Intermodal Freight Transportation and Railroads
David B. Clarke
University of Tennessee
Railroad Traffic Picture 2005

- U.S. carloads: 17,213,376, up 0.9 percent (151,665 carloads)
- U.S. intermodal loadings: 11,693,512 units, up 6.4 percent (699,850 trailers and containers)
- Combined cumulative rail volume on 15 reporting U.S. and Canadian railroads:
  - 21,144,607 carloads, up 0.5 percent (110,868 carloads)
  - 13,939,349 trailers and containers, up 6.0 percent (786,662 units)
Definition

- **Intermodal shipment**: a freight shipment that moves between origin and destination using two or more modes of transportation.
- **Types of intermodalism**:
  - unitized
  - bulk
- **Growth of unitized intermodal shipments** has been a spectacular trend in transportation.
Unitized Intermodalism

- **Objective**: reduce cargo handling, loss, and damage, thus supply chain cost
- **Standardization ensures compatibility**
  - modal
  - terminal
- **Types of unit (“box”)**
  - Trailer
  - Container
Intermodal Operations

• Service marketed by railroad, motor carrier, steamship line, or third party

• Roles of modes
  - Motor carriers perform pick-up and delivery
  - Railroads perform land-side line-haul
  - Steamship lines perform intercontinental movement

• Terminal facilities provided by port, steamship line, railroad, customer, or third party
Railroads and Intermodalism

- Railroads recognized very early the advantages of intermodalism
- Until late 1950s, regulatory restraints and supply chain practices restricted the growth of rail intermodalism
- Modern rail intermodalism started with:
  - deregulation of rail trailer transportation
  - advent of marine containerization
Types of Service

- Railroad intermodal transportation is typically described as either:
  - Trailer on flatcar (TOFC)
  - Container on flatcar (COFC)
- These categories no longer cover all types of service (e.g., RoadRailer)
- Current intermodal rail cars don’t necessarily resemble flatcars.
(Above) TOFC Train, Union Pacific RR, Austin TX

(Right) Double stack COFC, Norfolk Southern Ry, Greeneville, TN
Rail Intermodal Traffic Growth

- Railroads began offering TOFC service in the late 1950s
  - many small, non-mechanized terminals
  - service in general freight trains
- Trailer Train Corporation (now TTX) was formed to handle equipment pool
- COFC service paralleled the rise of marine containers
- Rise of global trade propelled COFC growth during 1980s
HISTORIC GROWTH

Annual Intermodal Volumes
(Sources: AAR & IANA)

Year

Units


0 2000000 4000000 6000000 8000000 10000000 12000000 14000000 16000000
Recent Traffic Trends

2004-2008 Yearly Traffic Totals
By Month

Source: IANA Intermodal Market Trends and Statistics
Rail Intermodal Operations

- Truck competitive intermodal service requires:
  - scheduled, dedicated trains
  - high average speeds
  - reliable performance
  - efficient terminal handling
  - equal or lower cost to customer
## Intermodal Truck/ Rail Comparison

<table>
<thead>
<tr>
<th>Source: BNSF Railway</th>
<th><strong>Truck</strong></th>
<th><strong>Intermodal Train</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit of Shipment</td>
<td>1 truckload</td>
<td>1 train (250 truckloads)</td>
</tr>
<tr>
<td>Labor (2000 mile trip)</td>
<td>1 person</td>
<td>26 people (1 train)</td>
</tr>
<tr>
<td>Frequency of Service</td>
<td>Daily / Hourly</td>
<td>Daily (if volume warrants) Often less than daily</td>
</tr>
<tr>
<td>Annual Volume Required for Daily Service</td>
<td>365</td>
<td>91,250</td>
</tr>
<tr>
<td>Transit</td>
<td>Mile/ day: 500 Average MPH: 50 Operates: 10 hrs/ day</td>
<td>Mile/ day: 500 Average MPH: 21 Operates: 24 hrs/ day</td>
</tr>
<tr>
<td>Route Infrastructure</td>
<td>Unlimited use of Federal and State road system</td>
<td>Use of privately owned rail network with limited use of alternate networks</td>
</tr>
<tr>
<td>Route Options</td>
<td>Virtually unlimited: many route options between origin and destination</td>
<td>Normally just one viable route between origin and destination</td>
</tr>
</tbody>
</table>
Rail Intermodal Economics

