Background

- Corps is resource-constrained but must maintain an aging water resources infrastructure portfolio that is critical to national well-being.

- Navigation projects at coastal ports and along inland waterways facilitate marine transportation and help support complex, dynamic, global freight supply chains.

- Challenge going forward is how to optimally support the national Marine Transportation System (MTS) using available resources.
• Waterborne freight corridors cannot be separated from landside (road, rail, pipeline) systems.

• Recent federal transportation bills increasingly focus on intermodal systems and the need to evaluate supply chains across modes.

• Corps Senior Leadership has been stressing systems-based approaches to mission execution.
Need for Objective Decision Support

- Two-year budget cycle consists of
  1) selection of work packages for full/partial funding
  2) work plan development (job assignment/scheduling)
- Limited HMTF outlays → insufficient funding to execute full O&M needs at all projects every year
- Environmental work windows effectively reduce dredge fleet capacity, limit competition, and drive program-level cost increases.
- Districts competing against each other for available funding as well as for availability of contracted dredges.
Navigation Performance Monitoring Tools

• Channel Portfolio Tool (CPT) – https://cpt.usace.army.mil
  - provides Corps personnel with improved access to and understanding of the data provided by the USACE Waterborne Commerce Statistics Center (WCSC)
  - web-based decision-support tool which helps convey the importance of Corps dredging activity to the efficient movement of maritime commerce

  - web-based tool for acquiring, analyzing, and visualizing real-time and archival vessel position report data from the U.S. Coast Guard’s Nationwide Automatic Identification System (NAIS)
  - Unprecedented access to quantitative, statistically robust measures of navigation project performance through time
  - Provides scalable (across time and space) analysis capabilities that answer questions about navigation project utilization and interactions between vessel traffic and the natural environment
Identifying Significant Corridors

- CPT allows for scalable queries of the rich Waterborne Commerce tonnage database, so significant commodity corridors at the local, regional, and national level can all be quickly identified and sorted.

- Users can sort unique origin-destination flow combinations for subsets of traffic based on commodity, vessel type, draft, direction, and year.

Top Ohio River Destination Segments (short tons)

<table>
<thead>
<tr>
<th>Destination</th>
<th>Short Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>@Wellsville, OH (RM 44-53)</td>
<td>584k</td>
</tr>
<tr>
<td>@ Steubenville, OH (RM 54-83)</td>
<td>502k</td>
</tr>
<tr>
<td>Upstream of Louisville, KY (RM 542-600)</td>
<td>492k</td>
</tr>
<tr>
<td>Upstream of Cincinnati (RM 434-446)</td>
<td>472k</td>
</tr>
<tr>
<td>@Huntington, WV (RM 305-315)</td>
<td>449k</td>
</tr>
</tbody>
</table>

Downbound Cargo Flows past Pittsburgh (6.84M short tons)
Major Commodity Flows

IMTS Top Commodities, 2011-2015 (Million Short Tons)

- **Coal**, 157.1
- **Sand/Gravel**, 59.9
- **Distillates**, 48.5
- **Chemicals**, 33.7
- **Crude Oil**, 30.9
- **Soybeans**, 28.6
- **Corn**, 27.0
- **Petrol. Pitches, Coke, Asphalt**, 25.0
- **Gasoline/Kerosene**, 16.4
- **Primary Iron and Steel**, 15.5
- **Wheat**, 10.9
- **Fertilizers**, 14.9

Obtained via a CPT “Rollup” query for all federally designated fuel taxed waterways.
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Corps Shoaling Analysis Tool

➢ What will the channels look like in the future?
➢ Use historical survey data from eHydro and generate difference grid sets between dredging events
➢ Predict average shoaling rates and dredging requirements per channel reach
➢ Report volumes at different depth/time intervals and shoaling rates
➢ Efficiently process large spatial datasets
CPT/e-Hydro/CSAT Integration

Comparing these quantities provides optimal dredge-to depth

Total dredging costs

Disrupted tonnage

Dredge target depth

Rollup Project Commodity Draft vs. Average Yearly Tons for All Shipments

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## Dredge Work Package Formulation

<table>
<thead>
<tr>
<th>Optimal Target Depth (ft)</th>
<th>Time Until Dredging Takes Place (Years)</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculasieu Gap</td>
<td></td>
<td>35.03011</td>
<td>52.46583</td>
<td>68.87481</td>
<td>82.36058</td>
<td>90.64498</td>
<td>94.80497</td>
<td>94.14798</td>
</tr>
<tr>
<td>Columbia near MCR</td>
<td></td>
<td>35.77783</td>
<td>26.92696</td>
<td>11.9538</td>
<td>7.313952</td>
<td>5.418806</td>
<td>4.439269</td>
<td>3.880387</td>
</tr>
<tr>
<td>Texas City outer</td>
<td></td>
<td>39.39505</td>
<td>55.06927</td>
<td>62.90344</td>
<td>64.24062</td>
<td>62.38521</td>
<td>59.47904</td>
<td>56.6367</td>
</tr>
<tr>
<td>Texas City total</td>
<td></td>
<td>38.41477</td>
<td>46.30422</td>
<td>44.95194</td>
<td>41.97186</td>
<td>39.26637</td>
<td>37.47005</td>
<td>36.23801</td>
</tr>
<tr>
<td>Charleston Entrance</td>
<td></td>
<td>12.3408</td>
<td>18.51115</td>
<td>24.65794</td>
<td>30.19148</td>
<td>33.13396</td>
<td>32.66262</td>
<td>30.26347</td>
</tr>
<tr>
<td>Cook Inlet</td>
<td></td>
<td>2.29658</td>
<td>3.44487</td>
<td>4.593099</td>
<td>5.741193</td>
<td>6.888865</td>
<td>8.034747</td>
<td>9.174922</td>
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<tr>
<td>Galveston Entrance</td>
<td></td>
<td>185.0326</td>
<td>255.9148</td>
<td>280.0451</td>
<td>262.7408</td>
<td>230.1306</td>
<td>197.8446</td>
<td>170.9211</td>
</tr>
<tr>
<td>Galveston Entrance</td>
<td></td>
<td>77.2865</td>
<td>81.43576</td>
<td>78.16375</td>
<td>73.73789</td>
<td>69.79972</td>
<td>66.44992</td>
<td>63.59281</td>
</tr>
<tr>
<td>Galveston Harbor</td>
<td></td>
<td>2.881098</td>
<td>3.141968</td>
<td>3.078682</td>
<td>2.926068</td>
<td>2.788178</td>
<td>2.876293</td>
<td>2.961408</td>
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<tr>
<td>Galveston Harbor</td>
<td></td>
<td>2.719758</td>
<td>2.909423</td>
<td>2.875424</td>
<td>2.788714</td>
<td>2.723247</td>
<td>2.844596</td>
<td>2.969029</td>
</tr>
</tbody>
</table>

