American Marine Highway Modeling Toolset

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Overview

- Project Goals
- DES Introduction
- Input Architecture
- Features
- I-64 Express Route
- East Coast Route
- Brown / Blue Water Route

Project Goals

- **GMU Project Deliverable**
  - A simulation of the economic, environmental, and logistic factors of transferring cargo from trucking routes to American Marine Highways for two scenarios:
    - Short route between Norfolk and Richmond (I-64 Express)
    - Long route between New Bedford, Norfolk, and Cape Canaveral

- **GMU Parallel Project Goal**
  - Create a reusable modeling tool for evaluating AMH alternatives
    - Excel-driven / runtime model for a marine highway between two ports and three ports

- **Current Work**
 - Model blue/brown water route on Mississippi and Gulf

Introduction to DES Modeling

- Discrete Event Simulation (DES) is a computer simulation that models the chronological sequence and interaction of events
  - Example: Bank teller operations

- Model is created in ExtendSim 8 DES software
  - Uses Hierarchical Blocks - designed for "toolset" implementation
  - Allows for random interactions and variability
  - Has Monte Carlo capability to optimize process
  - Imports data from Excel – simplifies data input for user
 - Has free runtime version

Scalability Feature

- Fully scalable model for distances and amount of ports/travel segments
- "Lego-block" style architecture allows for interconnection of each block type
- Attributes tracked through each process can be fixed and time based
 - (Mileage based for road travel)
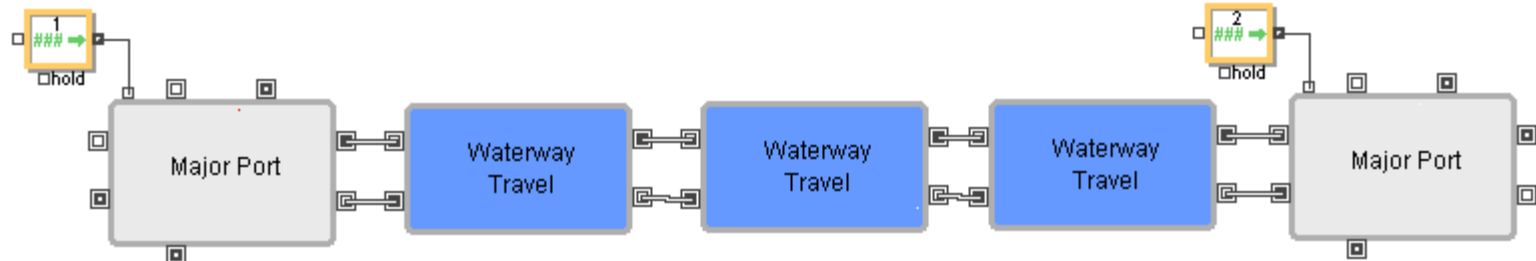
Intelligent Ship Control Feature

- Model tracks amount of cargo available to system. Releases ship only if it's economically viable.

- Routes cargo if shipping route can't handle volume

- Optimized release architecture predicts when it is most efficient to sail based on river currents/tides
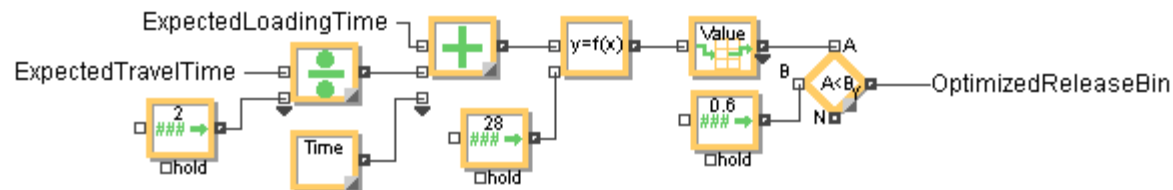
Seasonal Probability of Cancellation/Costs Feature

- Built in architecture that allows user to specify any possible additional cost or cancellation

- Can be specified to be only activated within certain times

- Examples:

  – Seasonally dependent events such as route cancellation due to heavy fog in autumn or additional stevedoring costs due to rain-pay

