Tomorrow and beyond in Equipment Evolution
Innovations & Trends

Presented by Robert E. Pickel
Senior Vice President, Marketing and Sales
National Steel Car N.A. Inc.

June 18, 2013
Today’s Railcars Provide More Efficiency
Light Weight Railcars

Higher payload per car:

Example: *50’ 6” Box car carrying capacity increase*

Between the 50s and 2011,

1 pound of additional tare weight => 7 pounds of additional carrying capacity

![Diagram showing tare weight and carrying capacity evolution from Prior 1960 to 2011.](image)
Light Weight Railcars

Impact on Transportation Costs

*Additional capacity or lighter tare reduces transportation cost per unit carried:*

Obvious when rate per car. Other example:

- Shipping documentation
- Switching (intra plant)
- Placing a car
- Diversion
- Fuel Surcharge
- Weighing a car
- Cancellation of an empty car order
- Others…
Light Weight Railcars

Impact on Transportation Costs

Additional Capacity Reduced Transportation cost:

Reduction not so obvious when Tariff based on GRL. Example, published tariff for urea between specific Origin-Destination (distance of approximately 1,300 miles):

<table>
<thead>
<tr>
<th>CAR (shipper supplied)</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRL&lt; 263,000 lb.</td>
<td>$5,578</td>
</tr>
<tr>
<td>GRL&gt; 263,000 lb.</td>
<td>$6,024</td>
</tr>
</tbody>
</table>
Light Weight Railcars
Impact on Transportation Costs

Additional Capacity Generally Reduces Transportation cost. Example:

The Benefits are:

<table>
<thead>
<tr>
<th>CAR</th>
<th>CAPACITY</th>
<th>Cost/100 lb.</th>
<th>Cost/100 lb. for Add. Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRL&lt; 263,000 lb.</td>
<td>198,000 lb.</td>
<td>$2.82</td>
<td>Not applicable</td>
</tr>
<tr>
<td>GRL&gt; 263,000 lb.</td>
<td>225,067 lb.</td>
<td>$2.82</td>
<td>$1.39</td>
</tr>
</tbody>
</table>

Note: The car with a GRL of 263,000 lb. was picked from The Car and Locomotive Cyclopedia and the car with a GRL of 286,000 was built by NSC in 2011.
Light Weight Railcars

Impact on Transportation Costs

Additional capacity generally reduces transportation cost. Example:

Other factors come to play. For example, Published Rate for lumber between specific Origin-Destination (distance of approximately 750 miles, tariff from a US Class 1):

<table>
<thead>
<tr>
<th>CAR (shipper supplied)</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>50’ Box Car</td>
<td>$5,799</td>
</tr>
<tr>
<td>60’ Box Car</td>
<td>$6,822</td>
</tr>
</tbody>
</table>
Light Weight Railcars

Impact on Transportation Costs

However, matching of the car to the commodity remains crucial. Example:

Depending of the type of lumber, the cost/1000 board-feet in a larger car may be higher. For Example:

Red Cedar

<table>
<thead>
<tr>
<th>CAR</th>
<th>CAPACITY</th>
<th>Cost/1000 b.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>50’ Box Car</td>
<td>215,000 lb.</td>
<td>$77</td>
</tr>
<tr>
<td>60’ Box Car</td>
<td>208,000 lb.</td>
<td>$75</td>
</tr>
</tbody>
</table>

Hickory

<table>
<thead>
<tr>
<th>CAR</th>
<th>CAPACITY</th>
<th>Cost/1000 b.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td>50’ Box Car</td>
<td>215,000 lb.</td>
<td>$115</td>
</tr>
<tr>
<td>60’ Box Car</td>
<td>208,000 lb.</td>
<td>$139</td>
</tr>
</tbody>
</table>
**Shorter Foot Print**

Impact on Transportation Costs

*Shorter foot print improves train productivity.*

**Example:**

![Graph showing Covered Hopper Car Length in ft. per 100 c.f. from 1980 to 2011. The graph indicates a decrease in length over the years.](image-url)
Shorter Foot Print
Impact on Transportation Costs

**Shorter foot print improves train productivity. Example Covered Hopper car, taking into consideration the specific car length:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Train Cubic Capacity</th>
<th>% Improvement (1980)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>779,443</td>
<td>base</td>
</tr>
<tr>
<td>1993</td>
<td>864,407</td>
<td>11%</td>
</tr>
<tr>
<td>1994</td>
<td>871,257</td>
<td>12%</td>
</tr>
<tr>
<td>1995</td>
<td>872,881</td>
<td>12%</td>
</tr>
<tr>
<td>1996</td>
<td>912,281</td>
<td>17%</td>
</tr>
<tr>
<td>1999</td>
<td>952,096</td>
<td>22%</td>
</tr>
<tr>
<td>2011</td>
<td>972,934</td>
<td>25%</td>
</tr>
</tbody>
</table>

(Based on the car length for old to new cars from the previous graphic and 10,000 ft train)
Impact on Transportation Costs

Globally fuel consumption declined for two major factors:

- Better locomotives
- Car tare weight reduction

21.3% Fuel reduction between 1990 & 2008

The U.S. Energy Information Administration in their 2013 Outlook predicts an improvement from 3.4 to 3.5 ton-miles per 000 BTU between 2011 & 2020. (PAGE 136)
Hybrid Railcars

*Hybrid cars built are steel-aluminum or steel-stainless steel*

Use of more “exotic” materials present the following advantages:

- Lighter weight
- Corrosion resistance

Aluminum commonly used for coal cars and composite for bi-tri level cars doors.
Hybrid Railcars