- Terminals require high volumes to keep unit terminal cost low
- Cost of drayage increases with distance
- Rail line-haul cost/ton-mile much less than truck
- Railroad capital and maintenance costs for truck competitive infrastructure high
- Intermodal service and cost only truck competitive when the rail movement exceeds 500-750 miles
- Regardless, intermodal margins typically less than carload traffic
Relative Costs

DeBoer provided the following cost indices for a 1,000 mile haul:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Cost Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>89’ railcar with TOFC</td>
<td>0.55</td>
</tr>
<tr>
<td>89’ railcar with COFC</td>
<td>0.53</td>
</tr>
<tr>
<td>Double stack railcar</td>
<td>0.41</td>
</tr>
<tr>
<td>RoadRailer</td>
<td>0.57</td>
</tr>
<tr>
<td>Truck</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Containers

- Many configurations (e.g., dry freight, reefer, tank, bulkhead)
- Marine
  - Width 8 ft
  - 20 and 40 ft ISO (8’ 6” height)
  - 40 and 45 ft high cube (9’ 6” height)
- Domestic
  - Width 8’ 6”, height 9’ 6”
  - 48 and 53 ft
  - height and width exceed marine dimensions
- Interbox connectors secure stacked containers
### 20' x 8'6" Composite Light Weight Dry Freight (New)

<table>
<thead>
<tr>
<th>Sea Box, Inc. Container Types</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>Door Opening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exterior</td>
<td>Interior</td>
<td>Exterior</td>
<td>Interior</td>
</tr>
<tr>
<td>20' DRY FREIGHT</td>
<td>19'10 ½&quot;</td>
<td>19'3 13/16&quot;</td>
<td>8'6&quot;</td>
<td>7'9 7/8&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sea Box, Inc. Container Types</th>
<th>Tare Weight in pounds</th>
<th>Payload in pounds</th>
<th>Gross Weight in pounds</th>
<th>Cubic Capacity in cubic feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>20' DRY FREIGHT</td>
<td>3,450</td>
<td>49,460</td>
<td>52,910</td>
<td>1,158</td>
</tr>
</tbody>
</table>
### 40' x 9'6" Steel Dry Freight High Cube Refurbished

<table>
<thead>
<tr>
<th>Sea Box, Inc. Container Types</th>
<th>Length</th>
<th>Height</th>
<th>Width</th>
<th>Door Opening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exterior</td>
<td>Interior</td>
<td>Exterior</td>
<td>Interior</td>
</tr>
<tr>
<td>40' DRY FREIGHT</td>
<td>40'0&quot;</td>
<td>39'5 1/2&quot;</td>
<td>9'6&quot;</td>
<td>8'9 7/8&quot;</td>
</tr>
</tbody>
</table>

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<th>Gross Weight in pounds</th>
<th>Cubic Capacity in cubic feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>40' DRY FREIGHT</td>
<td>8,930</td>
<td>58,270</td>
<td>67,200</td>
<td>2,681</td>
</tr>
</tbody>
</table>

© Sea Box, Inc.
# Domestic Container Programs

## Norfolk Southern Domestic Container Equipment

### 48' Domestic Container Specs

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside L x W x H:</td>
<td>48' x 102&quot; x 114&quot;</td>
</tr>
<tr>
<td>Inside L x W x H:</td>
<td>47.5' x 98.5&quot; x 107&quot;</td>
</tr>
<tr>
<td>Door Height:</td>
<td>107&quot;</td>
</tr>
<tr>
<td>Container Tare Weight:</td>
<td>8550 – 9200 lbs.</td>
</tr>
<tr>
<td>Chassis Weight:</td>
<td>6300 lbs.</td>
</tr>
<tr>
<td>Floor Strength:</td>
<td>24,000 lbs.</td>
</tr>
<tr>
<td>Payload:</td>
<td>59,000 lbs.</td>
</tr>
<tr>
<td>Cubic Capacity:</td>
<td>3476 cu. ft.</td>
</tr>
</tbody>
</table>