  – Maintenance based costs dependant on ship characteristics
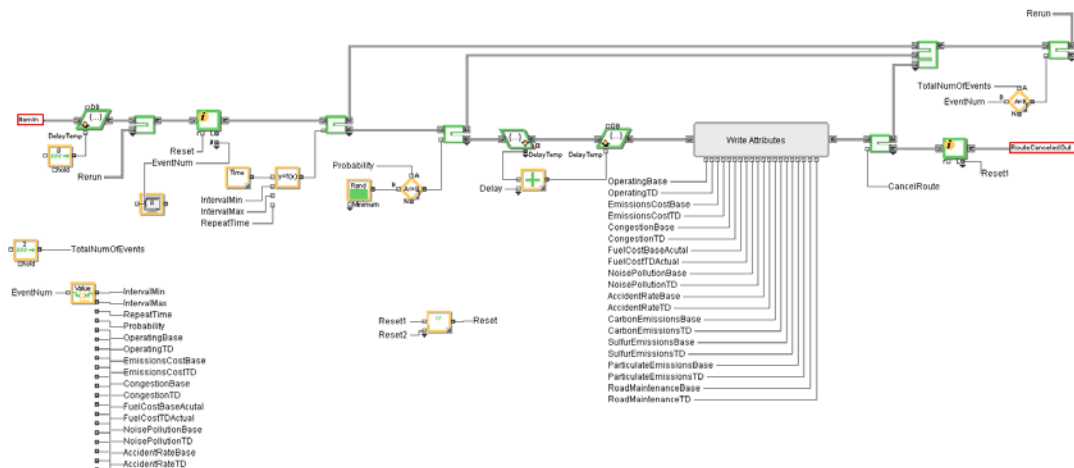
Input Architecture

- Inputs for all processes and metrics use the following format:

$$Cost = a \cdot time + b \cdot distance + c$$

- Where:
  - a – time dependant cost, e.g. $/hour
  - b – distance dependant cost, e.g. $/mile
  - c – constant or base cost

- Inputs are controlled via MS Excel spreadsheet

Metrics Tracked in Model

- Metrics tracked and summed for every piece of cargo:
  - Operating cost
  - Fuel cost
  - CO_2 emissions

- Metrics available for tracking:
  - Road maintenance cost
  - Congestion added
  - Accident rate
  - NO_x emissions
  - Particulate emissions
  - Noise pollution

