Marine Transportation System Travel Time Atlas

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U.S. Army Engineer Research and Development Center

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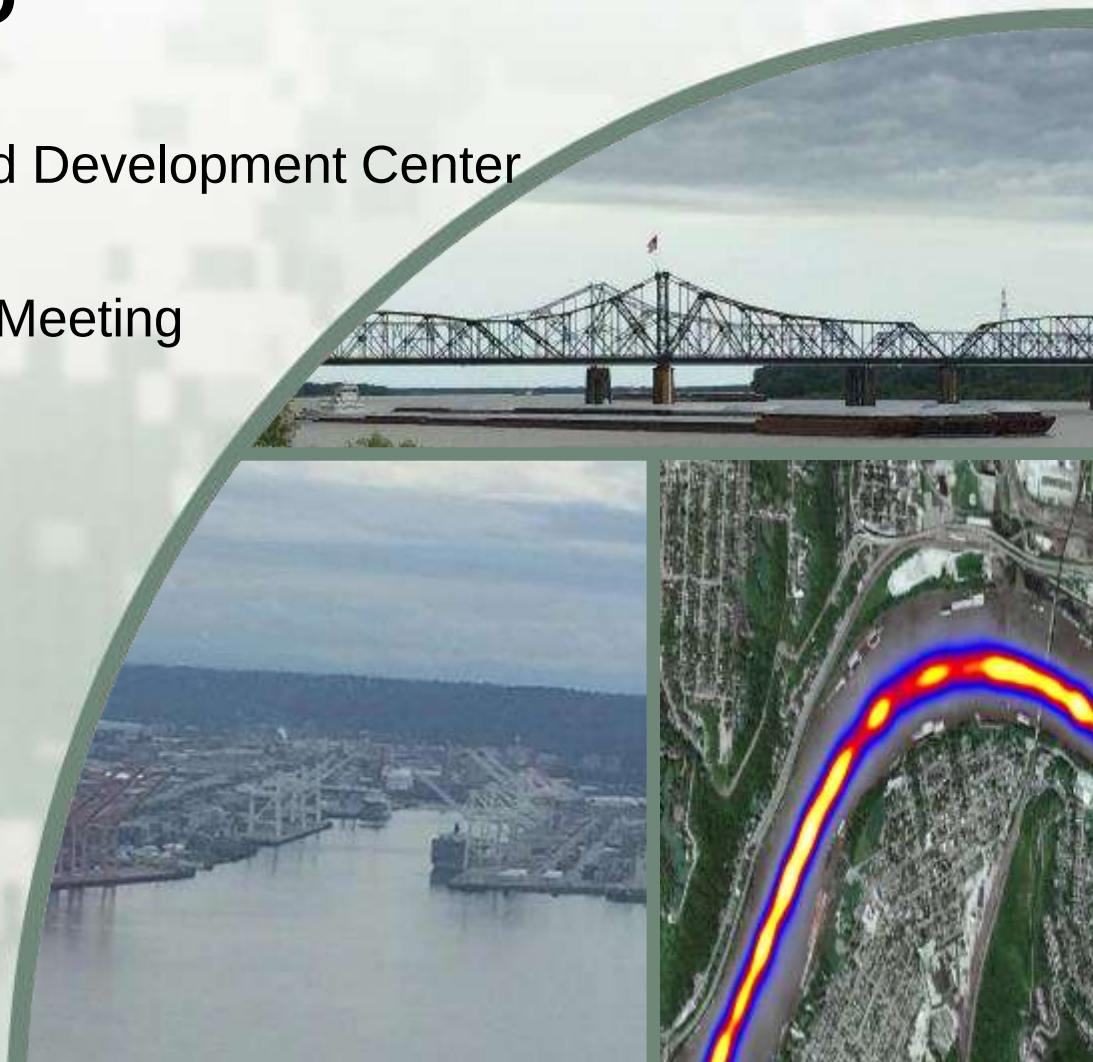

COASTAL & HYDRAULICS LABORATORY

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Project Motivation

- The Navigation Mission of the United States Army Corps of Engineers (USACE) facilitates the safe, reliable, and economically efficient movement of vessels on the nation's waterways.