### 53' Domestic Container Specs

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside L x W x H:</td>
<td>53' x 102.5&quot; x 114&quot;</td>
</tr>
<tr>
<td>Inside L x W x H:</td>
<td>52.5' x 99.5&quot; x 109.5&quot;</td>
</tr>
<tr>
<td>Door Height:</td>
<td>109.5&quot;</td>
</tr>
<tr>
<td>Container Tare Weight:</td>
<td>10,200 lbs.</td>
</tr>
<tr>
<td>Chassis Weight:</td>
<td>7250 lbs.</td>
</tr>
<tr>
<td>Floor Strength:</td>
<td>24,000 lbs.</td>
</tr>
<tr>
<td>Payload:</td>
<td>57,000 lbs.</td>
</tr>
<tr>
<td>Cubic Capacity:</td>
<td>3970 cu. ft.</td>
</tr>
<tr>
<td>Stenciling</td>
<td>&quot;EMHU&quot; or &quot;NSXU&quot;</td>
</tr>
</tbody>
</table>
Chassis are normally used for movement of containers over the highway, although flatbed trailers can be used.
Intermodal Trailers

- Dimensions same as regular trailers
  - 28 ft
  - 48 ft
  - 53 ft
- Modified construction to withstand railroad service
  - reinforced doors
  - lift rails
- All configurations used, dry van and reefer most common
Equipment Usage

Source: AAR Railroad Facts
Railcars for Intermodal Service

- Railcars are flatcar like
- Linear space for each box called a “platform”
- “Double stack” platforms handle two stacked containers
- Design issues:
  - tare weight and dimensions
  - single unit vs. articulated
  - TOFC, COFC, or both
  - Single or double stack
The Maxi-Stack IV car is the mainstay of the United States domestic double-stack car fleet because it provides the optimum balance between tare weight and capacity. It is a three-unit articulated double-stack car that can handle containers from 20' to 53' long in the well and containers from 40' to 57' in the top position. The Maxi-Stack IV utilizes 70-ton end trucks and 125-ton intermediate trucks. It has a capacity of 116,800 pounds per well.
53' All-Purpose Double-Stack Car

The 53' All-Purpose (AP53) double-stack well car is a single unit designed to maximize flexibility. It can carry either containers or trailers. The AP53 has a 53' well to accommodate containers from 20' to 53' long. It can handle containers from 40' to 53' long in the top position. The AP53 can also accommodate two 28' pup trailers or one long trailer up to 57' long. Each car is capable of carrying nose-mounted containers or trailer refrigeration units. The AP53 has 166,000 pounds of capacity per car to handle heavy loads. It can also be configured as a 3-unit drawbar car.
RoadRailer

- Low tare weight (800# > conventional trailer)
- Same dimensions as conventional trailer
- High strength
- Air ride
- Slack free coupling
- Air brake compatible with conventional railcar
- Maximum cargo security
- Low terminal cost
The RoadRailer may be handled over the highway like any conventional semitrailer.
Or coupled in trains of up to 125 units

Coupler Mate

Bogie
Terminal

- **Location where box changes modes**
  - rail-highway
  - rail-marine ("on-dock")

- **Also provides for**
  - box staging and storage
  - equipment storage and staging
  - equipment repair

- **Most rail-highway terminals are RR owned**
- **Most rail-marine terminals are port or steamship company owned**
Terminal Elements