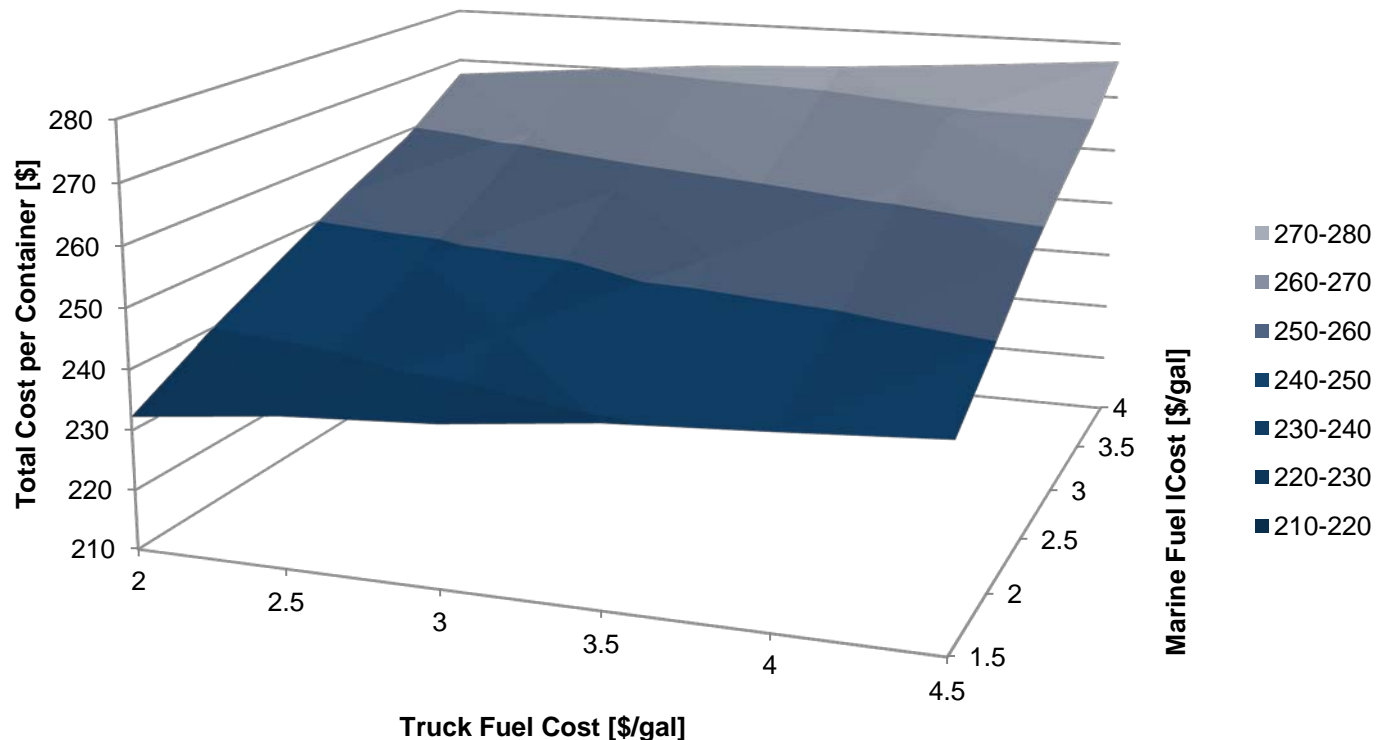# I-64 Express Route Translated to ExtendSim Model
