The Greening of Freight in Europe: Assessing the Market Potential of New Services and Lower Barriers Using a Dynamic Intermodal Simulation Assignment Methodology

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Organization of Presentation

- Barriers to seamless operation
- Evaluating operational changes:
  - Network modelling platform
- Operational and service design scenarios
  - Border crossing time improvements
  - Terminal improvements
  - Infrastructure improvements
  - Scheduling constraints and priorities
- The take-away: potential of operational changes
Network Modelling Structure

- Demand
- Supply

Mode and Path Choice
- Assignment
- Simulation
  - Link
  - Node
- Intermodal Path Computation

Modal/Market Shares, Service Travel Times, Terminal Delays

Infrastructure
- Network Services
- Schedule Design
- Route Design

CDM* Operation Rules

* Collaborative Decision Making
Dynamic Intermodal Simulation-Assignment Platform

Consolidation at Origin:
Shipments to trucks.

Intermodal Terminal:
Shipment transfer from trucks to railcars.

Shuttle Service (for traditional trains):
From terminal to classification yard.

Classification Yard:
Train assembly process. Not required for intermodal block trains.

Border Station:
Train is delayed.

Classification Yard:
Train is disassembled. For intermodal block trains, this process is not required.

Port:
Transfer of shipments from rail cars to ferry. Ferries move based on given timetables.

Destination:
Unloading shipments.

Shuttle Service (for traditional trains):
From classification yard to port.

Simulation-assignment method:
• processes simulated to determine processing costs and times at nodes and links of path
• Shipments assigned using joint mode-path choice assignment
• Detailed representation allows us to test various policies, such as infrastructure improvements, service frequency changes, and improvement in border crossing procedures.
Problem Statement and Assumptions

Assumptions
- Given time-dependent OD demand tables (multiple products)
- Calibrated mode/carrier choice model (truck only, intermodal container, and multimodal combination)
- Multimodal network with train/ferry timetable
- Terminal service time probability distribution functions

Solve for
- Assignment of time-varying multiple product (commodities) shipments to intermodal paths through network, and
- Associated service levels and delays

Methodological Approach
- Dynamic Simulation-assignment iterative solution framework
Simulation-assignment Solution Framework

OD shipment demand and historical paths

Multimodal Freight Network Simulator

Time-Dependent Intermodal Least-Cost Paths for multiple products

Network flow mode-path assignment

Update of mode and path assignment

Convergence checking

n = n + 1

No

Yes

Stop
Multimodal Freight Network Simulator

Inputs:
- OD flow;
- Path split;
- Mode share.

Demand loading:
- Shipment generation;
- Shipment consolidation;
- Conveyance loading.

Link moving:
- Truck moving;
- Shuttle train moving;
- Train moving;
- Ferry moving.

Node/mode transfer:
- Truck transfer at road intersection;
- Train transfer at intermediate station;
- Mode transfers at intermodal transfer terminal, classification yard, and port.

Have all shipments reached their respective destinations? Or,
Is simulation time at the end of planning horizon?

Yes
Stop

No

$t = t + 1$
Process at Classification Yard (Bulk queueing simulation model)

- Locomotive
- Railcar to destination 1
- Railcar to destination 2
- Railcar to destination 3
- Bulk arrival
- Bulk departure
- Train 1
- Train 2
- Train 3
- Bulk Service
- Queueing
- $AT_i$
- $W_i$
- $ΣxS_i$
- $ADT_i$
- Train 4
- Train 5
- Train 6
- ATi
- Wi
- ΣxSi
- ADTi
Simulation
The REORIENT Network

- Spans 23 countries
- Rail portion
  \((\text{Nodes};\text{Arcs}) = (5577;5753)\)
- Road portion
  \((\text{Nodes};\text{Arcs}) = (4713;5460)\)
- Sea portion
  \((\text{Nodes};\text{Arcs}) = (54;21)\)
Demand for Freight Transport

- 3.2 million shipments per week (2006)
  - 5.8 million for forecast year 2020
  - Source: ETIS

- 117 x 117 O-D zone pairs
- 11 commodity types
- 2 manifestations (‘bulk’ and ‘unitized’)
What Is the Current Freight Flow within REORIENT Corridor?

