Conceptual Framework for Analyzing the MTS within the Intermodal System

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**Conceptual Framework for Analyzing the MTS within the Intermodal System**

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Outline

- The U.S. economic challenges highlight the need for a national integrated freight system.
- No single organization can centrally manage all the required investments for an integrated freight system.
- Waterways are in a unique position to think system-wide.
- Overview of an MTS intermodal analysis framework.
- Next steps.
U.S. Economic Challenges

Business
- Reduce costs.
  - Raw materials
  - Imports
  - Exports
- Increase Jobs
  - Cost competitive exports
  - Lower costs-> increase demand
- Technology creates challenges
  - Tracking, communication, efficiency
- Sustainability
  - Environment, society, profit

Government
- Decreased funding
- Increased scrutiny
- Pressure creates focus
- Encourages co-operation
- Infrastructure demands attention

We need a better understanding of our integrated freight system to help us face these issues.
No single organization can do this alone.

- Investments can be coordinated without being centrally planned.
- Shared data helps analysis.
Waterways are in a unique position to think system-wide.

- Movement data sets available.
- Federal control/responsibility for much of the system.
- Detailed tracking data available (AIS).
- History of economic-based investment decisions.
- Potential to LEAD in transportation modeling.
US Commercial Freight Magnitude

Total US International Trade 2010
$4.1 Trillion

Exports
$1.8 Trillion (44%)

Imports
$2.3 Trillion (56%)

Total Goods
$3.2 Trillion (77%)
1.9 Billion tons

Waterborne
1.4 Billion tons (72%)

Air, Land, Pipeline
542 Million tons (28%)

Services
$549 Billion (13%)

Services
$403 Billion (10%)

A Conceptual Framework

CURRENT INTERMODAL SYSTEM

CURRENT MTS

INTERMODAL INVESTMENTS

MTS INVESTMENTS

FUTURE INTERMODAL SYSTEM

FUTURE MTS

FUTURE FREIGHT TRANSPORTATION DEMAND
Two Big Challenges

- Predicting the future is hard.
- The intermodal system is very complex and hard to understand.

- But this is our charge…
Example: Navigation Investment Model

- **WSDM**: Waterway Supply and demand
- **Traffic Levels**
- **LRM**: Lock Risk Module
- **Investment Plan**
- **Optimization Module**
- **Reliability Estimates**
Examples: FAF$^3$ and CPT
Current MTS
“We are a maritime nation.”

- MTS—A national resource
  - Ports, locks, waterways, vessels
  - Operational Practices
  - Technology in use

- Metrics we use for tracking MTS status
  - Cargo processed (tons, TEUs)
  - Average Delay at a lock
  - Ship drafts for arrivals/departures
  - Others—economic, environmental, social, security

- BIG DATA may tell us things we did not know.

**Not systems thinking.**
We need to understand how commodities flow on the network.

Rail movement of raw materials.
2022 Mode Specific Ethanol Movements (Ktons)
Multi-modal Freight Movements
MTS Intermodal Role
How do we estimate freight transportation demand?

- Waterborne Commerce Data
- FAF³
- AIS
- Import/Export Trends
- Input/Output models of manufacturing
- F**ecasting
• Mode Share for the Manufacturing Sector

Water movements are more likely to happen around 1000 miles

Based on a logit model using FAF data.
Biennial Research and Development Conference

Diagnosing the Marine Transportation System: Measuring Performance and Targeting Improvement


National Academy of Sciences Building
2101 Constitution Avenue, NW
Washington, D.C. 20418

Abstracts Due
March 31, 2012
System Investments

- Construction, maintenance/rehab, dredging
- Operational changes
- Technology—RIS, eNav, construction, materials
- Vessels
- Innovations by industry
Challenges for Investment Planning

- *What is our baseline for comparison?*
- *How should we finance the investments?*
- *How should we plan for unpredictable financing?*
Connect the Dots

Problem A

Problem B
Connect the Dots

Problem A
Easy

Problem B
Hard
Supply Chain Reliability

System Reliability = $R_D \times R_W \times R_R \times R_T$

- Traffic flows
- Physical conditions
- Investments
- Intermodal connections
Supply Chain Reliability

System Reliability = \( R_D \times R_W \times R_R \times R_T \)

- Traffic flows (congestion)
- Physical conditions (level of service)
- Investments (coordinated sustained funding levels)
- Intermodal connections (turn times)

Evaluated via Metrics

- But we must understand the system...
How to Improve System Reliability?