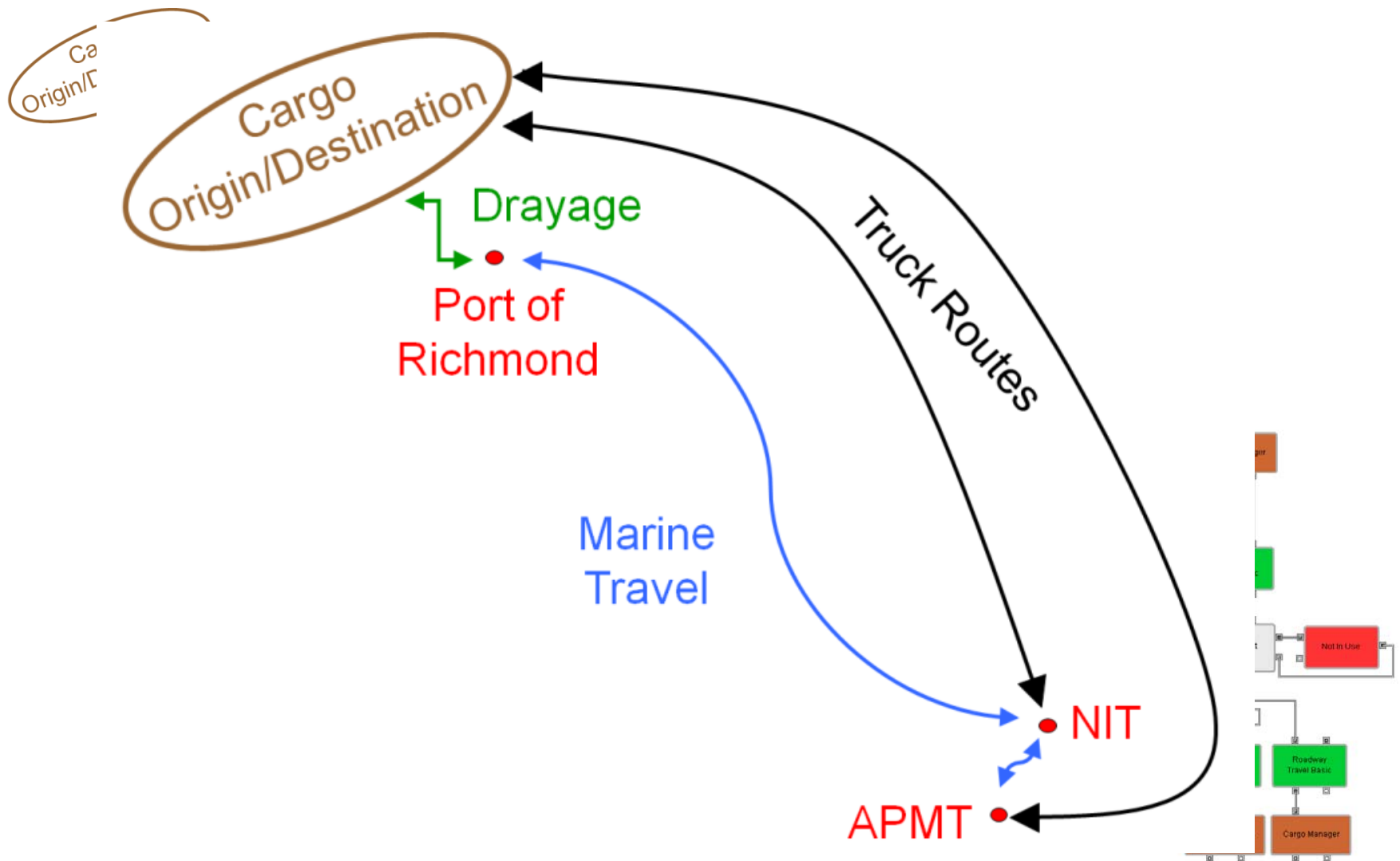
I-64 Express Route Results

