

Aluminum's Role in Meeting First-Ever Heavy Truck Fuel Economy Standards

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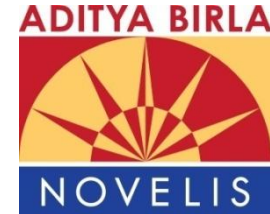
Alcoa, Inc.

on behalf of

The Aluminum Association's
Aluminum Transportation Group (ATG)

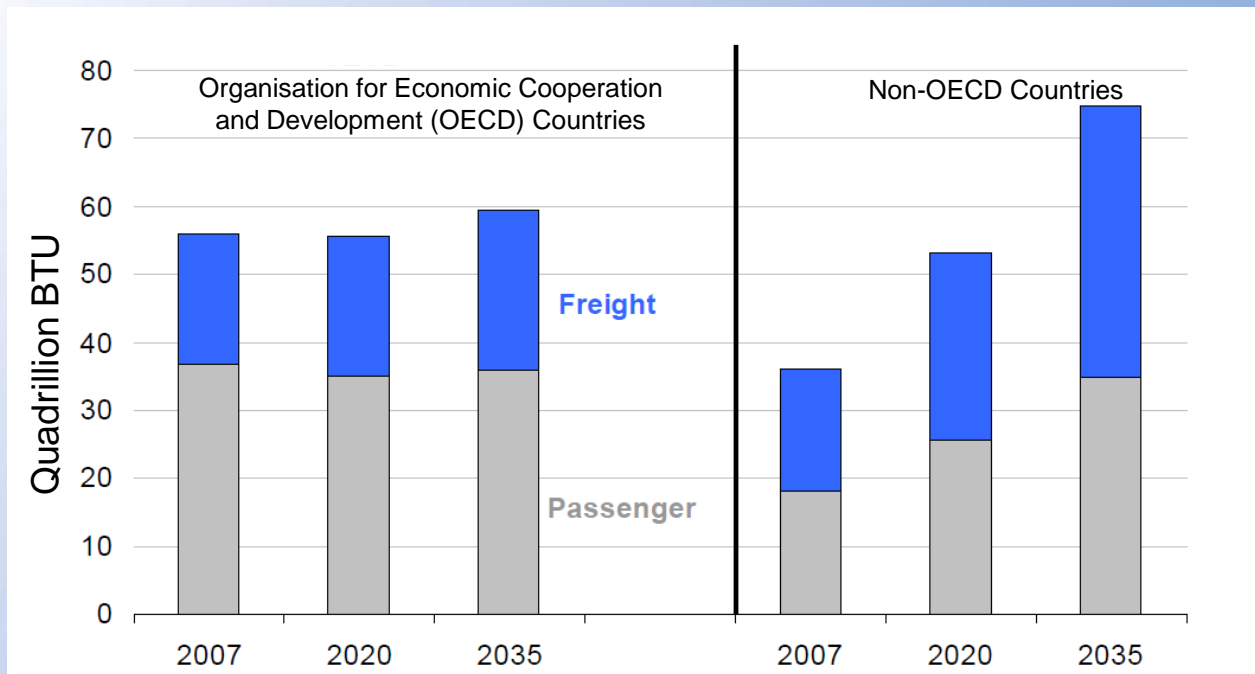
Defining Who We Are

The Aluminum Association's Aluminum Transportation Group (ATG)



Many Challenges Facing the Commercial Vehicle Industry Today

Transportation Energy Consumption



Freight energy use increasing faster than passenger energy use

- Rising energy costs
- Growing concern over greenhouse gas emissions
- Federal mandates continue to add weight to heavy-duty vehicles
- First-ever fuel efficiency standards

Source: International Energy Outlook 2010; U.S. EIA

Federal Mandates Add Weight

New emissions technologies have reduced fuel economy and increased weight

Emissions Mandate	Average Weight Impact (lbs.)	Fuel Economy Impact of Emissions Technologies
2002 EPA Engine Emissions	+150	-8%
2007 EPA Engine Emissions	+400	-3%
2010 EPA Engine Emissions (SCR)	+300	+3%
TOTAL	850 lbs.	-8%

Landmark Fuel Standards for Trucks



- First-ever fuel economy and greenhouse gas emissions regulations for medium- and heavy-duty trucks built from 2014 to 2018
- The rule aims to:
 - Reduce annual oil consumption by 530 million barrels
 - Cut annual greenhouse gas emissions by about 270 million metric tons