- Travel times are applied as performance measures for other transport modes:

  "By measuring travel-time performance, and related system metrics based on travel time, agencies will be better able to plan and operate their systems to achieve the best result for a given level of investment. At the same time, travelers, shippers, and other users of those systems will have better information for planning their use of the system." *National Cooperative Highway Research Program Report 618 "Cost-Effective Performance Measures for Travel Time Delay, Variation, and Reliability", 2008*

Project Objective

Create a statistical profile of waterway system travel times from vessel position reports including **travel time variability**, **speed**, and **delay**; evaluate during normal conditions as well as in response to recurring and non-recurring events such as storms, high and low water levels, vessel incidents, and operation and maintenance (O&M) actions.

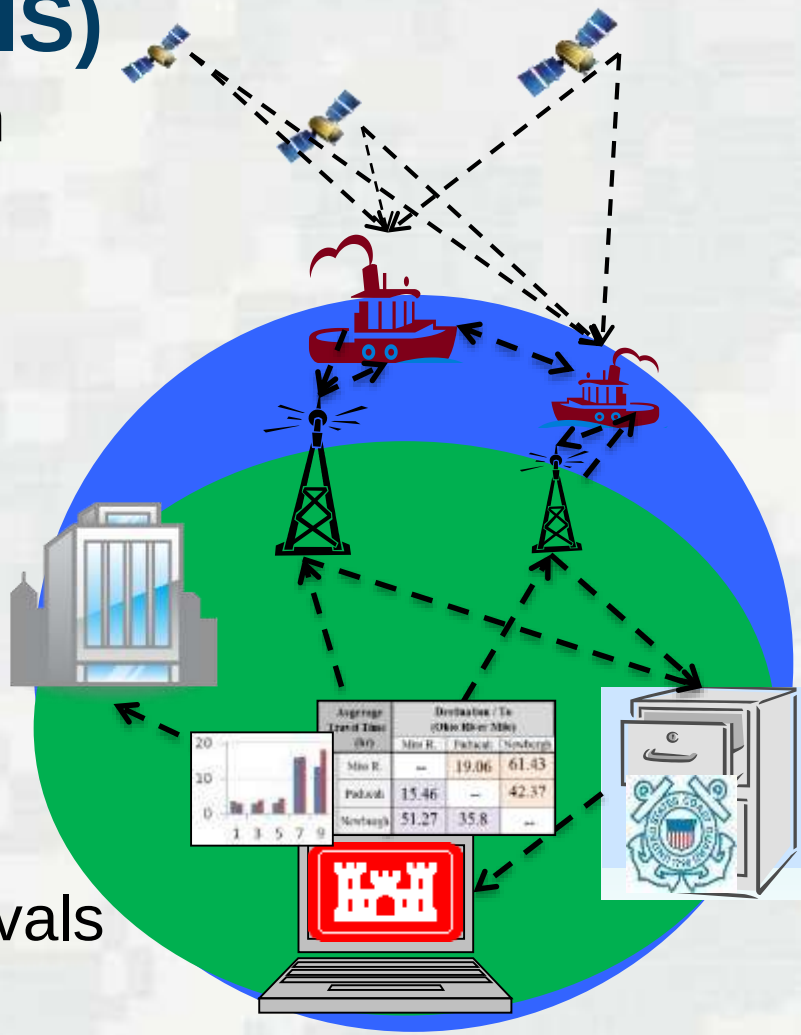
Applications

- Establish system performance baselines
- Quantify system performance during and after disturbances
- Measure system resiliency (withstand, recover)
- Locate system bottlenecks and areas with most critical needs
- Compare performance pre and post-O&M
- Aid decision making for O&M actions
- Identify vessel traffic patterns over time including port pairs, trip chaining, and systems

Resiliency Cycle

Data Source: Automatic Identification System (AIS)

- AIS is a shipboard broadcast system
  - Operates in the VHF radio spectrum
- Information includes the following:
  - Vessel identification
  - Location (latitude and longitude)
  - Time stamp
  - Heading
  - Speed
  - Vessel characteristics
- Broadcasts are at discrete time intervals
  - Every 2 to10 seconds while a vessel is underway
  - Every 3 minutes while at anchor