- 26% of cargo is rerouted

- Average time between container leaving NIT/APMT/Richmond area and arriving at destination is 1.69 days

	Average	Tug/Barge	Rerouted by Truck
Operating Cost	$237.06	$218.36	$317.30
Fuel Cost	$48.59	$44.84	$64.67
Total Cost	$285.65	$263.20	$381.97
CO_2 Emissions [g]	55,726	49,731	90,029

Exploration Capabilities

- Design of Experiments approach to total cost per container with fluctuating fuel costs
  - Scenario does not have seasonal cancellations
  - Average rerouting rate is 14%

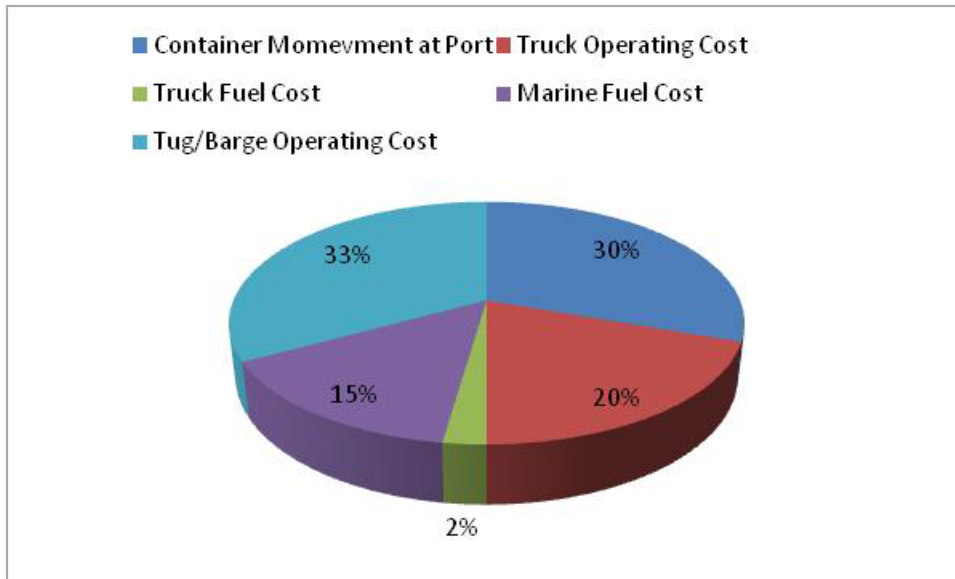# East Coast Long Route Model Translated to ExtendSim Model
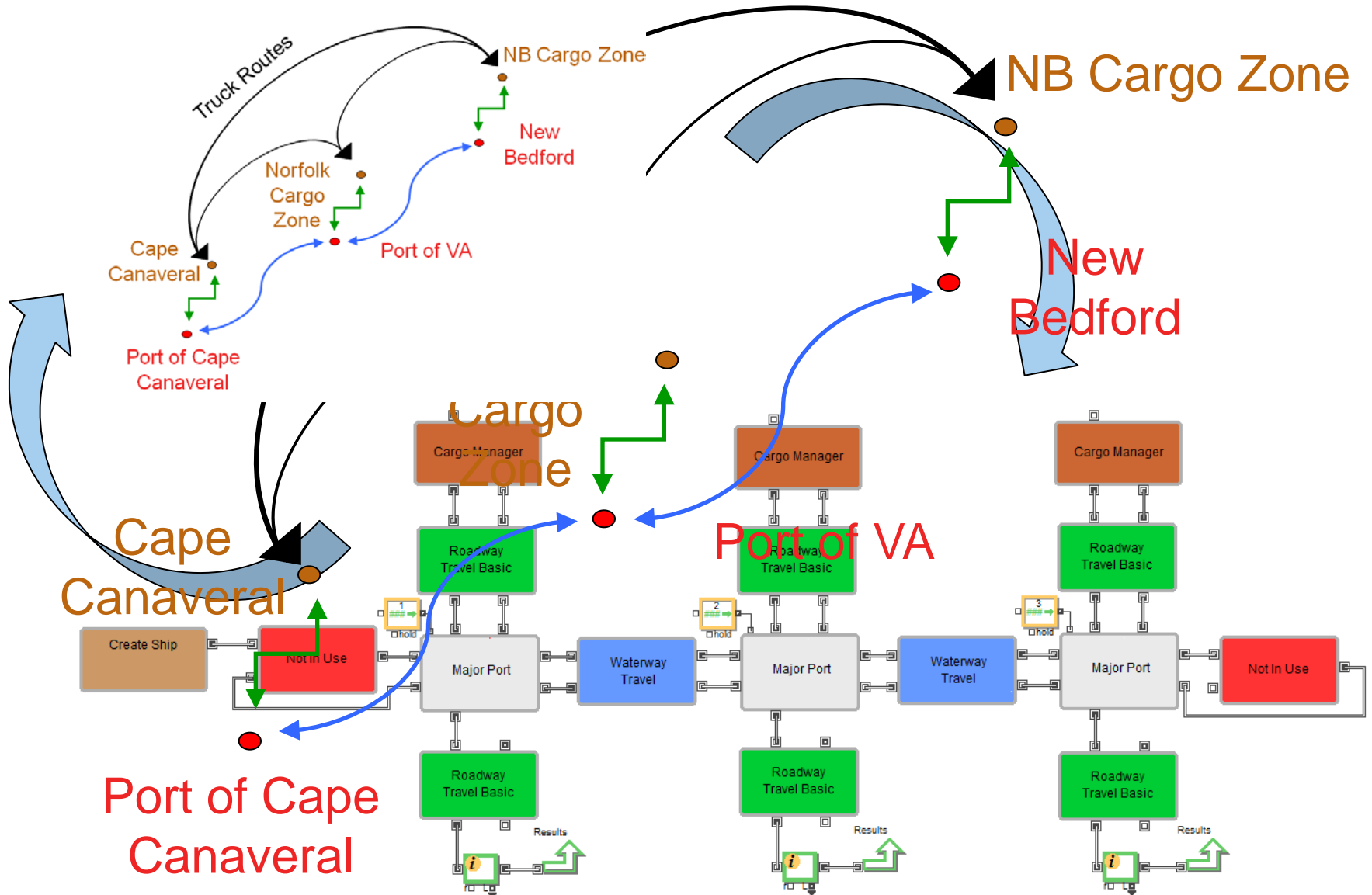
East Coast Long Route Results

- Average for door-to-door delivery
  - Canaveral – Norfolk: 6.84 days
  - Norfolk – New Bedford: 6.47 days
  - Canaveral – New Bedford: 8.19 days

	70% Full	80% Full	90% Full
Operating Cost	$1067.69	$1027.16	$982.93
Fuel Cost	$680.75	$611.58	$557.34
Total Cost	$1748.44	$1638.74	$1540.27

Costs from Canaveral <-> New Bedford

Legend:
- Container Momevment at Port
- Truck Operating Cost
- Truck Fuel Cost
- Marine Fuel Cost
- Tug/Barge Operating Cost

Pie chart values: 30%, 20%, 2%, 15%, 33%

Brown/Blue Water Route Diagram

Chicago, IL

Joliet, IL

Southern, IL
Southern, MO
Western, KY

Cairo, IL

NOLA

Port of NO

Key:

