

Inland Navigational Locks Travel Delay

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From Sail to Satellite: Delivering Solutions for
Tomorrow's Marine Transportation Systems

TRB-CMTS

Session 2A: MTS Performance Measures,
Part 1

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**US Army Corps
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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 time statistics 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.”

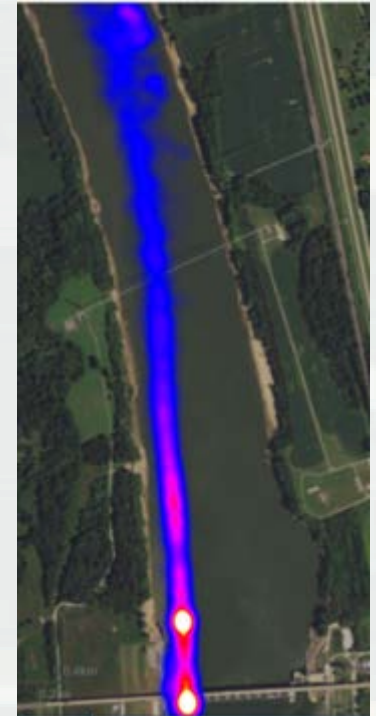
National Cooperative Highway Research Program Report 618 “Cost-Effective Performance Measures for Travel Time Delay, Variation, and Reliability”, 2008

Project Objective

Quantify travel time delay from lock closure events; compare delay by event type.

Closure Event Types

- Scheduled closure – repair or maintenance
- Unscheduled closure – repair or maintenance
- Unscheduled closure – accident or collision
- Unscheduled closure – weather



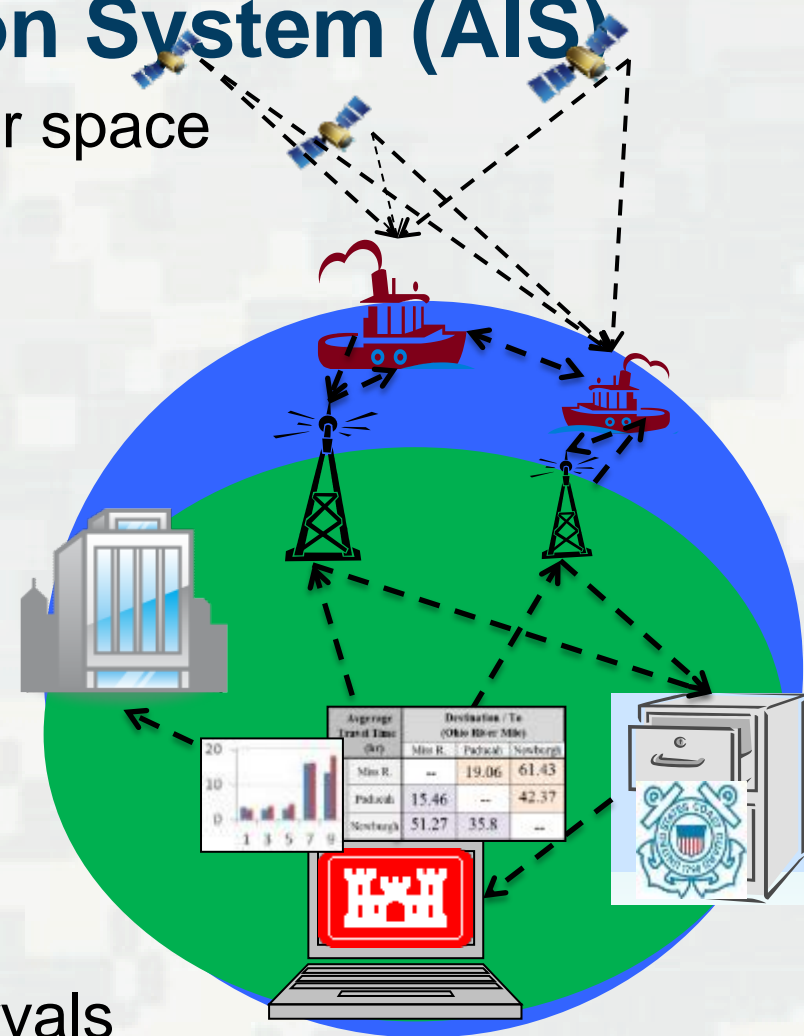
Possible Applications

- Establish lock performance baselines
- Quantify lock and system performance during Resiliency Cycle and after events
- Measure system resiliency (**withstand**, **recover**)
- Locate system bottlenecks and areas with most critical needs
- Compare performance pre and post-operations and maintenance (O&M) actions
- Aid decision making for O&M actions
- Identify traffic patterns including responses to events
- Assist voyage planning with travel time prediction capabilities



