Marine Transportation System
Performance Measures &
Waterway Travel Time Estimates

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CMTS
U.S. Committee on the Marine Transportation System

US Army Corps of Engineers®

ERDC

COASTAL AND HYDRAULICS LABORATORY
OUTLINE

Marine Transportation System Performance Measures (Marin Kress)

• Summary of agencies that manage and provide data about the marine transportation system

• Data sources discovered and available to the general public

• Summary of current MTS performance assessment across different categories: economic benefits, safety and security, capacity and reliability, environmental stewardship, and resilience

• Next steps for future research, available publications and products from this work

Waterway Transit Time Estimates Using Archived Data (Patricia DiJoseph)

• Description of Automatic Information System (AIS) data

• Method for developing waterway transit time estimates

• Case study results

• Other applications / future research in this area
Marine Transportation System Performance Measures Research

Marin Kress

CMTS
U.S. Committee on the Marine Transportation System
What is the MTS?

- The Marine Transportation System (MTS) consists of waterways, ports, and intermodal landside connections that allow the various modes of transportation to move people and goods to, from, and on the water. The MTS includes the following:

- 25,000 miles of navigable channels
- 236 locks at 192 locations
- The Great Lakes and the St. Lawrence Seaway
- Over 3,700 marine terminals
- Numerous recreational marinas
- Over 174,000 miles of rail, connecting all 48 contiguous US States, as well as Canada and Mexico
- Over 45,000 miles of interstate highway, supported by over 115,000 miles of other roadways
- Over 1,400 designated intermodal connections
Study Motivation

• The CMTS is a Federal effort to coordinate the myriad partners involved in the MTS. Chaired by the Secretary of Transportation, the CMTS is tasked with ensuring the development and implementation of national MTS policies consistent with national needs and to report to the President its views and recommendations for improving the MTS.

• The USACE Navigation Mission facilitates the safe, reliable, and economically efficient movement of vessels on the nation’s waterways

• Waterborne transport is a major mode of transportation, serving both recreational and commercial users

• Multiple MTS stakeholders have an interest in quantifying MTS performance to support informed decision-making
How do you meaningfully measure performance for a system that is geographically expansive, operationally diverse, and has multiple asset types, owners, and regulators?
Performance Measure Categories

• Economic Benefits
• Capacity & Reliability
• Safety & Security
• Environmental Stewardship
• Resilience

Performance Measure Data Requirements

• Authoritative
• National scale
• Publicly available
• Regularly collected

Categories Development Sources

• Expert elicitation
• Feedback from TRB-CMTS conferences
• PIANC 2010 report
  www.pianc.org/2872231836.php
Performance Measures

Economic Benefits to the Nation

• Total value and tonnage of international trade moved by MTS
• Income and disbursement of Harbor Maintenance and Inland Waterways Trust Funds
• Producer Price Index for Transportation Industries
• Direct employment in MTS industries for ten states with highest reported MTS employment
• Inland waterway shipping barge freight rates

Capacity and Reliability

• Navigation lock closures, hours and number of closures, unscheduled and scheduled
• High tonnage channels with NOAA PORTS® instrumentation
• Travel time estimates for key waterway segments

Sources, graphs, and details at: navigation.usace.army.mil/MTS/Performance/
Performance Measures - continued

Safety and Security

• Number of commercial vessel accidents (collisions, allisions, groundings)
• Number of commercial mariner and passenger casualties (personal injuries, deaths)
• Number of U.S. Coast Guard incident investigations

Environmental Stewardship

• U.S. petroleum-based fuel sales to the maritime industry (diesel fuel, residual fuel)
• Vessel pollution incidents (petroleum and other types)
• Amount of dredged material reclaimed for beneficial use
• Number of reported whale strikes by vessels

Resilience

• Physical condition ratings of critical coastal navigation infrastructure
• Age of federally owned and operated navigation locks