Tampa, FL

Port of Tampa

Marine Travel
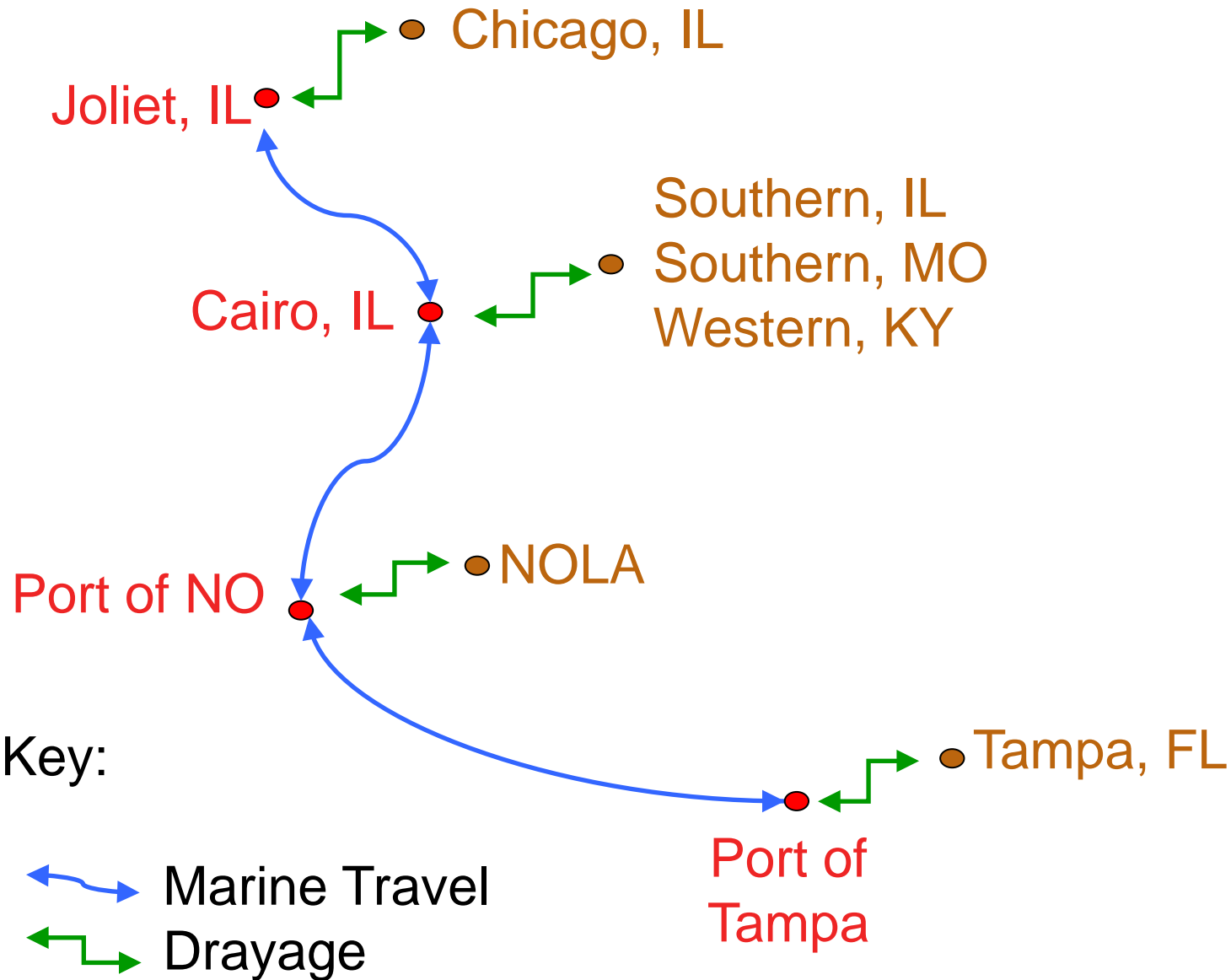
Drayage

Brown/Blue Water Barge Concept

Tow in Deep Draft Blue Water
FIG.2a

Tow in Shallow Draft
FIG.2b
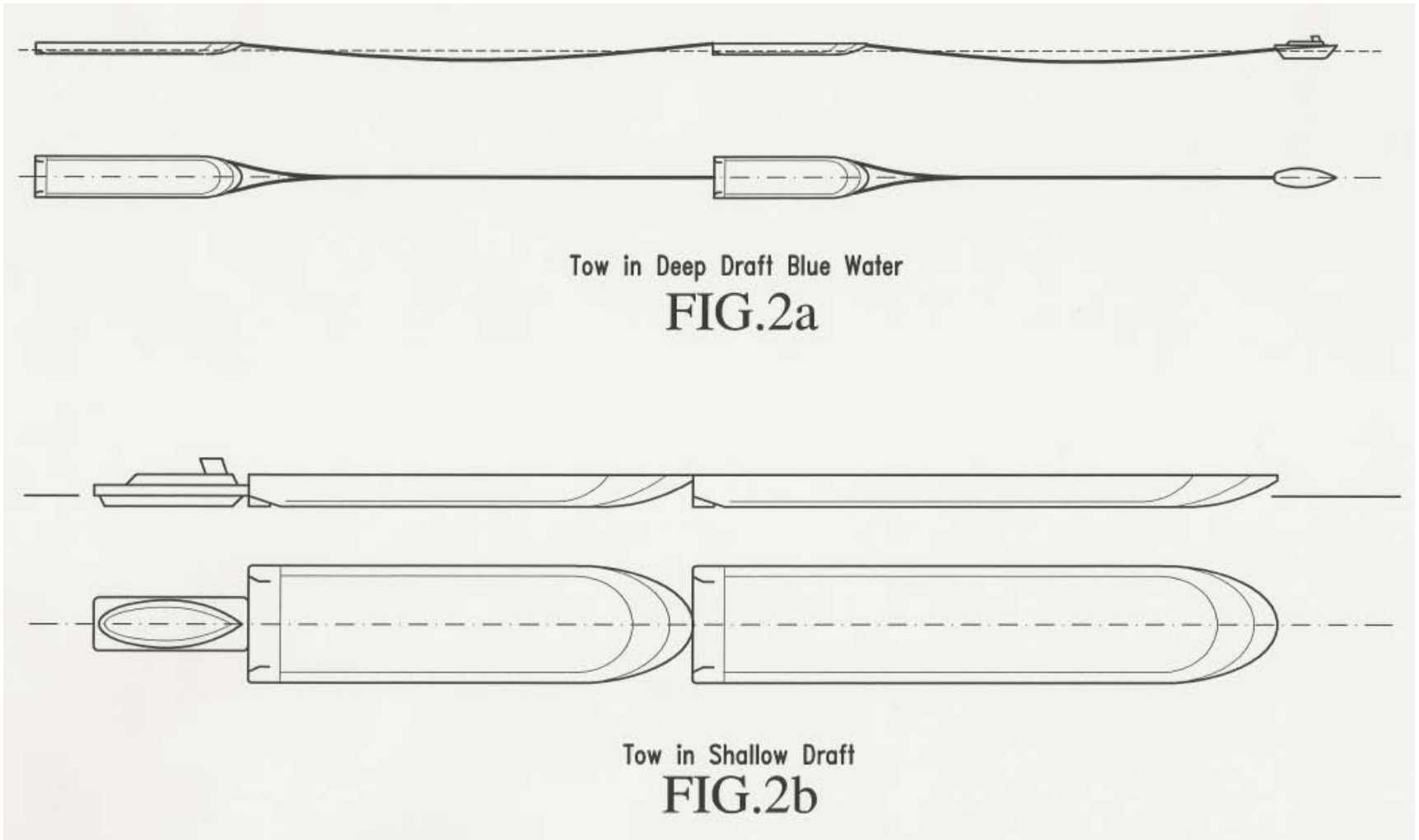
Brown/Blue Water Route Preliminary Results

	Chicago – Tampa	Cairo, IL – Tampa	NOLA - Tampa
Operating Cost	$1237.60	$1079.56	$954.79
Fuel Cost	$253.65	$215.73	$174.24
Total Cost	$1489.11	$1295.29	$1128.76
Total Cost – Drayage & Port costs	$947.15	$756.33	$589.79

- Drayage and port costs have a large affect on door-to-door cost

- Eight (8) locks with 5% failure rate have minimal affect on system
  - Need to include realistic lock schedules and tug/barge queuing

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Way Forward

- Support 2-port and 3-port models available to public
  - http://eastfire.gmu.edu/gmu-consortium/marine-highway/

- Add functionality
  - Inflation
  - Business fluctuations
  - Mid simulation fleet additions
  - ROI calculator

- Add model to PHX ModelCenter
  - Variable sensitivity analysis
  - Optimize systems

Questions

- Questions?