Data Source to Calculate Delay: Automatic Identification System (AIS)

- Provides vessel position reports over space and time
- Shipboard broadcast system
- Information includes the following:
 - Vessel identification
 - Location (latitude and longitude)
 - Time stamp
 - Heading
 - Speed
 - Vessel characteristics
- Broadcasts are at discrete time intervals
 - Every 2 to 10 seconds while a vessel is underway
 - Every 3 minutes while at anchor



Delay 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

Data Source for Lock Events

Lock Status Report

<http://corpslocks.usace.army.mil/lpwb/f?p=121:4:0:>

- Provides lock event details including the following:
 - Type,
 - Date/Time of start and stop,
 - Description.
- Data is publically available for the last 30 days.

US Army Corps of Engineers Lock Performance Monitoring System

<http://corpslocks.usace.army.mil/lpwb/f?p=121:1:0::NO::>

“The Corps Locks website contains lock and vessel specific information derived from the United States Army Corps of Engineers Lock Performance Monitoring System (LPMS). The information contained here represents an every 15-minute updated snapshot of Freedom of Information Act (FOIA) data on U.S. flag vessels and foreign vessels operating in U.S. waterways that transited a Corps-owned or operated lock structure. Detailed information on specific companies or commodities is considered privileged and is not included in the Corps Locks website.”

Sample Lock Status Report



US Army Corps of Engineers
Lock Performance Monitoring System

Home > Lock Status Report

Selection Criteria

Place cursor here for Instructions.

Rivers

ALLEGHENY RIVER	OHIO RIVER
CHICAGO RIVER	
CLINCH RIVER	
CUMBERLAND RIVER	
GREEN & BARREN RIVERS	
ILLINOIS WATERWAY	
KANAWHA RIVER	
KASKASKIA RIVER	
MISSISSIPPI RIVER	
MONONGAHELA RIVER	
TENNESSEE RIVER	

As of Date and Time: 06/01/2016 16:00

Submit

OHIO RIVER Hydrologic Conditions

Comm. Tows

Mile	Lock/Dam	Date			Gage		Dam	Weather		Wait		Lock		Avg
		Time			Elev	Change	Cond	Temp	Precip	Ab	Bl	Up	Dn	Delay
919	Smithland L/D	060116	U 12.60	+0.20			44.0 A66		0.00 FG	0	0	6	13	0
		1600	L 15.30	-1.10			W71							

UNSCHEDULED STALL/STOPPAGE

Starting: 06/01/2016 01:07 Ending: 06/01/2006 1:25

Chamber: 1 Reason: Interference by other vessel(s).