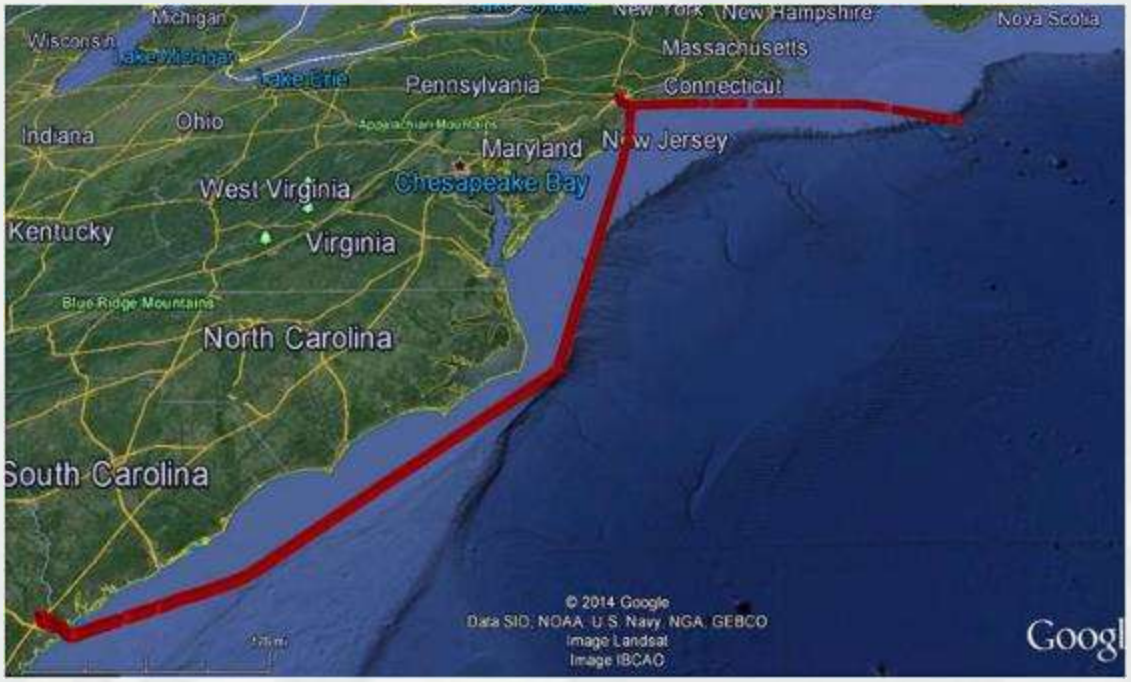


Data Source (Continued)

- AIS carry requirements are set by federal regulations:
  - Self-propelled vessel of 65 feet or more in length, engaged in commercial service
  - Towing vessel of 26 ft or more in length and more than 600 horsepower, engaged in commercial service
  - Self-propelled vessel that is certified to carry more than 150 passengers
  - Self-propelled vessel engaged in dredging operations
  - Self-propelled vessel engaged in the movement of dangerous cargo or flammable or combustible liquid cargo
  - Fishing industry vessels
- Obtaining data
  - Landside receivers can collect the broadcasts
  - Variety of commercial sources are available for data

Methodology to Estimate Travel Times Illustration

Vessel docked at a port in Bayonne, NJ 12/29/14



Vessel AIS position reports from 12/27/14 through 1/4/15

Methodology Illustration (Continued)

