETWORK MODEL
U.S. Waterway System in 2017

- 2.4 Billion Short Tons of U.S. Waterborne Traffic
- 600 Billion Ton-miles of Cargo movement
- 230 Million Cubic Yards of Dredging
- $1.4 Billion Spent in channel New Work & Maintenance (123 contracts)
- Approximately 100,000 Ship Calls per Year

AAPA Survey: $130 Billion shortfall in federal funding over the next five years in land- and waterside infrastructure
Tidal Impacts on Draft and Air Draft
Air Draft vs Tidal Variation, Lion’s Gate Bridge Example
Impact of Weather on Vessel Operating Rules

- Ports may occasionally close, or operate with more restricted rules
- Two-way channels may become one-way in fog or high wind conditions
- More tugs may be required in some conditions
- Weather probability will vary with seasons
Ships Need Pilots and Tugs to Move

- Location for Pilot on/off?
- Number of tugs per vessel?
- Total port-wide pilot/tug capacity?
- Will lack of pilots or tugs affect port capacity?
- Is work schedule 24/7?
- What total time required to move ships to each neighborhood?
Vessel Passing rules

- What gap required between ships?
- Fixed gap or % of ship beam?
- What gap between ship and shore?
- Same for night vs day?
- Same in all weather?
- Dependent on ship cargo?
- Dependent on # tugs used?
- How closely can ships follow each other when moving in the same direction?
Daylight vs Night Navigation

- In some harbors, some vessels can only move during daylight
- Harbor capacity changes for summer vs winter as daylight expands
- Larger ships tend to have more restrictive rules
- Investment in navigation aids can perhaps change rules
- Vessels with restricted rules want to have terminals close to the open sea
Port of Corpus Christi has more than 45 Individual Terminals / Docks
Increasing Number of Ship Arrivals at Port of Corpus Christi
Corpus Christi Ship Channel Snapshot of Activity in 2015

- 5,425 pilot events
- 4,849 ship movements (some with more than one pilot)
- 115% ratio of peak/mean week
- 54 ship moves per peak week
- 8 ship moves per mean day, peak week

Port-Wide Vessel Mix
A Busy Port with Vessels Coming in Every Day

Monthly Arrival Pattern

Day of Week Arrival Pattern

Hourly Arrival Pattern
Weather (fog+wind) Closure By Month 2011-2015, Corpus Christi
Port Users are Rapidly Shifting to Larger Vessels
Draft vs Cargo Capacity

<table>
<thead>
<tr>
<th></th>
<th>VLCC</th>
<th>SuezMax</th>
<th>AfraMax</th>
</tr>
</thead>
<tbody>
<tr>
<td>500,000</td>
<td>75</td>
<td>52</td>
<td>-</td>
</tr>
<tr>
<td>1,000,000</td>
<td>45</td>
<td>52</td>
<td>-</td>
</tr>
<tr>
<td>1,500,000</td>
<td>45</td>
<td>52</td>
<td>-</td>
</tr>
<tr>
<td>2,000,000</td>
<td>45</td>
<td>52</td>
<td>-</td>
</tr>
<tr>
<td>2,500,000</td>
<td>45</td>
<td>52</td>
<td>-</td>
</tr>
</tbody>
</table>
Several Additional Tug Boats required for VLCC Docking
Bigger Vessels Take Longer to Load/Unload

Dwell Time vs Ship Size

Dwell Time vs Cargo Transfer Size
Corpus Christi Ship Channel Vessel Beam Restrictions

- Cut A @ 500’ wide - 265’ of total beam
- Cut B @ 400’ wide - 215’ of total beam
- Citgo/ADM, 357’ of total beam for berths+channel
- La Quinta Channel is one way only regardless of size
Operating Rules Vary by Vessel Class

- VLCC and LNGC vessels cannot meet/pass any other vessel types regardless of channel width

<table>
<thead>
<tr>
<th>Rule</th>
<th>VLCC</th>
<th>LNGC</th>
<th>Suezmax</th>
<th>Aframax</th>
<th>Panamax</th>
<th>Handy</th>
<th>Sub-hand</th>
<th>ATB (Ocean Barge)</th>
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</thead>
<tbody>
<tr>
<td>Tugs inbound</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2.5</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Tugs outbound</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2.5</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pilots @ day</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1.5</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pilots @ night</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Typical beam (ft.)</td>
<td>200</td>
<td>154</td>
<td>158</td>
<td>138</td>
<td>106</td>
<td>90</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Daylight only Y/N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y for 40.9'</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>
Variables to Adjust to Achieve Calibration

- Ship speed
- Mix of ship sizes
- Pilot/tug deadhead time
- Ship dwell time at berth
- Berth availability (tankage constraints)
- Port-wide shutdown time (fog etc.)
AECOM Vessel Network Model (VNM)
Optimize and Prioritize Dredging Requirements
Optimize Piloting Rules
Sample Modeling Results

Existing Terminal Delay vs 2018 Condition

- 2018 @ 45'
- 2023 @ 45'
- 2023 @ 52'
- 2023 @ 52' Suez Travel at night
- 2023 @ 52' LNGC Travel at night
- 2028 @ 45'
- 2028 @ 52'
- 2028 @ 52' + Harbor Island @ 75'

- 100%
- 125%
- 102%
- 138%
- 112%
- 109%
- 81%
- 106%
- 0%
- 20%
- 40%
- 60%
- 80%
- 100%
- 120%
- 140%
- 160%
Ship Channel and Waterways Planning and Design using Simulation

- Channel Capacity
- Phasing of Capital Dredging
- Phasing of Maintenance Dredging
- Congestion Mitigation Planning
- Lay berth or in-harbor anchorage options
- Convoy options
- Identify Landside capacity issues for key terminals
- Detailed analysis of pilot and tug resources
- Reverse lightering

Thank you for your attention!