Backup

I-64 Express Route Inputs Used

- Environment
  - Simulation time is 365 days
  - Distance between Richmond and NIT is 85 NM
  - Bi-diurnal current on James river fluctuates up to 3 knots
  - 20% route cancellation due to fog in Spring and Fall
  - Marine fuel $3.00/gal Truck fuel $4.00/gal

- Tug/Barge
  - 3 round trips per week
  - 1 barge attached to tug with a capacity of 85 containers
  - 6 knot sailing speed
  - 65 gal/hour fuel burn rate when sailing
  - 10 gal/hour fuel burn rate when idling
  - $7000 operation cost per round trip

I-64 Express Route Inputs Used

- Trucking
  - Distance between Richmond and NIT/APMT is 76 statute miles
  - Drayage distance at Richmond is 10 statue miles
  - Speed
    - 30 MPH minimum
    - 40 MPH most likely
    - 50 MPH maximum
  - Operating cost
    - $83.68/hour
    - $1.73/mile
  - Fuel burn rate is 5 MPG

I-64 Express Route Inputs Used

- Cargo
  - ~16 containers per day are modeled at both APMT and NIT
  - ~32 containers per day are modeled in the Richmond area
  - Cargo is has a deadline to be delivered in 14 days after creation

- Ports
  - $40 per move
  - Ship cancels trip if less than 40 containers are available among all ports

East Coast Long Route Inputs Used

- Environment
  - Simulation time is 180 days
  - MGO fuel $3.00/gal Truck fuel $4.00/gal

- Ship
  - Capacity:
    - 151 53' trailers
    - 104 53' containers
  - Design speed 23.7 knots
  - Fuel consumption 106 tons/day at cruising
  - Operating cost $70,000/day*

    *Finance costs, ownership costs, owner's return on equity, insurance, and crew wages

East Coast Long Route Inputs Used

- Trucking
  - Speed
    - 45 MPH minimum
    - 55 MPH most likely
    - 60 MPH maximum
  - Distances
    - Canaveral – Norfolk: 800 miles
    - Norfolk – New Bedford: 600 miles
    - Canaveral – New Bedford: 1300 miles
  - Operating cost
    - $83.68/hour
    - $1.73/mile
  - Fuel burn rate is 5 MPG

East Coast Long Route Inputs Used

- Cargo
  - 30 containers per day are modeled at all ports
  - Cargo is has a deadline to be delivered in 21 days after creation

- Ports
  - $40 per move
  - Each move takes 3 minutes
  - Trip cancels trip if less than 100 containers are available among all ports

- Marine Routes
  - Canaveral – Norfolk: 620 nautical miles
  - Norfolk – New Bedford: 380 nautical miles

Brown/Blue Water Route Inputs

- Tug/barge lease/insurance/labor $14,000

- 65 gal/hour fuel burn rate when sailing

- 10 gal/hour fuel burn rate when idling

- Cargo Capacity
  - Juliet   264 53' containers
  - Cairo   534 53' containers
  - NOLA   950 53' containers

- Tug/barge speed
  - 10 mph brown water South
  - 8 mph brown water North
  - 9 mph blue water (7.8 knots)

Brown/Blue Water Route Inputs

- Environment
  - Simulation time is 365 days
  - MGO fuel $3.00/gal Truck fuel $4.00/gal

- Cargo
  - 20-40 containers per day are modeled at all ports (stochastic)

- Ports
  - $80 per move
  - Each move takes 3 minutes

Brown/Blue Water Route Inputs

- Locks
  - Average time 1.5 hours (min 1 hour, max 2 hours, triangular distribution)
  - 8 locks between Juliet and Cairo
  - 5% failure rate

- Distances
  - Juliet - Cairo   405nm
  - Cairo - NOLA   640nm
  - NOLA - Tampa   475nm

- Flooding and drought cause cancellation of voyage 10% of trips in summer and winter months

Brown/Blue Water Route Inputs

- Drayage
  - Speed
    - 45 MPH minimum
    - 55 MPH most likely
    - 60 MPH maximum
  - Distances
    - 100 miles from each port
  - Operating cost
    - $83.68/hour
    - $1.73/mile
  - Fuel burn rate is 5 MPG