- Provision for loading/unloading railcars
- Box storage (long term or temporary)
- Vehicle storage (railcars/trailers/chassis)
- Check-in/check-out control
- Vehicle and box servicing/repair
- Security and lighting
- Office and administration
- Information systems
Roberts Bank, BC Marine Terminal

Area: 160 acres
Marine berths: 2 (2,198 ft)
Daily truck trips: 1,800
Other trips: 2,100
Annual TEU capacity: 900,000
Ground storage: 24,000 TEUs
7 Post Panamax gantry cranes

Image from GoogleEarth
Marion, AR Intermodal Terminal

- **Annual box capacity:** 375,000
- **Ground storage:** 2,600 boxes
- **Ramp track capacity:** 326 cars
- **Storage track capacity:** 748 cars
- **Length shown:** ~2 mi
- **Parcel width:** ~960 ft

*Image from GoogleEarth*
Lift Capability

- **Container gantry crane**
  - large lift height and/or extension
  - high capacity
  - fixed guideway
- **Straddle loader**
  - moderate lift height, lateral movement
  - mobile or fixed guideway
- **Side loader**
  - moderate lift height
Marine Gantry Cranes
Rubber Tired Straddle Loader
Lift Spreader Assembly
RoadRailer Terminals

- RoadRailers do not require a terminal lift capability
- This greatly lowers terminal costs
- Basic terminal requirements
  - paved surface level with track
  - storage for trailers and bogies
  - lighting and security
Mark V RoadRailer® Terminal Operations

1. Hostler tractor positions trailer
2. Trailer air suspension lifts rear of trailer, tractor backs trailer onto rail bogie.
3. Trailer air suspension is vented. Steel rail springs lift tires clear of rail.
4. Tractor backs trailer to coupling with balance of train.
5. Tractor leaves leading trailer on landing gear. Air lines are connected and landing gear is raised on second trailer.
6. Rail locomotive backs Couplermate® to trailer. Air lines are connected and landing gear is raised on all trailers.

Source: Wabash National Corporation
Good Terminal Location and Design

- Streamlines train make-up and dismantling process
- Simplifies train set-outs and pick-ups
- Decreases overall shipment transit time
- Increases service reliability
- Decreases costs for
  - providing service
  - operating facility
  - operating trains
- Makes it more easier to make effective investments in infrastructure
Factors in Terminal Location

- Access to railroad and highway system
- Area, configuration, and topography of site
- Cost to acquire site and provide infrastructure
- Adjacent land uses
- Proximity to customer base
- Ability to accommodate future growth
- Local support
Access To Terminals

- **Rail Side**
  - prefer location near or adjacent to mainline
  - access should require no reverse movements
  - provide signals, power switches, leads to avoid interference with mainline traffic

- **Highway Side**
  - geometry to accommodate large trucks
  - pavement suitable for heavy truck axle loads
  - no height or width restrictions
  - close proximity to arterial roadway
Truck Trip Generation

- Truck volume correlated to train volume
  - Two truck trips per box
  - Up to 280 containers or 140 trailers per train at endpoint terminals

- Movements include loads, empties, bobs tails

- Peaking associated with train arrivals, cut-off times for departures
Future Issues for Intermodalism

- **Railroad infrastructure needs**
  - additional capacity
  - better performance

- **Funding**
  - private sector
  - public sector
  - partnership

- **Developing short-haul intermodal**
Capacity

- Freight forecasts for railroads are bullish over the next 20 years
- High energy costs further the case for increased rail growth, esp. intermodal
- After years of network shrinkage, railroad capacity is now a major concern
- Maintaining and enhancing rail capacity is a key challenge
Railroad Flows Past and Future

1998 (Actual)

2018 (Forecast)
Truck-competitive intermodal rail service requires:

- High-performance rail infrastructure
- Designed to be truck-time competitive

The Steel Interstate

- Rail and spot highway infrastructure upgrades
- Traffic management and enforcement options for quick-fix safety improvements

RAIL – SAFER, FASTER, CHEAPER, CLEANER
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