Sources, graphs, and details at:
navigation.usace.army.mil/MTS/Performance/
Performance measures website

• All MTS performance measures assembled have been published online

• Each performance measure includes a brief description and a graph to show changes over time

• Each graph includes the URL for the source data and other relevant information

• [http://navigation.usace.army.mil](http://navigation.usace.army.mil) [Marine Transportation System]

• Related information available through the same portal
  • Survey & Mapping
  • Systems Approaches
USACE Navigation Portal

**Dredging**
Coming Soon

**Survey & Mapping**
Hydrographic survey and National Channel Framework (NCF) maps and data

**Marine Transportation System**
Performance measures, including economic benefits, safety & security, environmental stewardship, system performance, capacity & reliability, and resilience

**Systems Approaches**
Regional Sediment Management and Engineering With Nature

**Infrastructure & Asset Management**
Coming Soon

**River Information Services**
Coming Soon
Marine Transportation System

Welcome

About MTS
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One of these partners is the US Army Corps of Engineers (USACE). Under federal law, companies must report the domestic waterborne commercial movements of their vessels to USACE. These vessels include dry cargo ships and tankers, barges (both loaded and empty), fishing vessels, towboats (with or without barges in tow), tugboats, crew boats and supply boats to offshore locations, and newly constructed vessels from the shipyards to the point of delivery. Vessels remaining idle during the monthly reporting period must also be reported.

This website visually summarizes various MTS performance measures and allows you to search for additional data, maps, tools, and applications available through the CMTS, USACE, and other Federal agencies.
Performance Measures

The Marine Transportation System (MTS), US Army Corps of Engineers (USACE), US Department of Transportation (USDOT), Maritime Administration (MARAD), US Coast Guard (USCG), National Oceanic and Atmospheric Administration (NOAA), Saint Lawrence Seaway Development Corporation (SLSDC), US Environmental Protection Agency (EPA), Bureau of Transportation Statistics (BTS), Federal Maritime Commission (FMC), National Transportation Safety Board (NTSB), Oak Ridge National Lab (ORNL), Oceanographer of the Navy, and The Volpe Center.

This page visually summarizes various MTS performance measures in several different categories.

### Economic Benefits

### Safety & Security

### Environmental Stewardship

### Capacity & Reliability

### Resilience

**Number of Navigation Lock Closures: Scheduled and Unscheduled**

- Unscheduled Closures (#)
- Scheduled Closures (#)

**Number of Navigation Lock Closures, Scheduled and Unscheduled**

`Source: U.S. Army Corps of Engineers`  
`Update frequency: Biannual, Statistics: Annual`  
Performance Measures
Non-recreational Maritime Injury and Death Events Investigated by USCG

Non-recreational Maritime Injury and Death Events Investigated by U.S. Coast Guard, 2001 - 2013

- Injury and death cases unresolved as of April 2014 data release
- Commercial - Deaths
- Commercial - Injured, Exposure No Injury, Missing, or Unspecified

Source: U.S. Coast Guard MISLE Data (April 2014)
Files: MaleActivity.txt, Maleinjury.txt, Malecomponent.docx

The U.S. Coast Guard investigates injuries and deaths related to vessel activity on U.S. waterways. Once an investigation has been resolved, a limited number of facts about the event are released through the USCG's MISLE Data files. For unresolved cases, the only information available is the total number of cases. Shown in grey in the bar graph to the left, these could be either recreational or commercial. Note that the injury category includes cases of "exposure no injury", "missing", and "unspecified" events.
## Marine Transportation System Performance Measures Research


### Purpose

The purpose of this research is to investigate the number of USCG incident investigations related to maritime safety, law enforcement, pollution incidents, and other maritime operational issues. Incident investigation records include information about the vessel, organization, and facility involved.