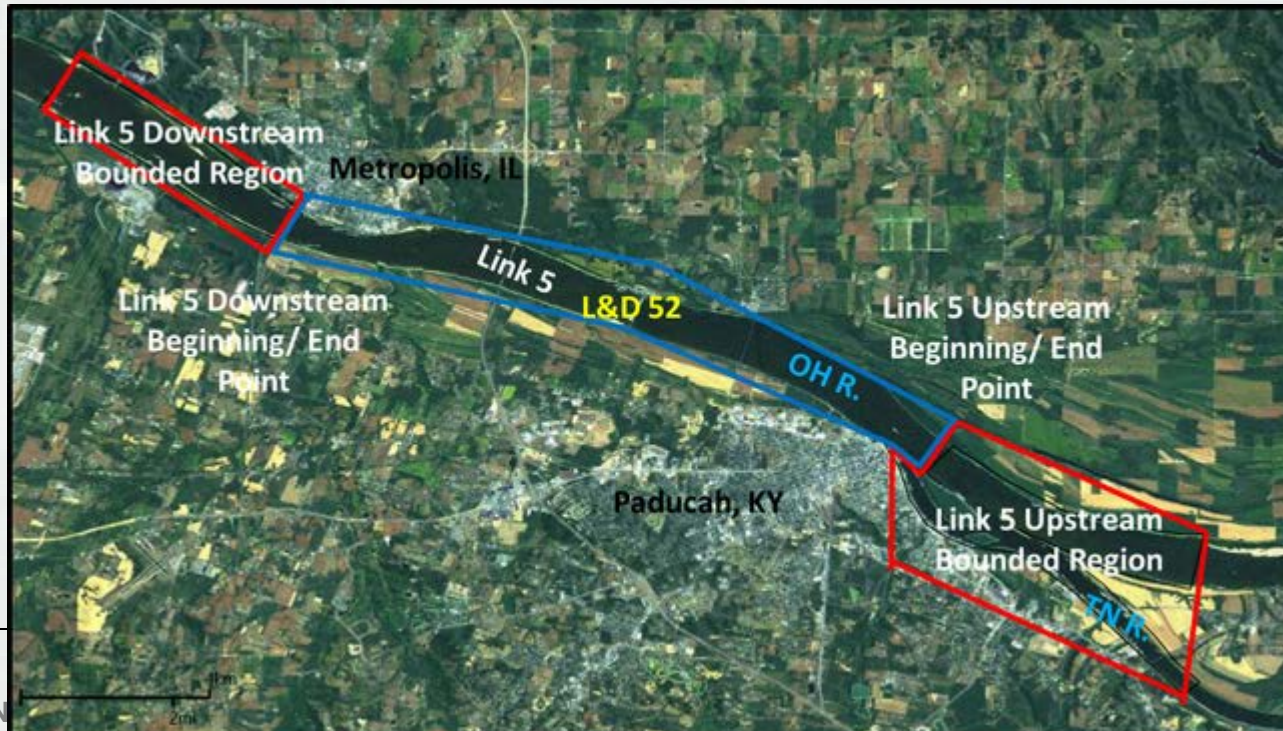
Delay Definition for this Study

- Delay: The amount of travel time over what's expected by users
- Expected travel time = annual average 25th percentile travel time
- Total Delay is the sum of all vessels' delay
 - Reflects traffic volume and delay per vessel
 - No negative delay



Delay Calculation Methodology

1. Acquire AIS data for study location and time period
2. Define the study link around each lock
 - a. 5 miles upstream to 5 miles downstream of lock
 - b. Captures vessels' deceleration time approaching the lock, queuing time to enter the lock, passage time through the lock, and acceleration time away from the lock.
 - c. Each lock link is the same length to compare travel times at different locks.



Delay Calculation Methodology

3. Calculate link travel times (travel time from beginning to end of link)
 - a. Define 4 mile bounded regions at end of each link
 - b. The time stamps of the AIS position reports that fall within the bounded regions serve as the link entrance and exit times
 - c. Sorting the records corresponding to the regions by vessel ID and then by ascending chronological order
 - d. The estimated entrance time equals the timestamp of a record for one bounded region that is immediately followed by a record for the other region

Record	Vessel ID	Time	Latitude (decimal degrees)	Longitude (decimal degrees)	Bounded Region
1	111	8/10/2013 17:35	39.096506	-84.667894	downstream
2	111	8/10/2013 17:40	39.094875	-84.659986	downstream
3	111	8/10/2013 21:30	39.044143	-84.397226	upstream



