The National Academy's Approach to Medium and Heavy Duty Truck Fuel Consumption

Presented to

“Focus for the Future”

Automotive Research Conferences

by

John Woodroofe

July 13, 2010
Essential Aspects of Truck Transport

- Large trucks exist to do work and to do it efficiently. Their worth and function are tied directly to work performance in exchange for money – there is a large incentive to be efficient.

- Freight tasks vary, as do the weight, shape and density of cargo transported, therefore vehicle efficiency varies for a given cargo and vehicle design.
Essential Aspects of Truck Transport

- The nature of freight transport can be volume limited or mass limited. Transport efficiency for volume limited freight task is evaluated differently than mass limited freight task.

- A specific vehicle with a low fuel consumption does not necessarily have good fuel efficiency. In the context of this study:
  - Fuel consumption references fuel used to move a vehicle.
  - Fuel efficiency refers to the fuel used to accomplish a specific freight or work task.
Complexity of the total vehicle
Complexity of the total vehicle

Plus many more truck options

Plus many more trailer options

All bus types
OECD Study - Moving Freight with Better Trucks Improving Safety, Productivity and Sustainability

- 40 heavy vehicles representing 10 participating countries were examined.

- The study focused on Class 8 highway transport vehicles.
  
  Note: In the U.S. class 8 vehicles consume 59% of all fuel used by commercial vehicles.

Vehicle Classification

- Workhorse – common “go anywhere” vehicle.
- High capacity – up to 57 tons.
- Very high capacity – up to 77 tons greater than 98 ft.
Energy efficiency: cargo mass volume
(Cargo mass x cargo volume x distance / energy consumed)
CO₂ emissions

Cargo Mass by CO₂ Emissions

Very high capacity

Workhorse

High capacity

Vehicle

cargo-tonne km /kg CO₂

AU1-w, ZA1-w, ZA2-w, BE1-w, DK1-w, DK2-w, DK3-w, EU1-w, EU2-w, EU3-w, UK1-w, UK2-w, CA1-w, CA2-w, MX1-w, MX2-w, US1-w, US2-w, US3-w, AU2-hc, ZA3-hc, ZA4-hc, BE2-hc, DK4-hc, DK5-hc, DE1-hc, NL1-hc, NL2-hc, NL3-hc, CA3-hc, CA4-hc, US4-hc, US5-hc, AU3-vhc, CA4-vhc, MX3-vhc, US6-vhc, US7-vhc
National Academies Medium and Heavy vehicle Fuel Consumption Committee

Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles
Study Components

- Vehicle fundamentals, fuel consumption, and emissions
- Review of current regulatory approaches for trucks and cars
- Powertrain technologies for reducing load-specific fuel consumption
- Vehicle technologies for reducing load-specific fuel consumption
Study Components (continued)

- Costs and benefits of integrating fuel consumption reduction technology into medium- and heavy-duty vehicles
- Alternative approaches to reducing fuel consumption in medium-duty and heavy-duty vehicles
- Approaches to fuel economy and regulations
## Classification of the fleet

<table>
<thead>
<tr>
<th>Light-Duty</th>
<th>Medium Heavy-Duty</th>
<th>Heavy-Duty</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class 1</strong></td>
<td><strong>Class 3</strong></td>
<td><strong>Class 7</strong></td>
</tr>
<tr>
<td>Less than 6,000 lb</td>
<td>10,000 to 14,000 lb</td>
<td>26,000 to 33,000 lb</td>
</tr>
<tr>
<td><strong>Class 2</strong></td>
<td><strong>Class 4</strong></td>
<td><strong>Class 8</strong></td>
</tr>
<tr>
<td>6,000 to 10,000 lb</td>
<td>14,000 to 16,000 lb</td>
<td>Greater than 33,000 lb</td>
</tr>
<tr>
<td><strong>Class 5</strong></td>
<td><strong>Class 5</strong></td>
<td></td>
</tr>
<tr>
<td>16,000 to 19,500 lb</td>
<td>19,500 to 26,000 lb</td>
<td></td>
</tr>
<tr>
<td><strong>Class 6</strong></td>
<td><strong>Class 6</strong></td>
<td></td>
</tr>
<tr>
<td>19,500 to 26,000 lb</td>
<td>26,000 to 33,000 lb</td>
<td></td>
</tr>
</tbody>
</table>

*Images of different types of vehicles corresponding to each class.*
Energy balance at cruise

- **Engine Losses**
  - Urban: 58 – 60%
  - Interstate: 58 – 59%

- **Aerodynamic Losses**
  - Urban: 4-10%
  - Interstate: 15-22%

- **Inertia/Braking**
  - Urban: 15-20%
  - Interstate: 0-2%

- **Rolling Resistance**
  - Urban: 8-12%
  - Interstate: 13-16%

- **Drivetrain**
  - Urban: 5-6%
  - Interstate: 2-4%

- **Auxiliary Loads**
  - Urban: 7-8%
  - Interstate: 1-4%
Fuel Reduction Strategies

**Tractor Strategies**
- Tractor Mounted Gap Reducers
- Idle Reduction Equipment
- Integrated Cab Roof Fairing
- Aero Mirror
- Aero Profile Tractor
- 2007 MY Engine
- Aero Bumper
- Fuel Tank Side Fairings
- Low Rolling Resistance Tires

---

**Trailer Strategies**
- Trailer Mounted Gap Reducers
- Trailer Rear Fairings or Boat-tail
- Trailer Side Fairings
- Low Rolling Resistance Tires

~11% Reduction or greater
~6.5% Reduction or greater
2015 – 2020 Potential Fuel Saving

![Bar chart showing potential fuel savings across different categories and vehicle types.](chart.png)
Metrics for fuel consumption

Guiding principles for metrics

- Metrics should incentivize subcomponent and total vehicle development
- Metrics should relate to the transport task or vehicle vocation
- Metrics should encourage energy conservation for a given task
Metrics for fuel consumption

Guiding principles for metrics (con’t)

- Metric should be based on energy or fuel consumption – i.e. equivalent diesel gal/cargo ton-mile
  - Fuel type used will likely change over time
  - Energy density varies with fuel type
Cube vs Mass 50/50

Identical trailer volume

**Vehicle “A”**
- **Cargo capacity 48,000 lbs**
- Best suited for cargo weights 48,000 lbs or less

**Vehicle “B”**
- **Cargo capacity 61,000 lbs**
- Best suited for cargo weights greater than 48,000 lbs

If the “mass” metric were applied, vehicle B would always outperform vehicle A – mass metrics (gal/ton mile) promote heavier vehicles. Need a volume-based metric (gal/cargo ft³-mile) for low density freight vehicles that accounts for the value of cargo volume.
Methods for certification and compliance

- “Direct regulation” of fuel consumption is complicated and very challenging - (must avoid unintended consequences)
- “Indirect methods” – fuel tax, speed limiters, liberalized size and weight

*It’s all about “transport efficiency”*

*All of these options can contribute*
Component method

Distinct Energy consuming elements

Power train
Aerodynamics
Tires

System integration and analysis

Base vehicle assembly

Optimized integration

Final stage manufacturer

Power unit governed by performance

Point of final regulation

Final fuel performance evaluation

Standard performance evaluation
Presidential Memorandum Regarding Fuel Efficiency Standards

- Issued May 21, 2010
- requests EPA and NHTSA to begin work on a joint rulemaking under the Clean Air Act (CAA) and the Energy Independence and Security Act of 2007
- Establish fuel efficiency and greenhouse gas emissions standards for medium- and heavy-duty vehicles
- beginning with model year 2014
- Final rule to be completed by July 30, 2011