### Data Source

- **Number of USCG incident investigations**
  - **Source:** U.S. Department of Homeland Security, Coast Guard
  - **Description:** The USCG investigates and records incidents related to maritime safety, law enforcement, pollution incidents, and other maritime operational issues. Incident investigation records include information about the vessel, organization, and facility involved.
  - **Website:** homeport.uscg.mil/mycg/portal/ep/home.do Marine Casualty and Pollution Data for Researchers, MISLE DATA file
  - **Regulatory/Legislative Driver:** The USCG investigates accidents under its authority (Part D of Title 46, U.S. Code) to enforce U.S. laws and protect public safety.
  - **Unit:** Number of investigations
  - **Collection Frequency:** Ongoing
  - **Reporting Frequency:** Monthly, with an approximate 3-month lag
  - **Geographic Scope:** National
  - **Objective:** The number of incidents that are investigated can reflect changing operational conditions for USCG enforcement activities.
  - **Application Value:** Reference (historical data series)
  - **Comment:** Combining with measure with the associated resource-availability (staff, funding) and number of incidents would provide more nuanced information.
Future Work: Using Machine Readable Data

Machine readable = format that can be understood by a computer

Original data published in machine-readable format

→ Served to Internet

→ Actively and automatically search for MTS data

→ Assemble data and update graphics

→ Publish for users across all disciplines

This part of the update process can be automated, if machine-readable data is published by authoritative sources at the start.
Ongoing and Future Performance Measures Work

- Data sourcing - continue updating and expanding
- Adding measures in each category when possible
- Providing assembled historical data to those interested in relevant freight modeling or scenario development
- Incorporating AIS travel time records into a standardized performance measure for the category “capacity and reliability”

*Described in the next section by Dr. DiJoseph*
Vessel Transit Time Statistics via Automatic Identification System (AIS) Data

Patricia K. DiJoseph, PhD
Coastal and Hydraulics Laboratory
United States Army  Engineer Research and Development Center
Study Objective

Create a statistical profile of waterway system transit times from vessel position reports over space and time

Applications

• Provide quantifiable performance measures for system decision makers
• Improve voyage planning capabilities for system stakeholders
• Examples:
  • Measuring effects of operational and maintenance decisions
  • Understanding variations in transit times due to river stages, seasonal traffic variations, vessel and freight characteristics
  • Optimizing trip departure times and estimating arrival times
  • Multi-modal freight transportation system modeling
Automatic Identification System (AIS) Data

- Vessels broadcast information via VHF radio waves every 2-6 seconds:
  - Vessel identification
  - Location (longitude and latitude)
  - Time stamp
  - Heading
  - Speed
  - Vessel size characteristics
- Landside receivers collect the broadcasts
- Broadcasts are stored in a database
- Each broadcast is processed into a readable record
- Records are analyzed for navigation patterns and travel time statistics
AIS Data Acquisition Options

- Personal data collection
- USCG Navigation Center
  - Government agency requestors:
    http://www.navcen.uscg.gov/?pageName=AISmain
  - Private individual requestors:
    http://www.uscg.mil/foia/
- Commercial sources
Methodology to Estimate Individual Transit Times

1. Designate the waterway link
2. Geofence **upstream** and **downstream** ends of the link
3. Determine the AIS records corresponding to the geofence
4. Set the departure time equal to the time stamp of the last record in the upstream geofence
5. Set the arrival time equal to the time stamp of the first, subsequent record in the downstream geofence
6. Estimate travel time = arrival – departure time
7. Apply method for all vessels and waterways of interest

Travel time = 30 minutes
Red and blue dots are separate vessels
Case Study: Ohio River Travel Times

- 981 miles long
- Feeds the Mississippi River at Cairo, IL
- Includes 5 of the nation’s top 100 ports in freight tons
- 20 navigation locks

Legend
- Ohio River Locks
- Cities
- U.S. Navigable Waterways
- State Boundaries

Sources: U.S. Department of Transportation "National Transportation Atlas 2013" and U.S. Army Corps of Engineers
Ohio River links near Cairo, IL
Each lock is centered within a 10 mile long link.