Bayonne, NJ

Savannah, GA

Estimated travel time = 2 days, 1 hour, and 25 minutes

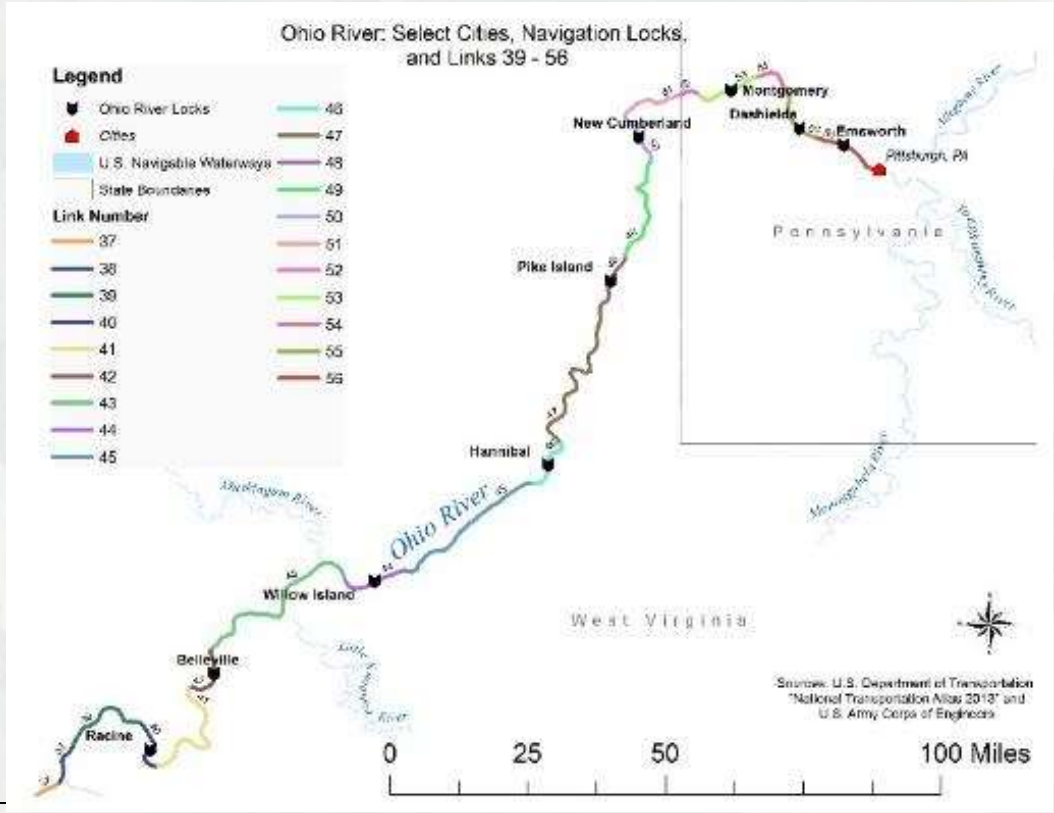
TX_DTTM	LAT	LON	AOI
12/28/2014 19:30	40.6701	-74.0783	Bayonne
⋮	⋮	⋮	Bayonne
12/31/2014 3:50	40.6679	-74.0750	Bayonne
1/2/2015 5:15	32.1295	-81.1391	Savannah
1/2/2015 5:20	32.1295	-81.1391	Savannah
⋮	⋮	⋮	Savannah
1/4/2015 15:45	32.1294	-81.1389	Savannah

Consecutive entries with different AOI flags indicate an inferred transit between respective locations

Inland Waterway Travel Time Estimation Methodology

The methodology is flexible and scalable across space and time:

