Marine Highway System
A Multimodal Short Sea Freight Shipping System

07 May 2010

Surface Congestion Reduction
Analysis & Modeling (SCRAM) Team:
Karen Davis
Greg Haubner
James Hingst
Bill Judge
Chris Zalewski

Think. Learn. Succeed.
Agenda

• Background
  • Introduction
  • Problem Statement
  • Stakeholders

• Approach
  • Overview, Objective and Scope
  • Technical Approach
  • Global Assumptions
  • Metrics
  • Simulation
  • Decision Analysis Tool/ Multiple Objective Decision Analysis

• Analysis & Results

• Recommendations
Background – Introduction

• Increasing GDP has stressed the domestic transportation system

• From DOT Maritime Administration (MARAD)*:
  • Trucks account for ~40% of the time Americans spend in traffic
  • ~ 60% of federal highway funding is used for maintenance
  • Truck volume on interstates are estimated to double by 2035

• One solution – Domestic movement of freight via waterways or Multimodal Short Sea Freight Shipping (MSSFS)
  • Inland marine shipping is 270% more fuel efficient than trucking**
  • DOT has established a framework to provide federal support to expand the use of marine highways for freight shipment

* Projections from MARAD website: [http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm](http://www.marad.dot.gov/ships_shipping_landing_page/mhi_home/mhi_home.htm)
** US Maritime Administration, *Americas ports and Intermodal transportation system*, January 2009, Page 33
Background – Problem Statement

• The Problem:
  • Surface freight shipment via truck contributes significantly to congestion and roadway maintenance costs

• The Questions:
  • Can increasing the use of the marine highway system provide cost-competitive and time-reliable service?
  • What can be inferred relative to highway congestion?
Background – Stakeholders

GMU
CRS&SI TECH APPLICATIONS
INFRASTRUCTURE SYSTEMS
FREIGHT ANALYSIS

CSC/AMC
MODELING & SIMULATION
MARINE OPERATIONS
MULTIMODAL SYSTEMS

RUTGERS/CAITS
FREIGHT TRAFFIC ANALYSIS
INTERMODAL SYSTEMS

GEOEYE
WORLD LEADERS IN
IMAGERIES
CRS&SI DATA SYSTEMS

DLR - GERMAN
TRANSPORTATION
RESEARCH CENTER
SHORT SEA SHIPPING
CRS & SI APPLICATIONS

THE I-95 COALITION
VIRGINIA DOT
VIRGINIA PORT AUTHORITY
NEW YORK/NEW JERSEY PORT AUTHORITY
Background – Sea Shipping

- Containerized freight is shipped in twenty foot equivalent units (TEU)

- Cargo is loaded in 2 major ways:
  - Crane on to a “lift on lift off” ship (LOLO)
  - Driven on to a “roll on roll off” ship (RORO)
The SCRAM Team will evaluate the MSSFS* concept along the James River utilizing:

- Simulation – Capture time variability and resource consumption of
  - Port operations
  - Road and marine highway systems
- MODA** – Propose size and type of ships to maximize potential benefit of MHS*** in selected corridor

*MSSFS – Multimodal Short Sea Freight Shipping
**MODA – Multiple Objective Decision Analysis
***MHS – Marine highway system
Approach – Objective and Scope

Evaluate the MSSFS* concept via transfer of land-based freight from I-64 to the James River

• Determine cost-competitiveness
• Determine time-reliability of end-to-end transportation time, including variability
• Estimate any environmental benefits

* MSSFS – Multimodal Short Sea Freight Shipping

Image Ref: http://maps.google.com
Approach – Technical Approach

Data Gathering → Marin Terminal & Multimodal Simulations

Trip time
Time reliability

Scenario Feedback

Decision metrics

Analysis

Recommendations

Deliverables

Final Presentation
Final Report
Project Website

DAT*/MODA**

*DAT = Decision Analysis Tool
**MODA = Multiple Objective Decision Analysis
Approach – Global Assumptions