Delay Calculation Methodology

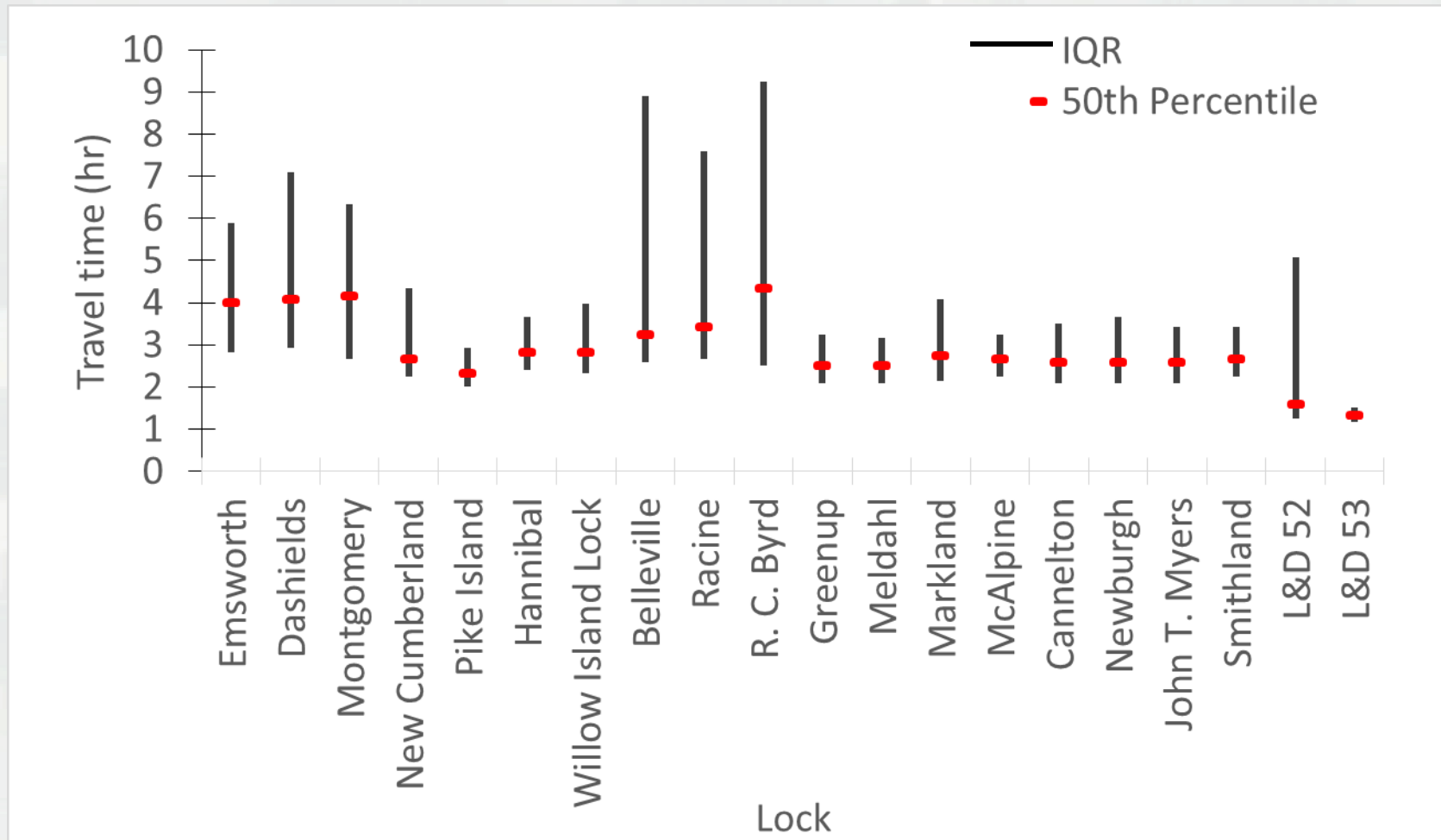
4. Identify and remove outliers
 - a. Causes of outliers:
 - AIS reports not received
 - Non-direct link transits
 - b. Outlier definition:
 - Lock links: travel times greater than >72 hours
5. Calculate the average annual 25th percentile travel time
 5. Definition: The travel time that 25% of transits are faster than, or conversely, that 75% of transits are slower than
6. Calculate delay for each transit
7. Calculate total (cumulative) delay by summing the individual transits' delay