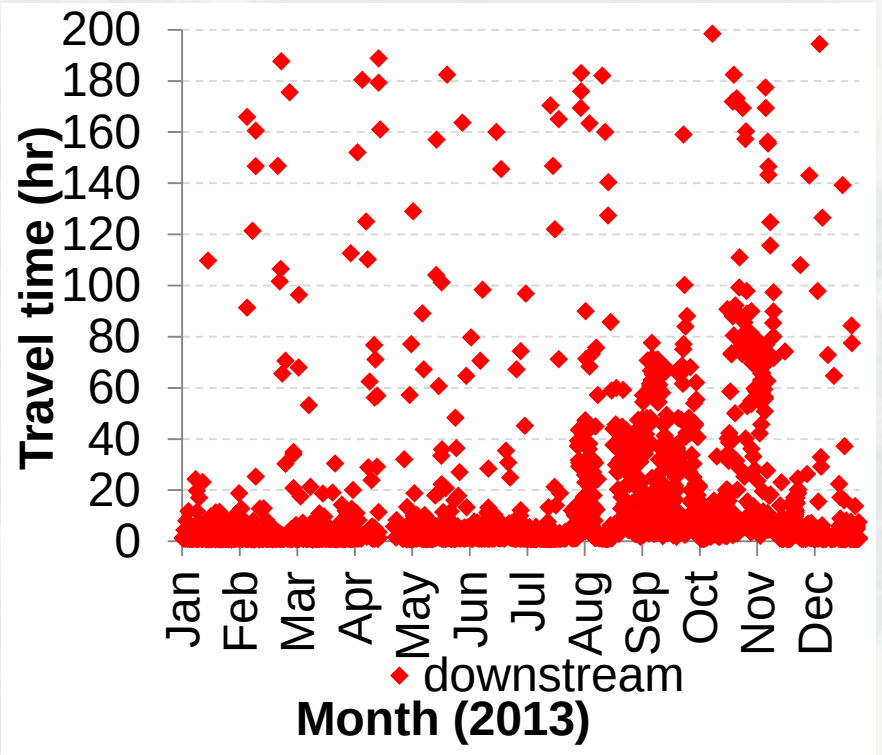
1. Define the origin and destination (O-D) and the time period
   - O-D example is a port
2. Segment the navigational waterway between the O-D into links
   - Increases the sample size
   - Isolates factors that affect travel time and variability
   - Link endpoint examples:
     - A location queuing begins,
     - Waterway confluence
3. Calculate link travel times
4. Identify and remove outliers
5. Calculate O-D statistics from summing link travel times



Methodology Step 4 Outlier Removal

- Processing of data includes identifying, investigating, and removing outliers (13% for this example)
- Causes of outliers:
  - Position reports not received
  - Vessels not traveling directly from the beginning to the end of the link
- Outlier definition:
  - Lock links = >72hrs
  - Non-lock link = transit time of a vessel that travels entire link at < .5kts
  - Future research on refining
- Occurrence of outliers may decreases with new carriage regulations and as AIS coverage increases

2013 Travel Time Estimate for a 10 Mile Link Centered at L&D 52 – No Outliers Removed



Inland Waterway Example Results: 2013 Ohio River Trip Table

Travel Time (hrs): 25th percentile / Median / 75th percentile		Destination/To (river mile)					
		Downstream end of River (981)	**Mount Vernon, IN (827)**	**Louisville, KY (602)**	**Cincinnati, OH (480)**	**Huntington -Tristate, WV (317)**	**Upstream end of River/ Pittsburgh, PA (0)**
Origin/From (river mile)	**Downstream end of River (981)**		28.0 / 34.2 / 46.4	73.8 / 89.4 / 116.7	97.0 / 117.4 / 152.0	127.5 / 154.9 / 202.7	200.2 / 243.9 / 320.1
	Mount Vernon, IN (827)	20.1 / 24.0 / 35.3		45.8 / 55.3 / 70.3	69.0 / 83.2 / 105.6	99.5 / 120.7 / 156.3	172.2 / 209.8 / 273.7
	Louisville, KY (602)	50.2 / 59.5 / 82.2	30.1 / 35.5 / 46.9		23.2 / 28.0 / 35.3	53.7 / 65.5 / 86.0	126.4 / 154.5 / 203.4
	Cincinnati, OH (480)	66.3 / 78.4 / 109.1	46.2 / 54.4 / 73.8	16.1 / 18.9 / 26.9		30.5 / 37.5 / 50.8	103.2 / 126.5 / 168.1
	Huntington-Tristate, WV (317)	88.6 / 106.0 / 149.1	68.5 / 82.0 / 113.8	38.4 / 46.5 / 66.9	22.3 / 27.6 / 40.1		72.7 / 89.0 / 117.4
	Upstream end of River/	142.8 / 174.9	122.7 / 150.9	92.6 / 115.4	76.5 / 96.5	54.2 / 68.9	

