How Freight Moves: Estimating Mileage and Routes Using an Innovative GIS Tool

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Background: What is the CFS?

- Freight survey of U.S. businesses (shippers)
- Performed by RITA/BTS in partnership with the Census Bureau
- Previous surveys in 1993, 1997, and 2002 as part of the U.S. Economic Census
- Provides data on actual shipments by mode of transportation
CFS Roles

- Funded primarily by BTS
- Actual survey carried out by the Census Bureau
- BTS is responsible for calculating the mileage, by mode, travelled by each shipment
CFS Mileage Calculation: Why and How?

- **Why?**
  - Shippers generally do not know travel distance of shipments
  - Modal-mileages are critical for calculating ton-miles

- **How?**
  - Survey asks for origin and destination ZIP codes
  - Survey asks for mode sequence (e.g. road-rail-road)
  - Using this info, mileages are calculated for each shipment by mode (highway, rail, water, air, parcel, and pipeline)
Mileage Calculations in the 1993 and 1997 Surveys

- BTS contracted with the Oak Ridge National Laboratory (ORNL) to perform the work
- ORNL created a multi-modal surface transportation network (air separate)
- ORNL created routing applications using a variety of software (primarily FORTRAN and FOXPRO)
- Performed by ORNL staff
Mileage Calculations in the 2002 Survey

- In 2002 CFS, mileage calculations were performed by BTS analysts at the Census Bureau using the ORNL-developed applications.
- The BTS analysts quickly became aware of the limitations of a non-GIS approach to mileage calculations.
Problem Records: An Example
2007 CFS: Time for a Change

- Re-engineering the mileage calculation process was part of major performance push to:
  - Improve overall efficiency of estimating distances in the 2007 Commodity Flow Survey
  - Improve the methods used in generating the shipment mileages
  - Improve the quality of mileage information reported in the survey
The Mileage Calculation Problem

- Large proportion of shipments are multi-modal
- Few national level, multi-modal GIS networks available
- Few (if any) commercial routing routines with mode-change logic
The Solution: A Geospatial Approach

Our goals:

• Develop a multi-modal transportation network
• Develop core multi-modal routing models for domestic and export shipments for all modes
• Develop comprehensive pre-processing and post-processing modules that are part of the process flow
• Integrate map visualization tool to help Analysts better estimate mileages for problematic records

Put it all together, and you get GeoMiler!
2002 CFS: FLOW DIAGRAM OF DATA FILES

LEGEND:
Ω : PASS
→ : Primary File Flow
≈ : Rename File

Modal Mileage not found due to problem with mode, zip code, routing reasonableness, foreign country designation. Manual correction required.
**2007 CFS: FLOW DIAGRAM OF DATA FILES**

- CFS Analyst (B1) connects to File Server (A) and downloads CFS batch data file for processing.
- CFS data preprocessed on (B1) into an Access database.
- Preprocessor checks, corrects, and validates geographic and location information.
- Data need more processing & troubleshooting?
  - Yes: Mileage Solver (multi-modal, export, or intra-zip) on (B1) using CFS data in Access and spatial data located on each C:\drive.
  - No: (B1) runs the Post-Processor.
- Mileage Solver will access spatial data to run batch or individual solvers.
- (B1) uploads final results back to the Census Local P:\Drive File Server (A).
- END

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CFS Data Items Uses as Input to GeoMiler

- Valid Origin ZIP Code
- Valid Destination ZIP Code; if an export, valid Country Name (valid City Name for Canada and Mexico)
- Mode or Mode Sequence
- Commodity Type, particularly hazmat
- Commodity Weight
- Commodity Value
### Input from Survey Form

**SHIPMENT CHARACTERISTICS**

*NOTE: Each line runs across pages 4 and 5. After entering column H data on page 4 for any line, continue with column I on page 5 for the same line.*

