Geospatial Intermodal Freight Transportation (GIFT)
Topics

- The problem: Trade-offs between the economic, environmental, and energy impacts of freight transportation
- Intermodal freight transportation can help address the problems
  - GIFT enables trade-off case studies
- The GIFT model
The Problems
US Freight Transportation Emissions

- Freight accounts for 470 MMTCO$_2$ annually (7.8% total US CO$_2$ emissions)
- Contributes about 50% of NOx emissions and 40% of PM emissions from transportation sources (EPA)

Proportion of Carbon Emissions by Freight Type, 2004
(US DOE, 2007)
Goods Movement and GDP


For every trillion dollar increase in GDP, we expect an additional 242 billion ton-miles.
Carbon Comparisons by Mode

<table>
<thead>
<tr>
<th>Mode</th>
<th>gCO₂/tkm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck</td>
<td>153</td>
</tr>
<tr>
<td>Rail</td>
<td>13</td>
</tr>
<tr>
<td>Ship (Dom.)</td>
<td>19</td>
</tr>
<tr>
<td>Air</td>
<td>1135</td>
</tr>
</tbody>
</table>

Values in the above table are based on top-down analysis; emissions factors can change considerably based on specific cargo and mode characteristics. Data from the BTS, Special Release, Table 1-46b: http://www.bts.gov/publications/national_transportation_statistics/.
Research Questions

- What are the energy and environmental impacts of freight transportation?
- How do these impacts change:
  - With modal choice?
  - With changing infrastructure?
  - With the use of new technologies in transit or at transfer facilities?

GIFT is a model designed to address these questions
GIFT Projects

East Coast Freight Studies

Which mode is preferred
for least cost?
for least time?
for lowest emissions?

International Shipping Studies

Port-Generated Traffic
Local Congestion; National Delays

Great Lakes GIFT Studies
Example: Study Trade-Offs in Great Lakes Region

<table>
<thead>
<tr>
<th>Primary Mode</th>
<th>Least Cost</th>
<th>Least Time</th>
<th>Least CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Cost (S)</td>
<td>Ship</td>
<td>$240</td>
<td>$330</td>
</tr>
<tr>
<td>Time (hrs)</td>
<td>15.5</td>
<td>6</td>
<td>15.5</td>
</tr>
<tr>
<td>CO₂ (kg)</td>
<td>128</td>
<td>340</td>
<td>96</td>
</tr>
<tr>
<td>PM10 (g)</td>
<td>55</td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td>NOₓ (g)</td>
<td>4190</td>
<td>2210</td>
<td>2450</td>
</tr>
</tbody>
</table>

- Study implications of policies such as carbon tax, feebates, etc.
- Study impact of infrastructure investment
- Study impact of key supply chain flows
- etc.
Useful for evaluating tradeoffs and running experiments for different input values (e.g., costs, speed, emissions). Can be helpful for determining “green” supply chain pathways.

<table>
<thead>
<tr>
<th>Primary Mode</th>
<th>Ship</th>
<th>Truck</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost ($</td>
<td>240</td>
<td>330</td>
<td>290</td>
</tr>
<tr>
<td>Time (hrs)</td>
<td>20</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>CO2 (kg)</td>
<td>115</td>
<td>340</td>
<td>95</td>
</tr>
</tbody>
</table>
Useful for exploring infrastructure and technology investment decisions. For example, we could look at varying time delays to mimic port expansion options.
The GIFT Model
Connect Multiple Transportation Mode Networks at Intermodal Transfer Facilities

Road Network

Rail Network

Waterway Network

Intermodal Transfer Facility

© 2009 Rochester Institute of Technology
GIFT North American Network
Define Economic, Time, Energy and Environmental Costs of Traversing Each Network Segment

There is a “cost” (time, $, energy, environmental impact) associated with traversing each segment of the transportation network.

Costs are computed based on network information, user-input data, and external computations. ESRI ArcGIS Network Analyst finds the least cost routes. Allows trade-off studies of least time, least economic cost, least emissions, etc.
User-Specified Cost Factors

Specify the vehicle and facility operational characteristics to use in a given analysis scenario

<table>
<thead>
<tr>
<th>Emission Rates (gm/TEU mile for modes - gm/TEU for spokes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
</tr>
<tr>
<td>Truck</td>
</tr>
<tr>
<td>Rail</td>
</tr>
<tr>
<td>Ship</td>
</tr>
</tbody>
</table>

| Truck Spoke | 14281  | 1158  | 2659 | 63   | 12.3 | 335  |
| Rail Spoke  | 8035   | 35    | 110  | 3    | 1    | 5    |
| Ship Spoke  | 56626  | 424   | 1940 | 131  | 813  | 119  |
Integrated Emissions Factor Calculators

Select from pre-defined vehicles
Define and save new vehicles
Data Flow for GIFT Analysis

**Freight Transportation Data**
- Transportation Network Geospatial Data
  - Highways, Railroads, Waterways
  - Multimodal transfer facilities
  - Barriers and restrictions
- Vehicle and Facility Emissions and Operations Data
  - Trucks, Trains, Ships
  - Ports, Rail yards, Distribution centers
- Freight Flow Data
  - Originations/ Destinations
  - Volumes

**Scenario Configuration Data**
- Network Configuration
  - Barriers and restriction settings
  - Optimization attributes
- Vehicle and Facility Selection and Characterization
- Freight Flow Selection and Characterization

**Geospatial Intermodal Freight Transportation (GIFT) Analysis**

**Scenario Data Comparison and Analysis for Case Studies**

© 2009 Rochester Institute of Technology
Integrate International Trade Patterns with the Domestic Freight System
Mortality from Ship Emissions: A Global Assessment

Cardiopulmonary mortality attributable to ship \( \text{PM}_{2.5} \) emissions worldwide

(Corbett, Winebrake, et al.)
Intermodal system analyses that improve freight decisions through collaborative, innovative, data-driven transformative research to make the future of freight more sustainable.
Conclusions

- Freight transportation is an essential enabler of a vibrant economy
- Freight transportation is a significant contributor to energy consumption and environment emissions
- Intermodal freight transportation provides opportunities to balance economic, energy, and environmental impacts of freight movement
- GIFT enables a rich analysis of the trade-offs and opportunities of intermodal freight transportation
Contact Information

James Winebrake
+1 585-475-4648
jwinebrake@mail.rit.edu

James Corbett
+1 302-831-0768
jcorbett@cms.udel.edu

Scott Hawker
+1 585-475-2705
hawker@mail.rit.edu

RIT Laboratory for Environmental Computing and Decision Making
http://lecdm.rit.edu