Marine Highway System
A Multimodal Short Sea Freight Shipping System

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Think. Learn. Succeed.
Agenda

• Background
• Problem Statement
• Technical Approach
  • Decision Analysis Tool / MODA
  • Freight transshipment simulation
• Analysis & Results
• Recommendations
Background

• Increasing GDP has stressed the domestic transportation system
• According to the DOT Maritime Administration (MARAD)
  • Truck volume on Interstate Highway System may double by 2035
  • Trucks account for 40% of the time Americans spend in traffic
  • Roughly 60% of federal highway funding used for maintenance
• One solution – the underutilized marine highways
  • DOT established a framework to provide federal support to expand the use of America’s Marine Highways for freight transshipment

Limited Highway Capacity + Road Maintenance Costs + Traffic Congestion = Marine Highways
Problem Statement

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

• The Question:
  • Can increasing the use of the Marine Highway System relieve highway congestion and provide cost-competitive and time-reliable service?

Projections from MARAD website: http://www.marad.dot.gov/
Stakeholders: GMU Consortium Team

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
Our Approach

- The SCRAM Team will evaluate the Multimodal Short Sea Freight Shipping (MSSFS) concept along I-64 utilizing:
  - Simulation of port operations and surface and marine highway systems to capture time variability and reduction in surface movements
  - Multiple Objective Decision Analysis to propose size and type of ships to maximize potential benefit of Marine Highway System in this corridor
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
  - Determine reduction in surface road freight shipment
  - Estimate any environmental benefits
Technical Approach

Data Gathering

Marine Terminal & Multimodal Simulation

Decision Analysis Tool / MODA

Analysis

Recommendations

Deliverables

Final Presentation

Final Report

Project Website
Assumptions / Limitations

- Freight transportation data is split evenly in each direction
- No induced traffic resulting from any cargo moved off the highways onto the waterways
- Ship terminal/crane reliability is constant
- Manufacturers would be willing to pay more in time and/or cost for reliable deliveries
- A Twenty foot Equivalent Unit (TEU) is our standard for measuring cargo
Metrics

• Comparison of modes: short sea vs. land-based
  • Time (and variability)
  • Throughput volume
  • Transportation costs

• Indirect
  • Congestion mitigation
  • Savings in highway maintenance costs

• Outcome
  • Assess total benefit of the alternate transportation system compared to highway freight transportation for selected routes
Discrete Event Simulation

- Marine Terminal and Multimodal Transshipment discrete event simulation developed in Arena to capture key metrics between different destinations and freight transportation methods
  - Primary benefit is capture of time variability of different routes and equipment sets
  - Also captures throughput volume, cost, and resource usage
- Scenario variables
  - Truck, RoRo, LoLo Small/Medium/Large container ships
- Run Matrix

<table>
<thead>
<tr>
<th>Run:</th>
<th>Average Trip Time</th>
<th>Variability of Trip Time</th>
<th>Number of TEUs Moved</th>
<th>Fuel Consumed</th>
<th>Average Costs</th>
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<tbody>
<tr>
<td>Truck</td>
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<td>RoRo</td>
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<td>LoLo 1</td>
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<td>LoLo 2</td>
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<td>LoLo 3</td>
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</tbody>
</table>
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 point-to-point
ARENA Model Overview

Port of Richmond

Port of Virginia
Model – Decision Analysis Tool

• Output from ARENA simulations feeds the Decision Analysis Tool
• The Decision Analysis Tool will evaluate
  • the viability of port-port pairs along the I-64 corridor
  • water and land routes between Richmond and Norfolk, VA
Model – Decision Analysis Tool

• Assumptions:
  • Speed, land and sea, degraded by congestion
  • Delays associated with transshipment, waiting for a ship relative to ship size
  • Fuel consumptions and cost
  • Harbor maintenance tax

• Data
  • I-64 freight movement data, demand
  • Land and Sea distances
  • Congestion index

• Outputs
  • Traffic diverted from highways (congestion relief)
  • End to end time
  • Total costs
  • Fuel consumption
  • Ships necessary for certain frequency of service (integer constraints)
Model – Decision Analysis Tool

Assumptions
• Speed
• Delays
• Market share

Calculations
MODA

Data
• Freight volume
• Distances
• Congestion

Metrics:
• Cost
• Time
• Fuel Consumed

Ranked options for Various ship sizes

Weighted metrics
Multiple Objective Decision Analysis (MODA)

MODA is a methodology for selection among alternative where several preferentially independent objectives are at play

• SME input is taken to develop value functions for each objective
• SME developed weights are applied to each objective.
• The weighted value functions are summed
• Options are ranked

General form is:

\[ v(x) = \sum_{i=1}^{n} w_i \cdot v_i(x_i) \]

Where:

• \( v(x) \) is the overall value of \( x \) for the \( n \) objective metrics
• \( w_i \) is the weight of the \( i \)th metric
• \( v_i(x_i) \) is the value of the \( i \)th metric of \( x \)
MODA Continued

MODA Value functions can be tailored to meet various shapes that represent value.

For this project linear values were assumed accordingly:

\[ v(x_{ij}) = \frac{x_{ij} - \min(x_i)}{\max(x_i) - \min(x_i)} \]

Where:
- \( v(x_{ij}) \) is the value of option \( j \) for the metric \( i \)
- \( x_{ij} \) is a value of 1 is best and zero is worst.

Each metric was weighted equally for this project

Additive MODA model required preferential independence between objectives

Cost, time and fuel consumed are considered to be preferentially independent
Analysis and Results

MODA metric vs cost

- Truck
- RoRo
- Small Container
- Medium Container
- Large Container
Analysis and Results, Continued

• From the Simulation we found…

• From the Decision Analysis Tool we found…
Recommendations

• Based on our analysis, we recommend
  • TBD…
Incidental Findings – Roadblocks

• Costs
  • At this time, dock usage costs seem prohibitively high for short-sea shipping

• Shipbuilding
  • The U.S. currently doesn’t build many transport ships, except for military
  • Would have to purchase ships from other countries

• Truck
  • Domestic based trucking is not standardized (i.e., various sizes)
Future Work

• Expand the short-sea shipping problem to regions beyond the Virginia/I-64 region.
• Develop and implement the data architecture required to “feed” the data analysis tool
• Develop the simulation into a scalable product for assessment of MSSFS in any region
Acknowledgements

• Dr. Thirumalai
• Dr. Chen
• Dr. Laskey
For More Information Visit

Questions / Comments
Thank you!
Backup
Work Breakdown Structure

Data Collection
- Research
- Selection of Alternatives
  - Previous Work
  - Recommendations
  - Sea
    - Time
    - Fuel Consumption
    - Costs
    - Ship Information
    - Transshipment
  - Land
    - Time
    - Fuel Consumption
    - Current Demand
    - Costs
    - Truck Information

Analysis
- Metrics
  - Direct
  - Indirect
  - Baselines’ Excursions
- Data Sources
- Optimization
- Preliminary Results
- Model
- Simulation
- Advisor Review

Implementation
- Fuel Consumption
- Cost
- Throughput Volume

Validation
- Safety
- Congestion Mitigation
- Emission Reduction
- Cost

Assessment and Report Preparation
- Results Review
- Recommendations
- Report

Project Management
- Update Meetings with Client
- Status Reports
- Progress Presentation
Metrics, Analysis, Recommendations

- Want to validate multi-modal short sea shipping viability, routes, direct and indirect benefits
- If needed, recommend policy (incentives) changes that may help the viability

PoV: Port of Virginia // PoR: Port of Richmond // PoB: Port of Baltimore