Ohio River Lock Locations and their Associated Link

Beginning/End Boundaries

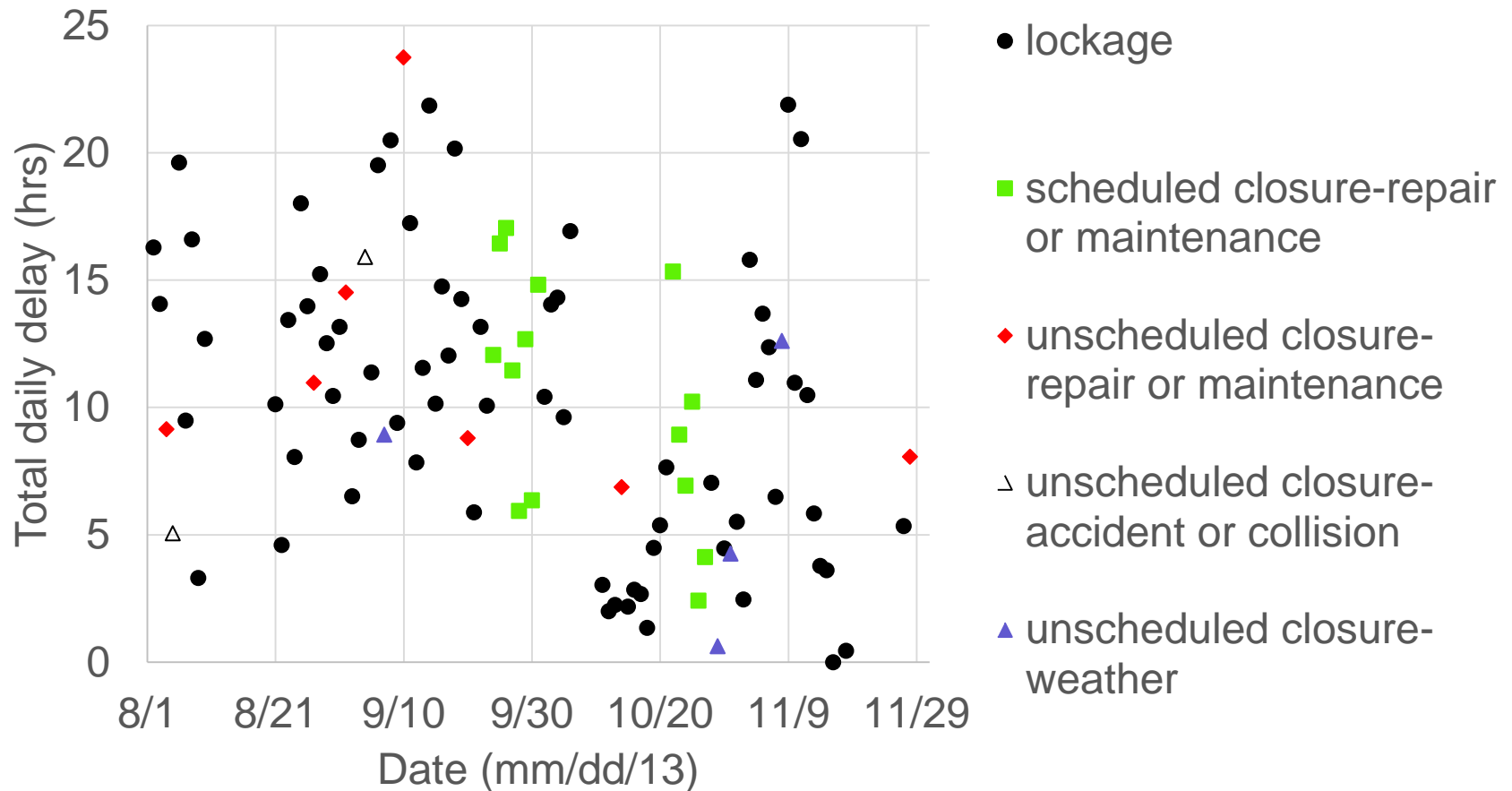
Lock	Location (river mile)	Link Upstream End (river mile)	Link Downstream End (river mile)
Emsworth	6.2	0	10
Dashields	13.3	10	20
Montgomery Island	31.7	27	37
New Cumberland	54.4	49	59
Pike Island	84.2	79	89
Hannibal	126.4	121	131
Willow Island	161.7	157	167
Belleville	203.9	199	209
Racine	237.5	233	243
R. C. Byrd	279.2	274	284
Greenup	341	336	346
Meldahl	436.2	431	441
Markland	531.5	527	537
McAlpine	606.8	602	612
Cannelton	720.7	716	726
Newburgh	776.1	771	781
John T. Myers	846	841	851
Smithland	918.5	914	924
L&D 52	938.9	934	944
L&D 53	962.6	13 958	968

25th, 50th, and 75th Percentile Travel Times for Ohio River Locks, 2014 Downstream