Example of stainless steel car

Use of stainless steel to prevent corrosion

Courtesy of Trinity Industries
Hybrid Railcars

Most of the hybrid cars built are steel-aluminum or steel-stainless steel

Use of more “exotic” materials present the following challenges:

- Some offer poor fatigue properties (ex. welded aluminum)
- Difficulty to achieve high strength structural connections
- Sometimes not weldable, or, when welding expertise not commonly available, must be bolted
- High material cost and high labor cost drive up the initial acquisition cost
Simultaneously apply and release the entire train brake resulting in:

- Reduced in-train forces
- Shorter stopping distances (40% to 60% versus conventional braking)
- Improved train handling
- Decreased coupler and draft gear failures
- Increase brake shoe and wheel life
- Fuel savings
- Automatic train consist identification and vehicle sequencing
- Real time train brake status feedback
The Smart Car

Real time monitoring of cars:

In addition of the 5 elements listed above the following sensors can be added:

- Internal temperature-pressure sensors
- Open gate and hatch sensor
- Draft gear sensor

From *Trains*, July 2013, page 20
Computer Models and Analysis

New software permits to design better cars:

3D Solid Modeling:
- To “assemble” the car to verify geometry and functionality
- Provides accurate dimensions of parts and assemblies
- Simulates components/assemblies in motion to verify interference
- Creates shop drawings

ANSYS: Finite Element Analysis
- To check the car design against AAR requirements
- Refine the design to meet customer requirements
- Stress analysis for fatigue calculations
New software permits to design better cars:

Design Simulation: Kinematics Analysis:
- To calculate the kinetic forces resulting in motion
- Feeds data to NUCAR

NUCAR: Dynamic simulation
- To calculate the stability of the car in motion
Today’s Railcars Impact on Railroad Operations
Longer Trains and Distributed Power

Placing additional remotely controlled locomotives at intermediate points in the middle of the trains:

**Reported Technical Advantages:**
- Reduction of coupler forces on the front cars
- Quicker application of standard air brake

Some intermodal trains with distributed power occasionally reach up to 14,000 ft.
Longer Trains and Distributed Power

 Reported Benefits:

- Improves safety, reduces derailment occurrences
- Improves hauling capacity
- Improves fuel efficiency by 6% to 12% (estimate) and route capacity
- Reduces CO$_2$ emissions
- Faster delivery by increasing average speed and route capacity
- Reduces track and car maintenance costs
- Accrued benefits when technologies combined (ECP, Friction Management Systems, etc.)
Greater Forces on Railcars

- Buff Force: Compressive force at the couplers. Maximum allowed: 900,000 lb.
- Impact Force: Compressive force on one coupler only. Maximum allowed: 1,250,000 lb. over a fraction of a second

Those limits are subject to change. Based on new recommended practices such as S-286.
M-976 Standards for Improved Railcar Performance and Reduced Stress on Railroad

**Truck Assembly:**
- Improved truck dynamics
- Restricted hunting, roll and twist, bounce and pitch and sway

**Side Bearing:**
- Long travel constant contact side bearings new standard
- Improved stability – higher hunting threshold
**Railroad Operations Monitoring**

*WILD Detectors: Wheel Impact Load Detector.*

Used to improve load signature to distinguish wheels with a high probability of failure from high impact wheels with a low probability of failure.

Consist in a series of calibrated strain gauges sensors welded to the rail and a signal processor that analyze the data to isolate wheel tread irregularities.
Railroad Operations Monitoring

WILD Detectors: Wheel Impact Load Detector

Reported Benefits:

- Prevents derailments
- Reduces damages to the car structure, bearings, lading, rail and other mechanical components
- Reduces damages to cargo and infrastructure
**Railroad Operations Monitoring**

*Truck Hunting Detectors*

Detect excessive side-to-side lateral instability (hunting)

Consist in a series of gauges measuring vertical and lateral loads to identify critical instances where the wheel flange and rail gage face geometry may promote flange-climb derailment.
Railroad Operations Monitoring

Truck Hunting Detectors

Reported Benefits:

- Reduces damages to the car
- Reduces damages to track structure
- Reduces damages to cargo
Railroad Operations Monitoring

**Overloads Detector:**

Detect the following conditions:

- Overload
- Load imbalance

Consist in a series of calibrated strain gauges sensors welded to the rail and a signal processor that analyze the data to isolate excessive/imbalance car loading.
Railroad Operations Monitoring

Overloads Detector:

Reported Benefits:

- Reduces operating costs
- Reduces track damages structure
- Reduces need to take cars out of service for axle weight
Railroad Infrastructure

Coopers Ratings and Bridges

Formula to estimate live loads on railroad bridges. The minimum truck center and the length over the pulling faces of the couplers (LOPFC) are function of the car GRL and calculated using the Coopers Rating formulas.

- AAR M1001, Section C-II: load limit of 6,820 lbs/ft for 263,000 & 286,000 GRL

For cars offering a 315,000 lb. GRL, the formula dictates longer LOPFC (46’ 2” vs 41’ 11” for 286,000 GRL)
Railroad Infrastructure

Coopers Ratings and Bridges

UP Kate Shelley Bridge… yesterday

and today…

Courtesy of Union Pacific
Railroad Infrastructure

315,000 pound Gross Rail Load generally will:

- Increase the GRL by 29,000 lbs.
- Increase tare weight: 6,000 to 12,000 lbs.
- Increase capacity by 17,000-23,000 lbs.
- Increase minimum car length by 10%
- Require adapted trucks and specialties
THANK YOU

Trusted to Deliver Excellence