<table>
<thead>
<tr>
<th>Weekly Flow in Tons (57,616,633)</th>
<th>Road only</th>
<th>IM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47,327,745</td>
<td>10,288,888</td>
</tr>
<tr>
<td></td>
<td>(82.14%)</td>
<td>(17.85%)</td>
</tr>
</tbody>
</table>

- **Intermodal**: 10,288,888 (18%)
- **Truck-only**: 47,327,745 (82%)

**Weekly Flow in Tons**

- Intermodal: 10,288,888
- Truck-only: 47,327,745

**Categories**

- Agricultural products and live animals
- Foodstuffs and animal fodder
- Solid mineral fuels
- Petroleum products
- Ores and metal waste
- Metal products
- Crude and manufactured minerals, building materials
- Fertilizers
- Chemicals
- Machinery, manufactured articles
- Crude oil
Proposed Service Routes

T1 = Green (Bulk)
Swinoujscie - Vienna/Bratislava - Budapest

T2 = Yellow (Unitized)
Trelleborg-Swinoujscie-Bratislava/Vienna

T3 = Red (Unitized)
Gdansk/Gdynia-Bratislava/Vienna-Budapest-Beograd-Thessalonica

T4 = Blue (Bulk and Unitized)
Bratislava-Budapest-Bucharest-Constantia
If we build it, will they come?
Proposed Services

- New rail services on current network
- New rail services on improved network
  - Multi-voltage locomotives
  - Improved signaling (e.g. ERTMS) along route from Gdansk to Thessaloniki
  - ICT for improved border station performance
  - 20% increase in speeds in Poland
  - Electrification of all tracks on proposed services
Potential Market for Proposed Rail Services

Weekly flow on new services in ton-km

Scenario 2 (Current)  Scenario 9 (Best)
Services: Catchment Area
(Origins of shipments using new services)

Current

Best

Legend:
- Less than 500 tons
- 500 - 1000 tons
- 1000 - 2000 tons
- 2000 - 5000 tons
- Greater than 5000 tons
Does Greater Access Increase the Proposed Rail Services’ Attractiveness?

<table>
<thead>
<tr>
<th>Level</th>
<th>Loading points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal</td>
<td>Harbors (including Thessaloniki), Vienna, Bratislava, Budapest, Beograd</td>
</tr>
<tr>
<td>Greater access</td>
<td>Additional loading points - Sofia, Bucaresti, and Poznan</td>
</tr>
</tbody>
</table>

Weekly Flow on new services in ton-km

- Scenario 2
- Scenario 3
Do Border Crossing Delays Hinder Rail Utilization?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Border crossing times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative</td>
<td>3-4 hours</td>
</tr>
<tr>
<td>Sophisticated</td>
<td>15-45 min</td>
</tr>
</tbody>
</table>

Weekly Flow on new services in ton-km

Scenario 3

Scenario 5

Map showing rail routes through European countries with border crossings indicated.
Do Border Crossing Delays Hinder Rail Utilization?

Before improvement

After improvement
Infrastructure Improvements

- Improved signaling
- 20% increase in speed in Poland
- Electrification of all track along proposed services
- Terminal processing time improvement

Weekly Intermodal Flows in tons in overall REORIENT network

9% increase in intermodal flows
## Relaxing Time of Day Scheduling

<table>
<thead>
<tr>
<th>Level</th>
<th>Scheduling Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Night time only</td>
</tr>
<tr>
<td>Level 2</td>
<td>Additional day time operations with strict priority for passenger trains.</td>
</tr>
</tbody>
</table>

14.9% increase in intermodal flows

[Diagram: Flow on new services in ton-km]
Market Opportunity for Rail Services
Running during Day Time?
Sum of Parts

- Services attract more freight when offered together

![Service usage in Ton-km](image)

- All services in tandem (scenario 9)
- Individually (scenarios 11 through 14)

*Services attract more freight when offered together*
How to pay for improved infrastructure?

Breclav Station
Streamlined border crossing

Budapest Terminal
Better equipment, more efficient handling
Doubling Infrastructure Charges…

Leads to
- estimated 18.2% reduction in total demand (flows in tons)
- though still 69% increase in revenues to pay for improvements

### Improved Network

**Current vs. Increased Charges (2006)**

Weekly Intermodal Flows in tons in overall REORIENT network
Concluding Remarks

- Improved border operations, infrastructure improvements, greater access to services, relaxing scheduling constraints have considerable potential to increase intermodal rail share.
- Further improvement possible through more sophisticated operation of the rail network to allow more efficient priority allocation to different services.
- Managing the rail system in the 21st Century will require new management models. Most promising models will be based on collaborative decision-making architectures.
Questions?

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