Aluminum's Potential Recognized by Regulators

- The EPA and NHTSA evaluated materials for the greatest mass reduction opportunities
 - Aluminum
 - High-strength steel
 - Composites
- Aluminum ranked far above the others
 - “Greatest potential” to safely reduce vehicle weight while boosting fuel economy and cutting emissions



2010 Industry Sponsored Study on Lightweighting and Freight Efficiency

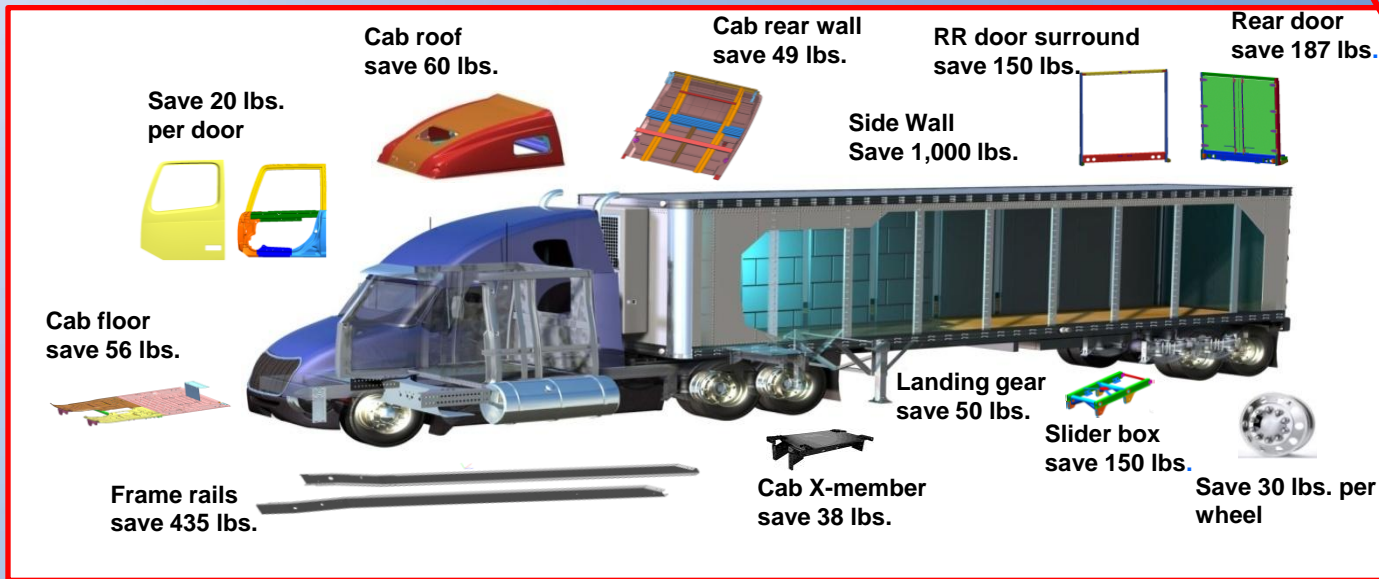
- **Objective**
 - Quantify fuel economy impact of weight reduction with aluminum specific to U.S. drive cycles
- **Methodology**
 - Analytical simulation (Ricardo)
- **U.S. drive cycle simulations**
 - EPA HWFET
 - WVU Interstate
 - HUDDS
- **Load conditions**
 - Un-loaded, ½ GVW Load, GVW
- **Engine and transmission**
 - Displacement: 13-liter, diesel
 - 10-speed automated manual transmission (AMT)
- **Vehicle specifications**
 - Frontal area: 10.68 m²
 - Coefficient of drag (C_d): .60 (baseline)



Photo Credit: East Manufacturing

Vehicle Configurations Studied

	Tractor (lbs.)	% Weight Saved	Trailer (lbs.)	% Weight Saved	Tractor & Trailer (lbs.)	% Weight Saved
Conventional (baseline)	16,000		13,500		29,500	
“Traditional” Lightweighting	15,500	3.1%	12,500	7.4%	28,000	5.1% (1,500 lb)
“High” Aluminum Content	14,500	9.4%	11,700	13.3%	26,200	11.2% (3,300 lb)