- Freight transportation data is split evenly in each direction
- Per sponsor recommendation – equipment failures are negligible
- Manufacturers will be willing to pay more in time and/or cost for reliable deliveries
- A TEU* is our standard for measuring cargo

*TEU – Twenty foot Equivalent Unit
Approach – Metrics

• Comparison of modes: short sea vs. land-based
  • Time:
    – Trip time ($\mu$)
    – Time reliability ($\sigma$)
  • Fuel consumption
  • Transportation costs

• Outcome
  • Assess total benefit of the MSSFS* compared to highway freight transportation for selected routes

* MSSFS – Multimodal Short Sea Freight Shipping
Approach – Discrete Event Simulation

- Marine terminal and multimodal transshipment discrete event simulations developed in Arena to capture key metrics between different destinations and freight transportation methods
  - Primary benefit – Capture time variability of different routes and equipment sets
  - Other output – Throughput volume, cost, and resource usage

- Scenario primary variables
  - Truck, RORO, LOLO, ship capacities

- Run Matrix

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<th>Scenario</th>
<th>Type</th>
<th>TEU Capacity</th>
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<tr>
<td>1</td>
<td>RORO</td>
<td>100</td>
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<tr>
<td>2</td>
<td>RORO</td>
<td>200</td>
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<tr>
<td>3</td>
<td>LOLO</td>
<td>100</td>
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<tr>
<td>4</td>
<td>LOLO</td>
<td>200</td>
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</table>
Approach – Marine Terminal & Multimodal Transshipment Simulation

Marine Highway:
• Freight transferred to ship (port ops)
• Ship travels James River
• Freight transferred to truck for delivery

Surface Highway:
• Freight travels I-64, US-460, or VA-10 point-to-point
TEU* arrives at port gate

TEU moved to storage

TEU loaded on ship

Ship departs

Ship transits water route

Ship arrives at port

TEU unloaded to trucks

Ship released

TEU trucked to destination

*TEU – Twenty foot Equivalent Unit
Approach – Surface Highway Simulation

TEU* generated

Determine route

Transit surface route

TEU arrives at destination

*TEU – Twenty foot Equivalent Unit
Approach – Decision Analysis Tool (DAT)

• Output from ARENA simulation feeds the DAT
  – Trip time
  – Time reliability
• DAT evaluates viability of port-to-port pairs along water and land routes
  – Overall utility metrics for various ship sizes
  – Number of ships necessary to support demand
• Feedback mechanism – DAT results are analyzed to inform further simulation scenarios
Approach – DAT Assumptions

- Speed (land and sea)
- Market penetration: 25% of existing freight will take MSSFS
- Data
  - Freight demand
  - Land and sea distances
  - Harbor maintenance tax
  - Fuel consumption
  - Fuel cost
Approach – DAT Flow

Assumptions
• Speed
• Transshipment delays
• Data

Multiple Objectives:
• Trip Time
• Time Reliability
• Fuel Consumption

Calculations MODA

Weighted metrics

Ranked options for various ship sizes

Marine Terminal & Multimodal Simulation

Trip time

Data
• Freight volume
• Distances
MODA is a methodology for selection among alternatives where several preferentially independent objectives are at play*

- Subject Matter Expert (SME) input is taken to develop value functions for each objective
- SME developed weights are applied to each objective
- Weighted value functions are summed
- Options are ranked

General form is:  
\[ V(x) = \sum_{i=1}^{n} w_i v_i(x_i) \]

Where:
- \( V(x) \) is the overall value of \( x \) for the \( n \) objective metrics
- \( w_i \) is the weight of the \( i^{th} \) measure
- \( v_i(x_i) \) is the value of the \( i^{th} \) measure of \( x \)

Approach – MODA (continued)

- MODA Value functions can be tailored
- For this project linear values were assumed accordingly:
  
  \[ v(x_{ij}) = \frac{x_{ij} - \text{Worst}(x_i)}{\text{Best}(x_i) - \text{Worst}(x_i)} \]