Sample Results

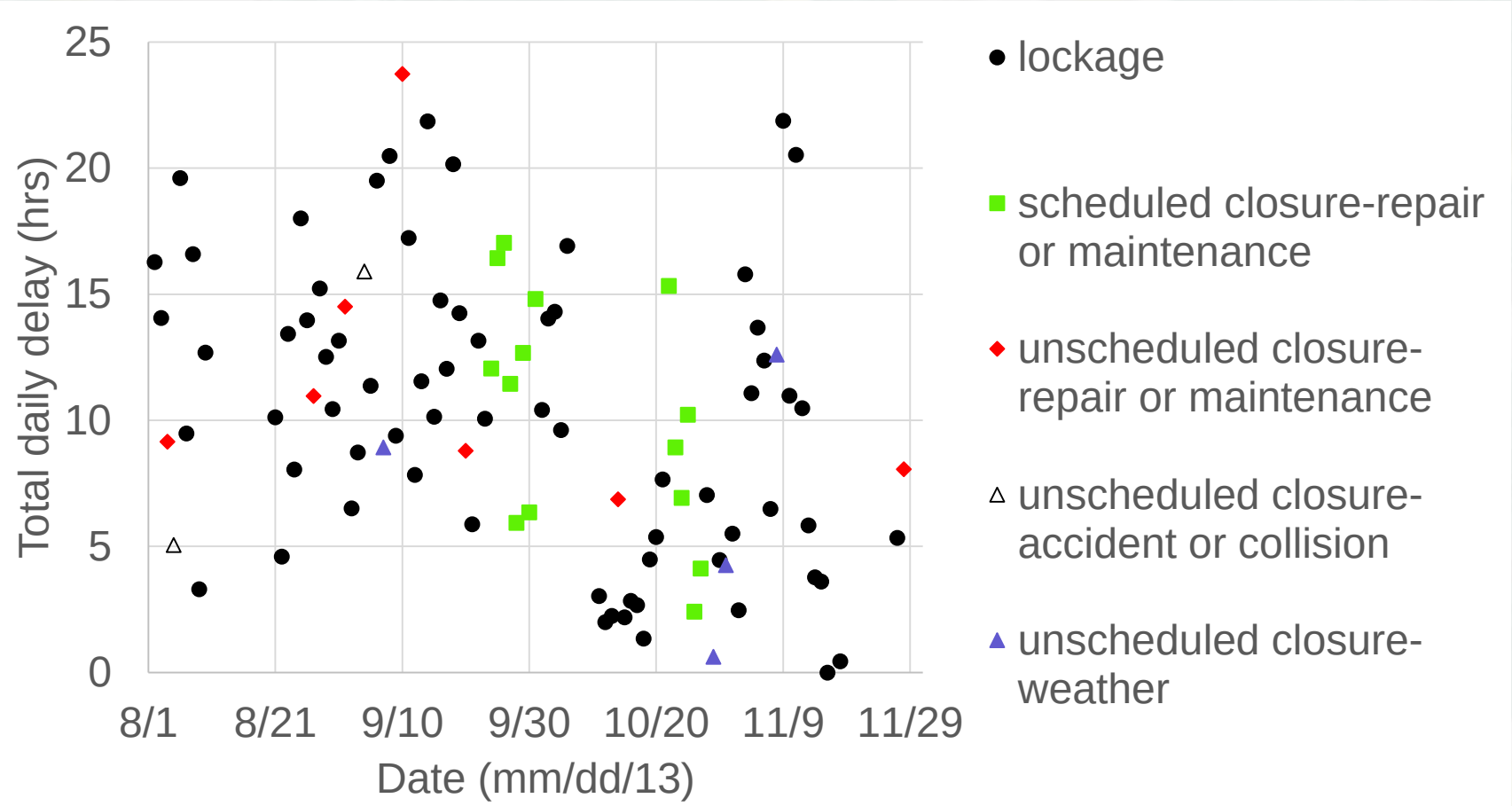
Origin	Destination	Distance (river mi)	25th Percentile Travel Time (days)*
Pittsburgh, PA	Cairo, IL	981	6.8
Cairo, IL	Baton Rouge, LA	717	2.7