Payload Configurations Studied

Vehicle Configuration	Tractor Mass (lbs.)	Trailer Mass (lbs.)	Payload (lbs.)	Total (lbs.)
Conventional (baseline)	16,000	13,500	50,500	80,000 GVW
“Traditional” Lightweighting	15,500	12,500	52,000	80,000 GVW
“High” Aluminum Content	14,500	11,700	53,800	

**6.5% more payload
→ 6.5% fewer trips**

Payload Configurations Studied

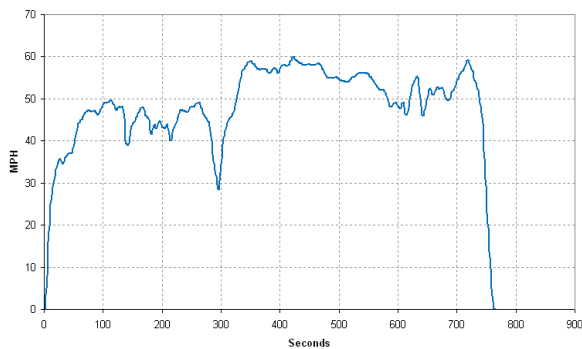
Vehicle Configuration	Tractor Mass (lbs.)	Trailer Mass (lbs.)	Payload (lbs.)	Total (lbs.)
Conventional (baseline)	16,000	13,500	50,500	80,000 GVW
			25,250	54,750 half load
			0	29,500 unloaded
“Traditional” Lightweighting	15,500	12,500	52,000	80,000 GVW
			25,250	53,250 half load
			0	28,000 unloaded
“High” Aluminum Content	14,500	11,700	53,800	80,000 GVW
			25,250	51,450 half load
			0	26,200 unloaded

11.2% mass saved

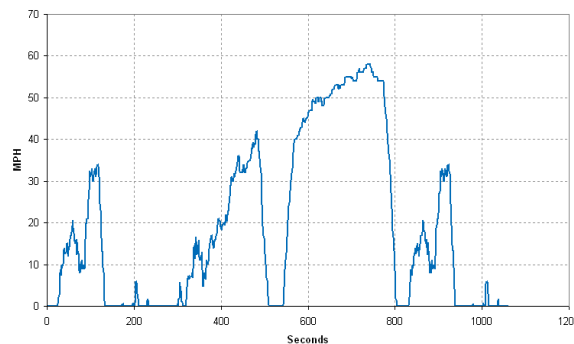
U.S. Drive Cycles Simulated Via Physics-Based Model

- **Highway Fuel Economy Test (HWFET)**
 - One of EPA’s official highway cycles
 - Duty cycle designed for medium to high speed operation, no mid-cycle stops
- **Heavy-Duty Urban Dynamometer Drive Schedule (HUDDS)**
 - One of EPA’s drive cycles for heavy-duty vehicles
 - Several idle and start-stop positions
 - Many acceleration and deceleration events
- **West Virginia University Interstate Drive Cycle (WVUIDC)**
 - Simulates interstate operation
 - Speeds vary from medium to high, many moderate acceleration events

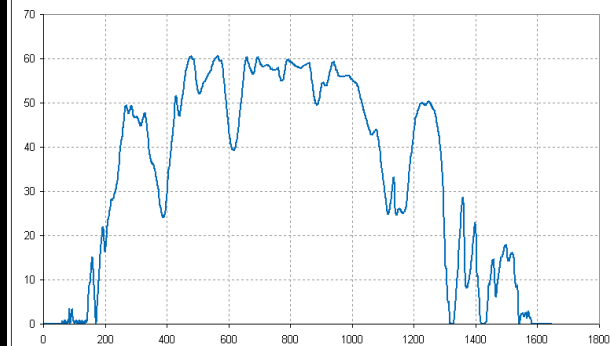
EPA Highway Fuel Economy Test (HWFET)