- Yes, target the weak links, but understand their contribution to the overall system.
- We need coordination and understanding across:
  - Government
  - Industries
  - Operators
  - Generations
Future MTS Synergies

- Government
  - Commodity flow data (USDOT, USACE)
  - Investment coordination
  - Implementing new technologies

- Industries and Operators
  - Understand the full supply chain, conduct business and advocate accordingly
  - Competition

- Generations
  - Sustained societal commitment to MTS
National Needs → Metrics and Objectives

**National Needs**
- Reduced Cost
- Increased Profits
- Economic Growth
- Jobs
- Security
- Resiliency
- Safety
- Environment
- Energy reduction

**Metrics**
- Traffic accommodated
- Traffic diverted
- Average Delays
- Capacity utilization
- Transit times

**Optimization Objectives**
- Net benefits
- Profit
Future MTS
Ultimate Measure of Success

Reduced Cost for MTS

Reduced Cost for all Modes

Stronger Economy

Bigger Modal Share for MTS

Maximum Value to the Nation
Conceptual Framework for Analyzing the MTS within the Intermodal Freight System

Questions and Discussion
Backup slides
Raw Materials → Components → Sub Assemblies → Final Product
The 40,000 foot view

**Measure and Model**
- **Current MTS**
  - Ports
  - Locks
  - Channels
  - Fleet
  - Operating costs

**Current Freight Traffic**
- Water
- Highway
- Rail

**Investments & Plans**
- Short Term
- Long Term
- Operational Changes
- Taxes, fees
- Industry evolution

**Envision the Future & Choose Alternatives**
- **Potential Future MTS**
  - Ports
  - Locks
  - Channels
  - Fleet
  - Operations costs

**Potential Future Freight Demands**
- Imports
- Exports
- Domestic

**Investment Alternatives**
- Construction
- Maintenance/Rehab
- Dredging
- Taxes, fees
- Information technology
- Operational changes

**Implement Goals and Plans**
- **Goal MTS**
  - Ports
  - Locks
  - Channels
  - Fleet
  - Operations costs

**Future Freight Traffic**
- Water
- Highway
- Rail

**Investment Plan**
- Construction
- Maintenance/Rehab
- Dredging
- Information technology
- Operational/policy changes

**Satisfy National Needs**
- Cost
- Profits
- Econ. Growth
- Jobs
- Security
- Resiliency
- Environment
- Safety

**Reduced**
- Cost
- Profits
- Econ. Growth
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The 40,000 foot view

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- Goal MTS
  - Ports
  - Locks
  - Channels
  - Fleet
  - Operations costs

Future Freight Traffic
- Water
- Highway
- Rail

Investment Plan
- Construction
- Maintenance/Rehab
- Dredging
- Information technology
- Operational/policy changes
- Financing

Satisfy National Needs
- Cost
  - Profits
  - Econ. Growth
  - Jobs
  - Security
  - Resiliency
  - Environment
  - Energy
  - Safety
Example: Navigation Investment Model

- WSDM: Waterway Supply and demand
- Traffic Levels
- LRM: Lock Risk Module
- Investment Plan
- Reliability Estimates
- Optimization Module
20,000 Foot View - Measure and Model

Ports -> Capacity Models -> Current System
Locks -> Channels -> Network

Water, Commerce -> AIS -> LOMA/eNavigation -> Freight Analysis Framework

Estimates Traffic -> Current Intermodal Freight Traffic

Construction Plans -> Maintenance Plans -> Dredging Plans
Operational Changes -> Technology Changes

Model Changes -> Investments and Plans
Envision The Future—system changes

- Improvements and degradation
- Multiple years
- Multiple scenarios

Scenarios

Current System

Investments and Plans

Model planned & potential system changes

Investment Alternatives

Cost & effect

Capacity
Speed
Reliability
Connectivity
Costs
Externalities

Potential Future MTS
Example: Lock Risk Module

How does maintenance affect reliability?