- Object framework for comparing benefits derived to dredging costs incurred at federal navigation projects.
Tons per vessel trends

Based on Waterborne Commerce data for 2010-2014 (annual avg.) processed via CPT.
# Draft Restrictions in Context

<table>
<thead>
<tr>
<th></th>
<th>Avg. Total Tonnage (xM)</th>
<th># of Additional Required voyages (6-ft reduction in controlling depth)</th>
<th>Total Additional Shipping Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Miss.</td>
<td>412.6</td>
<td>99 74 43 220</td>
<td>$167.2M</td>
</tr>
<tr>
<td>HSC-Galv.-TX-City</td>
<td>210.8</td>
<td>95 51 6 11</td>
<td>$34.2M</td>
</tr>
<tr>
<td>Sabine-Neches</td>
<td>81.8</td>
<td>444 184 30 68</td>
<td>$110.5M</td>
</tr>
<tr>
<td>Corpus Christi</td>
<td>66.7</td>
<td>30 2 2 7</td>
<td>$11.9M</td>
</tr>
<tr>
<td>Mobile</td>
<td>54.3</td>
<td>-- -- 62 82</td>
<td>$39.1M</td>
</tr>
<tr>
<td>Calcasieiu</td>
<td>52.8</td>
<td>55 21 12 32</td>
<td>$26.8M</td>
</tr>
<tr>
<td>Freeport</td>
<td>23.9</td>
<td>144 19 -- --</td>
<td>$34.7M</td>
</tr>
</tbody>
</table>
Dredge Fleet Scheduling Optimization

- Formulate Year 1 as Project Selection Optimization, solve via Genetic Algorithms
- Formulate Year 2 as Job Assignment/Scheduling Optimization Problem; solve via constraint programming using interval variables
- Ask the models questions…

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US Coast Guard’s Nationwide Automatic Identification System (NAIS)

- http://www.navcen.uscg.gov/?pageName=NAISmain
- Broadcast AIS messages include:
  - Vessel identification
  - Location (lat/lon coordinates)
  - Date-Time stamp
  - Course over ground
  - Speed over ground
  - Vessel characteristics
- Discrete data points
  - Transmission intervals from 2-10 sec. for class A units; 15-30 sec. for others
  - NAIS “full” coverage in U.S. coastal areas out to roughly 25 miles; much further in practical terms
  - Coverage along U.S. river system at USACE lock sites (LOMA program, run by CHL!)

Originally intended for real-time maritime domain awareness and port security
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AISAP Functional Layout

USCG NAIS

USCG-USACE Interagency Security Agreement

USCG web services

Scripts for batch service calls via GUI

AISAP web portal

USACE data cache

Basic data retrieval (.csv and .kml)

Built-in analysis and visualization features

USCG-USACE Interagency Security Agreement

Interagency Security Agreement

United States Coast Guard (USCG) Nationwide Automatic Identification System (AIS) and United States Army Corps of Engineers (USACE)

AISAP web portal

USACE data cache

Basic data retrieval (.csv and .kml)

Built-in analysis and visualization features
By querying the network bottlenecks, we can efficiently acquire AIS data for entire port systems over meaningful timeframes.
AISAP Heat Maps

Great way to visualize relative traffic densities across large (or small) spatial domains.
AISAP Track Line Overlays
Port Performance Evaluations

- **IAA with Bureau of Transportation Statistics**: 5-year agreement for technical support to BTS with AIS archival data, Channel Portfolio Tool (CPT) analysis, and truck probe data.

- **$100k first year reimbursable support** of the Port Performance Freight Statistics Program (PPFSP) and the biennial National Census of Ferry Operators.

- Looking to expand the range of support activities being provided to BTS for out-year planning:
  - Trends in Waterborne transportation
  - Truck probe data mining
  - Intermodal freight flows and scenario modeling
Intermodal Freight Connections

- Landside freight routing model and mapping capability
  - Internal ERDC capability, to be used in conjunction with CPT/AISAP
  - Uses county-level origin-destination data from the ORNL Freight Analysis Framework (FAF) procured previously
  - Routes movements along respective highway and rail networks
  - User can specify mode-commodity combinations and a geographic extent; queries include relative rankings, network flows, and rollup reports.