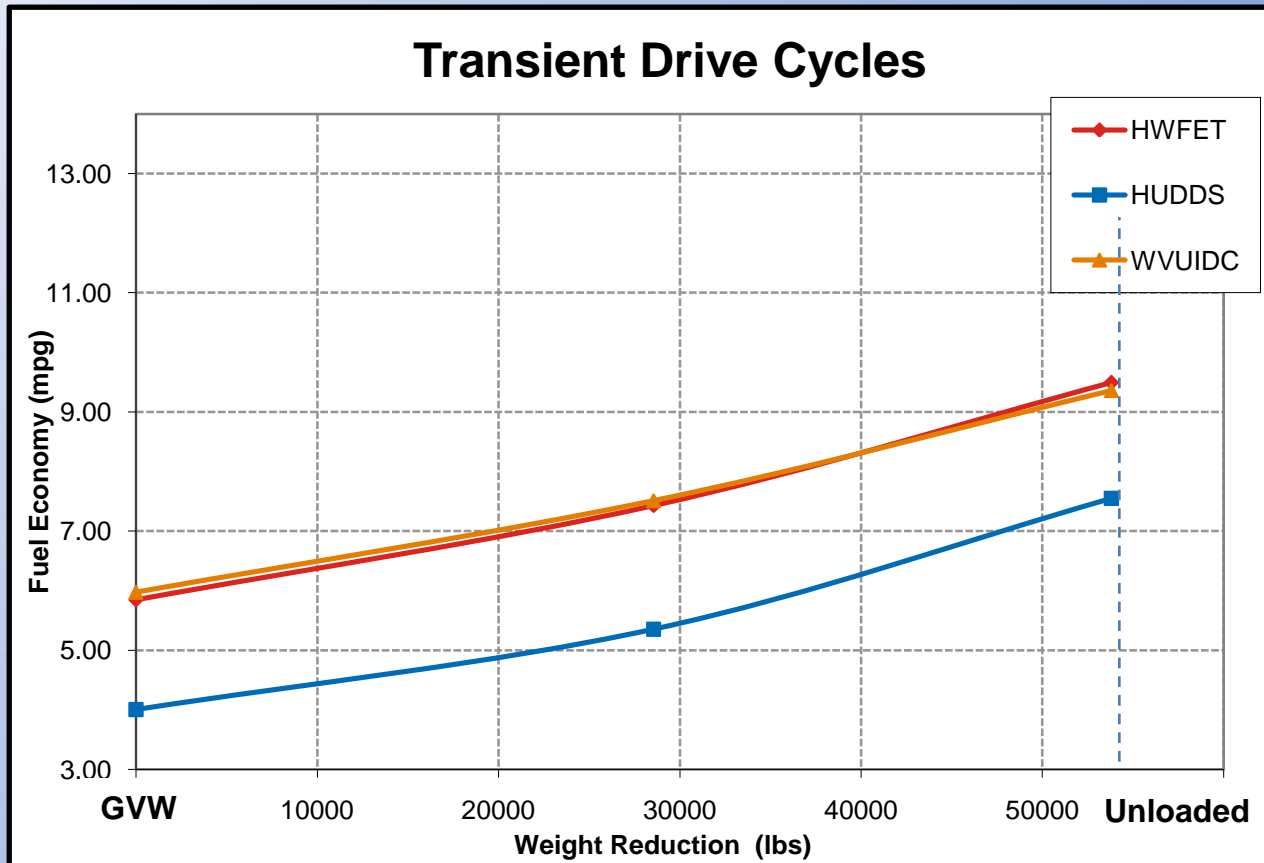
Heavy Duty Urban Dynamometer Drive Schedule (HUDDS)