*Estimates from 3 months of 2013 data

Sample Results

Total Daily Delay by Event for L&D 52 in 2013

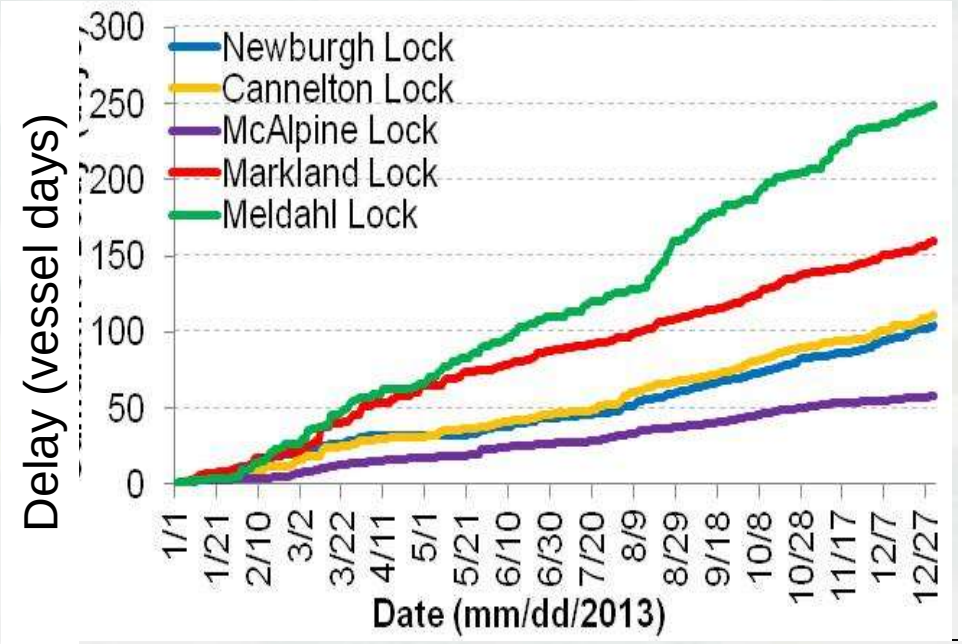
- Delay: The amount of travel time over what's expected
- Expected travel time = 25th percentile travel time during lockage conditions
- Total Delay considers traffic volume and delay per vessel



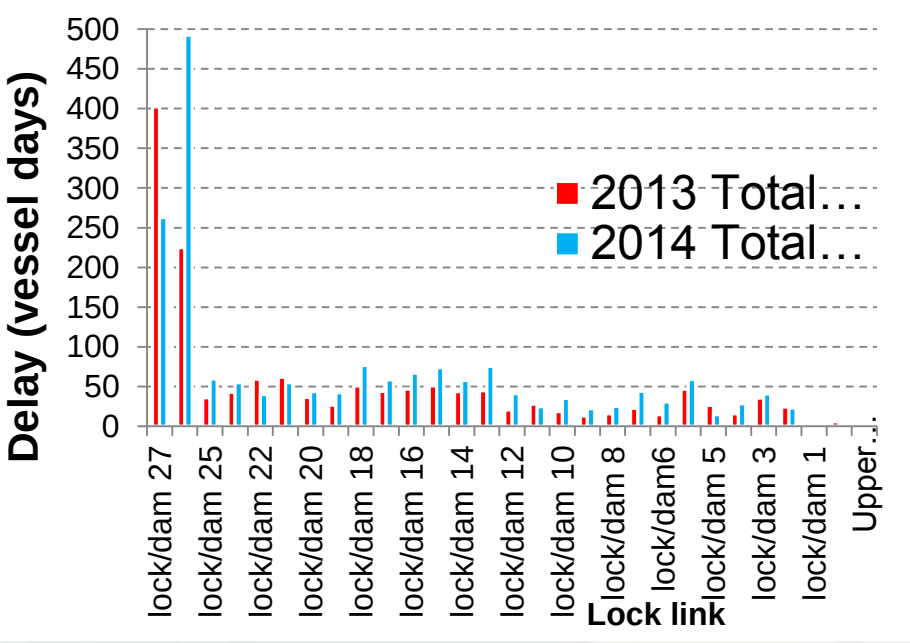
Sample Results: Cumulative Delay at Locks