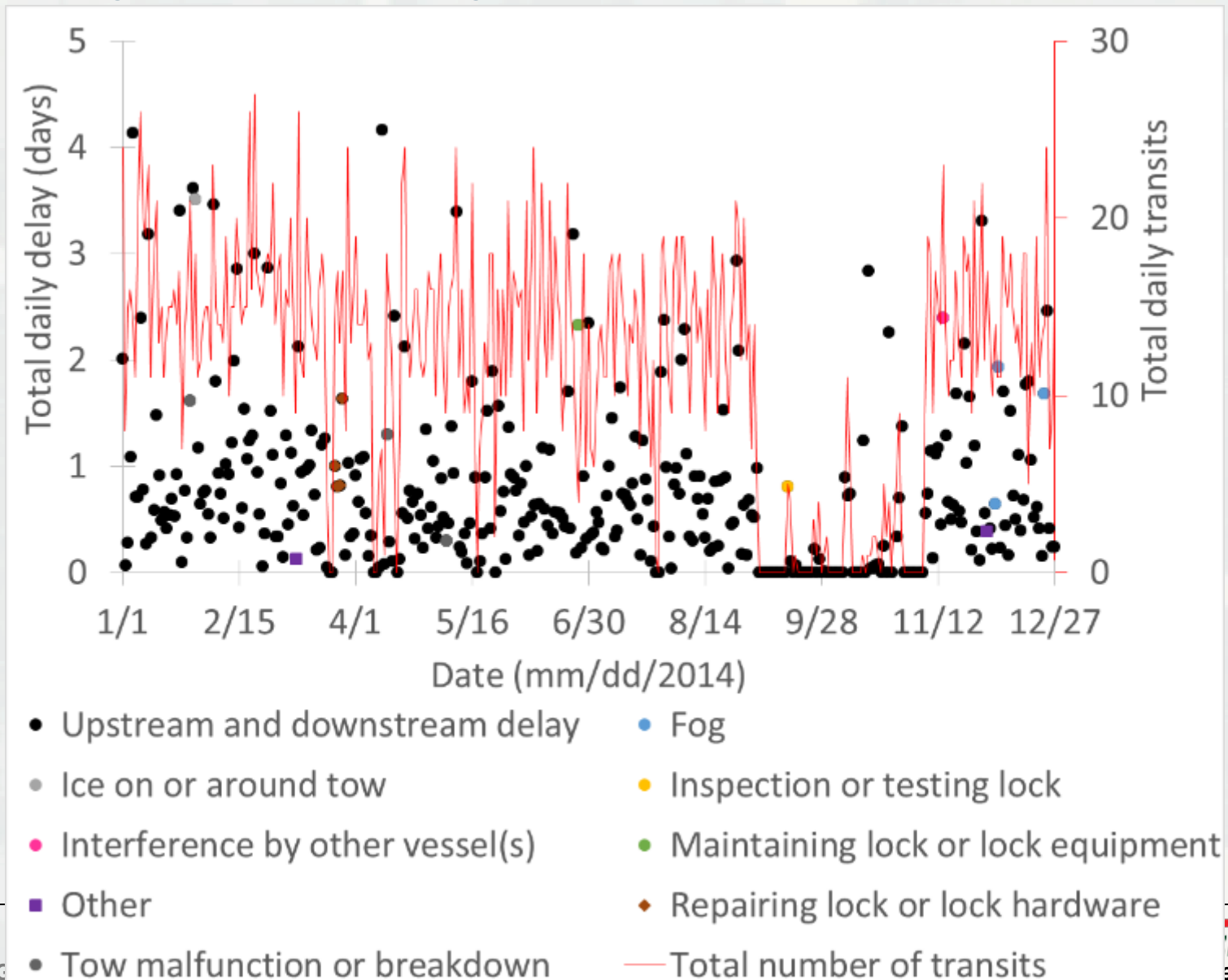


Sample Results

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



Newburgh Lock, 2014, Total Daily Delay by Event Type and Daily Number of Transits



Main Takeaways

1. Data sources are accessible.
2. Outputs include delay per trip, per day, and by year.
3. Provides quantifiable performance measures for system decision makers.
4. Improves voyage planning capabilities for system stakeholders.

Future Studies

1. Vary the delay definition.
2. Consider other outlier identification methods.
3. Apply methodology to more locks.
4. Statistically determine correlation between event type and delay.

Thank you

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Panoramic view of dewatered Wilson Lock on the Tennessee River in Alabama