<table>
<thead>
<tr>
<th>Line No.</th>
<th>Your Shipment ID Number</th>
<th>Shipment Date</th>
<th>Shipment value (excluding shipping costs) in whole dollars. Estimates acceptable.</th>
<th>Net Shipment Weight in pounds</th>
<th>SCTG commodity code from accompanying booklet</th>
<th>Commodity Description</th>
<th>If a hazardous material, enter the “UN” or “NA” number</th>
<th>Column(s) in which to continue, if necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>123-5</td>
<td>4 26</td>
<td>224,235</td>
<td>4840</td>
<td>34520</td>
<td>Mechanical machinery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>402H</td>
<td>4 26</td>
<td>1,375</td>
<td>50,125</td>
<td>20222</td>
<td>Sulfuric acid</td>
<td>1830</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U.S. Destination or U.S. Exit Port (Complete for all shipments.)</th>
<th>Mode(s) of transport to U.S. destination. Enter all that apply in order used. Use codes at bottom.</th>
<th>Foreign Destination (for export shipments only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>State</td>
<td>ZIP Code</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>CA</td>
<td>90040</td>
</tr>
<tr>
<td>Newark</td>
<td>NJ</td>
<td>07105</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Export mode Line No.</th>
<th>Export mode Line No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
The GeoMiler Application

Fully integrated GIS based tool

- Seamless functionality with fully mechanized geographic info correction
- Multimodal pathfinder and distance solver
- Based on ArcGIS 9.1 and Network Analyst
- ArcMap used for visualization of routes
The GeoMiler Networks

- Roads – Tele Atlas DynaMap Transportation
- Rail – FRA Rail Network
- Water – USACE Navigable Waterway Network
- Air – Based on BTS Office of Airline Information and Official Airline Guide
- Pipelines – Great Circle Distance
- “Spatial Joins” created to link the networks through intermodal facilities
Modeling Multimodal Transfer

TRUE ORIGIN

Highway network

Truck-Rail transfer facility

Modal spatial joins

Rail network

TRUE DESTINATION

Highway network

Truck-Rail transfer facility

Modal spatial joins
Building GeoMiler: Summary

- Began development in Spring of 2006
- Entire application (pre-processor, solver, post-processor) and multi-model network completed in 11 months
- GeoMiler not just for the 2007 CFS!
GeoMiler in Production

- Processing began on 4/16/2007
- 5.2 million records are expected for the entire survey
- As of 2/29/08, 4.5 million records have been processed
Old vs. New: Process

2002 CFS
- FORTRAN, Foxpro, no GIS component
- Separate components for pre-processor, solvers, and post processor
- ASCII representation of networks

2007 CFS
- VB, ArcGIS
- Seamless process flow
- GIS networks
Old vs. New: Results

2002 CFS
- 2 analysts
- Processed 2.7 million records in 12 months
- 112,500 records per analyst per month

2007 CFS
- 3 analysts
- Processed 4.5 million records in 10 months
- 150,000 records per analyst per month
Truck Shipment
Los Angeles, CA → Anchorage, AK

Origin: Los Angeles, CA 90045
Destination: Anchorage, AK 99501

Canadian Mileage not included
Air Shipment
Middletown, MO → Hilo, HI

Hub: HNL
Dest Airport: ITO

Hub: LAX
Orig Airport: STL

Hub: MEM

Destination: Hilo, HI 96720
Origin: Middletown, MO 63359

Truck component

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Truck-Rail-Water Shipment
Riverton, WV → Sudbury, MA

Origin: Riverton, WV 26814
Destination: Sudbury, MA 01776

Rail component

Water component

Truck component
Export Shipment via Great Lakes
Mtn Iron, MN → Marathon, CANADA

Canadian Miles not included

Foreign Destination: Marathon, Canada

Line of Demarcation

Origin: Mtn Iron, MN 55768

Port of Duluth, MN

Great Lakes component

Truck component
Questions?

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