Sources: U.S. Department of Transportation
"National Transportation Atlas 2013" and U.S. Army Corps of Engineers
## Case Study Results: 2013 Ohio River Trip Table

<table>
<thead>
<tr>
<th>Transit Time:</th>
<th>25&lt;sup&gt;th&lt;/sup&gt; percentile</th>
<th>Median</th>
<th>75&lt;sup&gt;th&lt;/sup&gt; percentile</th>
</tr>
</thead>
</table>

### Destination/To (river mile)

<table>
<thead>
<tr>
<th>Origin/From (river mile)</th>
<th>Downstream end of River (981)</th>
<th>Mount Vernon, IN (827)</th>
<th>Louisville, KY (602)</th>
<th>Cincinnati, OH (480)</th>
<th>Huntington-Tristate, WV (317)</th>
<th>Upstream end of River/ Pittsburgh, PA (0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream end of River (981)</td>
<td>28.0 34.2 46.4</td>
<td>73.8 89.4 116.7</td>
<td>97.0 117.4 152.0</td>
<td>127.5 154.9 202.7</td>
<td>200.2 243.9 320.1</td>
<td></td>
</tr>
<tr>
<td>Mount Vernon, IN (827)</td>
<td>20.1 24.0 35.3</td>
<td>45.8 55.3 70.3</td>
<td>69.0 83.2 105.6</td>
<td>99.5 120.7 156.3</td>
<td>172.2 209.8 273.7</td>
<td></td>
</tr>
<tr>
<td>Louisville, KY (602)</td>
<td>50.2 59.5 82.2</td>
<td>30.1 35.5 46.9</td>
<td>23.2 28.0 35.3</td>
<td>53.7 65.5 86.0</td>
<td>126.4 154.5 203.4</td>
<td></td>
</tr>
<tr>
<td>Cincinnati, OH (480)</td>
<td>66.3 78.4 109.1</td>
<td>46.2 54.4 73.8</td>
<td>16.1 18.9 26.9</td>
<td>30.5 37.5 50.8</td>
<td>103.2 126.5 168.1</td>
<td></td>
</tr>
<tr>
<td>Huntington-Tristate, WV (317)</td>
<td>88.6 106.0 149.1</td>
<td>68.5 82.0 113.8</td>
<td>38.4 46.5 66.9</td>
<td>22.3 27.6 40.1</td>
<td>72.7 89.0 117.4</td>
<td></td>
</tr>
<tr>
<td>Upstream end of River/ Pittsburgh, PA (0)</td>
<td>142.8 174.9 247.6</td>
<td>122.7 150.9 212.3</td>
<td>92.6 115.4 165.4</td>
<td>76.5 96.5 138.6</td>
<td>54.2 68.9 98.5</td>
<td></td>
</tr>
</tbody>
</table>
Case Study Results: Cumulative Delay at Locks

- For this study, delay is defined as any additional transit time above what is expected under normal operating conditions.
- The 25th percentile transit time is applied as a proxy for the expected transit time.
- Cumulative delay is the sum of individual transit delay over time.

![Cumulative Annual Downstream Delay by Date and Lock, Ohio River, 2013](image.png)
**Case Study Results Continued: Speed**

- AIS data can be used to calculate speed by waterway segment.
- In this figure, three different median speed ranges are shown as red (slowest), orange, and green (fastest).
- In this example, median speed is lowest in the segments containing locks.
Additional AIS Applications

• Port connectivity, trip chaining, and port dwell time analysis
• Transit time variability by independent variable (e.g., water level, vessel type) research
• Vessel incident, collision, or grounding investigations
• Environmental studies
Conclusions

• MTS performance measures have been assembled and published. Future work will continue to incorporate new data when available.

• AIS data can be used to calculate waterway transit times and results can be used for multiple applications.

• Waterway transit time estimates can be published as part of future MTS performance measures work.
Thank you for your attention.

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