  Where:
  - \( v(x_{ij}) \) is the value of option j for the metric i (value of 1 is best and zero is worst)
  - Additive MODA model requires preferential independence between objectives – Cost, time and fuel consumed are considered preferentially independent

- Weights:

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<th>Measure</th>
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<th>( x_b )</th>
<th>p</th>
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<td>Fuel Consumption (gal)</td>
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Analysis and Results – I-64 Corridor

Cost per TEU vs MODA metric w/ gate hrs and 1 crane

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<tr>
<th></th>
<th>Cost</th>
<th>Utility</th>
<th>Trip Time</th>
<th>Time reliability</th>
<th>Fuel consumption</th>
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<tr>
<td>Truck</td>
<td>$65</td>
<td>0.865</td>
<td>0.988</td>
<td>0.983</td>
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<tr>
<td>LOLO small</td>
<td>$252</td>
<td>0.551</td>
<td>0.190</td>
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<td>LOLO med</td>
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<td>LOLO large</td>
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<td>0.348</td>
<td>0.435</td>
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</table>
Analysis and Results – I-64

• Very short sea shipping does not appear to be competitive with surface freight shipping along the I-64 corridor
  • Trip length only 80 miles
  • Ship efficiencies not taken advantage of in such short trip
  • Lack of 24-hour operations at port facilities severely hampers on-load and off-load timeliness

• However, relaxing some of these conditions may provide more positive insight
  • Extend port operations to 24-hours
  • Provide additional crane resources
Analysis and Results – 24 Hr Gate/2 Cranes

Cost per TEU vs MODA metric w/ no gate hrs and 2 crane

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Summary

Can increasing the use of the marine highway system provide cost-competitive and time-reliable service?

• I-64 route not cost competitive but comparable utility appears attainable
• Longer routes are more promising → Competitive in cost at ~475 miles
• More congested routes may show greater benefits

What can be inferred relative to highway congestion?

• Congestion reduction probably not significant:
  • Existing studies show MSSFS throughput of 500 trucks per day*
  • 1 lane of highway can carry 700 trucks per hour
  • Our study shows ~600 trucks per day diverted from highways
• Congestion avoidance is significant motivation for shippers

*Global Insight, *Four Corridors Case Study of Short-Sea Shipping Services*, (submitted to US Department of Transportation, Office of the Secretary/Maritime Administration), August 2006,
Recommendations

- To promote the transfer of freight from surface to marine highways
  - Increase utility
    - Move to 24-hour operations
    - Increase terminal throughput
  - Increase cost competitiveness
    - Provide tax incentives or subsidies for use of marine highway
    - Re-evaluate harbor maintenance tax
- Policy reforms
  - Mandate certain % of freight use “greener” modes of transport
Future Work

• Simulation
  • Model multiple terminals
  • Expand the list of routes (marine and highway)

• Decision Analysis Tool
  • Consider other attributes for MODA
  • Research congestion metrics

• Architecture
  • Data feeds
  • Graphical User Interface
Acknowledgements

- Dr. C. Chen
- Dr. A. Landsburg
- Dr. K. Laskey
- Dr. K. Thirumalai
For More Information Visit

http://seor.gmu.edu/projects/grad-proj.html
Questions / Comments
Thank you!
Backup
Roles and Responsibilities

- Karen Davis – Research/Data Analysis Tool
- Greg Haubner – Project Manager/Simulation
- Jim Hingst – Simulation/Research
- Bill Judge – Data Analysis Tool/Multiple Objective Decision Analysis
- Chris Zalewski – Simulation/Research
Earned Value Management

BCWS – Budgeted Cost of Work Scheduled
ACWP – Actual Cost of Work Performed
BCWP – Budgeted Cost of Work Performed
# Work Breakdown Structure

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OR 680, Spring 2010