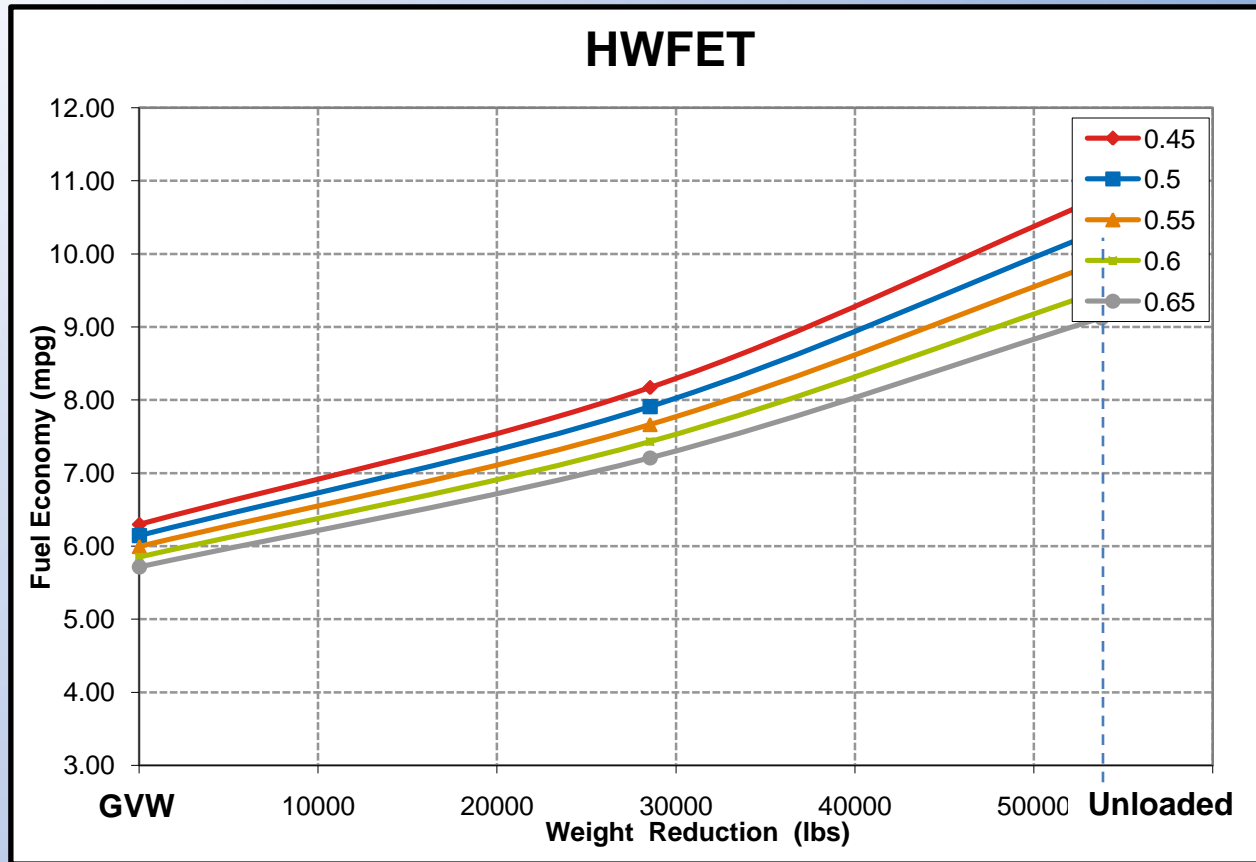
West Virginia University Interstate Drive Cycle (WVUIDC)



Weight Savings Increases Fuel Economy for All Drive Cycles



Weight Reduction and Aerodynamic Improvements are Complimentary



- Weight savings has greater impact at lower drag coefficient
- 3,000 lb. reduction equivalent to 0.05 C_d improvement

“High” Aluminum Content Truck

Aluminum Impacts Fleet Freight Efficiency

“High” Aluminum Content – 3,300 lb. Weight Reduction

Payload (% GVW)	% Annual Miles*	Fuel Efficiency Improvement
0 – 25 %	10 %	4.1 %
25 – 75 %	25 %	3.7 %
75 – 100 %	65 %	6.5 %
	Fleet Average =	<u>5.7 %</u>

6.5% more
payload /
fewer trips

* Average results from Aluminum Association Heavy-Duty Truck Use Survey

Aluminum is a Part of the Solution

- ***More payload***
 - Carry 3,300 lbs or 6.5% more cargo at GVW
- ***Improved fuel efficiency***
 - As high as 1,612 gallons each year for a weight constrained vehicle
 - Nearly **one billion gallons** of diesel annually for the current U.S. fleet
- ***Reduced CO₂ emissions***
 - Up to 17.9 tons annually for a weight constrained vehicle
 - Approximately **10 million tons of CO₂** per year for the current U.S. fleet



Time for Down Weighting is Now

- A necessity in the holistic approach to meeting U.S. and global regulations without sacrificing safety or functionality
- Complements advanced powertrains
- Offers more CO₂ and fuel savings than other materials
- Transition can happen faster than alternative powertrain breakthroughs while preserving U.S. jobs

Thank You



Contact Us

For additional aluminum research in the areas of safety, cost, alternative powertrains, growth and sustainability, to sign-up for the ATG's monthly newsletter and/or download this presentation, please visit us online at www.aluminumintransportation.org or e-mail atginfo@aluminum.org