- Cumulative delay on links containing locks can be compared to spot seasonal variations, identify system bottlenecks, and direct O&M resources
- Links are 10 miles long with the exceptions of locks spaced less than 10 miles apart

Cumulative Annual Delay by Date and Lock Link, Downstream Direction of Travel, Ohio River, 2013



Cumulative Annual Delay for Lock Links, Downstream Direction of Travel, Upper Mississippi River, 2013 and 2014



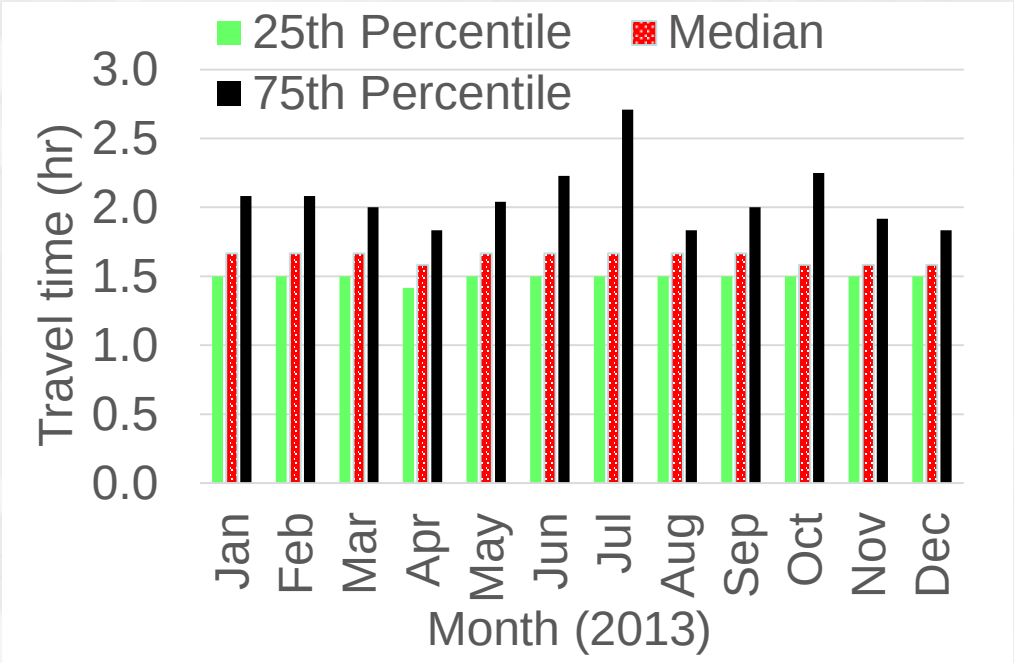
Sample Results: Link Speed

Coastal Ports Application

Derived coastal information:

- Travel times within navigation channels
- Travel times and number of vessels between ports (port connectivity, system analysis)
  - Cascading effects from “isolated” project events
  - Identification of critical network components
  - Network decision making

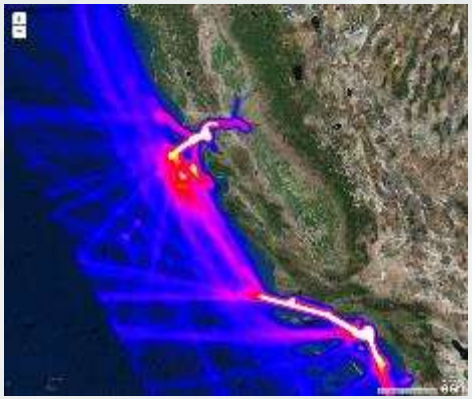
Coastal Port Example: Houston Ship Channel (HSC)



Monthly travel time statistics for HSC outbound traffic from the Bayport flare to the Gulf entrance

Main Takeaways for the Travel Time Atlas

1. Data source is accessible.
2. Outputs include travel times, speed and cumulative delay.
3. Analysis is scalable across space and time.
4. Enables, real-time and historic, snapshot of the state of the system and the ability to pinpoint time and location of changes in the state.
5. Provides quantifiable performance measures for system decision makers.
6. Improves voyage planning capabilities for system stakeholders.



Thank you

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