- Event Tree
- Hazard Function
- Equilibrium Tonnage Levels
- LRM
- Expected Failures and Costs
Envision The Future—freight demand

- Can be linked to an input/output model of business at the county level
- Based on a scenario(s)—robust decisions
- Supply chain based
- The F word
Demand is ultimately dependent on industry business patterns

- Business I/O graphic here
- Or other FAF graphic
Mode Share by Distance

Tonnage (thousands tons) by distance range (miles)

Share of tonnage by distance (miles)

- Truck
- Rail
- Water
- others
Example: Logit Model

- Mode Share for the Manufacturing Sector

Water movements are more likely to happen around 1000 miles.
Choose Alternatives—estimate impacts

- Demand $\rightarrow$ Traffic estimates
- What does the shipper “know” that is not captured by economics?
  - Cost of uncertainty
  - Cost of change
- Challenge: to account for ...

Estimate Future MTS Traffic under a set of alternatives
- Partial Equilibrium
- Supply/Demand
- Multi-modal
- Shipper behavior

Potential Future MTS System

Future Freight Demand

Investment Alternatives

Capacity
Speed
Reliability
Connectivity
Costs
Externalities

Imports
Exports
Domestic
Commodity mix
By O/D

Construction
Maintenance
Dredging
Operations
Technology

Mode share
Shipping costs
Delay
Capacity limits

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Waterway Supply and Demand Module

Traffic estimates based on demand and costs.

Cargo Forecasts → Waterway Network

Transit Time Curves → WSDM

Lock Operations → Demand Functions

Shipping Plans → Equilibrium Tonnage Levels
WSDM Equilibrium Process

Each movement has its own cost curve and demand function:

- **Demand function**
- **Cost function**
- **Consumer surplus**

$p^*$
$q^*$

price

tonnage
Select “best” investment plan

- Discounted costs and benefits
- Local standards vs. system metrics
- Optimality vs. heuristics vs. consensus
Example: Channel Portfolio Tool

- Need a graphic here, instead of NIM slide.
Example: NIM Optimization Module
Best investment at the best time.

Construction Plans → Optimization

Random Minors → Optimization

Expected Failures and Costs → Optimization

Optimal Alternative Selection and Timing

Graph showing replacement years and associated costs.
Current System

Investments and Plans

Estimate Future MTS Traffic under a set of alternatives
- Partial Equilibrium
- Supply/Demand
- Multi-modal
- Shipper behavior

Select “best” Investments
- Limited by budget
- System wide benefits
- Costs and benefits over time

Model future national freight demand

Future Freight Demand

Future Freight Traffic

Investment Alternatives

Current Freight Traffic

Econ. Forecasts
Policies
Business Input/output
Imports/exports

Future MTS

Potential Future MTS

Model planned & potential system changes
Implement Goals and Plans

- **Financing**

- **Short term plans**
  - Dredging
  - Maintenance
  - Systems deployment (e.g. RIS)
  - Policy changes (taxes, fees)

- **Long term plans**
  - Major rehab
  - Construction (e.g. lock extension)

- Visibility to MTS community

- Visibility to other modal planning
Waterways can demonstrate system-wide modeling to the freight community.

- Develop tools to use DOT transportation data (e.g., FAF)
- Leverage real-time data (LOMA, AIS)
- Integrate deep draft and inland modeling
- Integrate operational (short term) and long term models
PRRM Needs: Intermodal Freight Network

- National Highway Network Database
- National Rail Network Database
- National Waterway Network Database
- Global Seaways Network Database
- Intermodal, Truck, Rail and Water Terminals Databases

Unified Multimodal/Intermodal Freight Network (A National Resource)

Routing, Traffic Estimates, Reliability, Hazardous Restrictions
The national intermodal network provides a unified modeling framework for costs and traffic flows.