Trends in Automotive - Aluminum

Doug Richman
The Aluminum Association’s Transportation Group (ATG)
Aluminum Transportation Group (ATG)
Discussion Outline

Why Are We Here?
- Aluminum - long term automotive growth
- Automakers to double use of aluminum by 2025
- Mass reduction is key to improving vehicle fuel economy.

Changing Vehicle Make-up
Demand Drivers

Why Light Weighting? / Role of Aluminum
- Studies | Mass Reduction (Materials Perspective)
  - FEV/EDAG Venza – MMV
  - EDAG Venza – AIV

Outside Processor Opportunities - Aluminum

Q & A
Mass Reduction | Part of the Solution

VALUE PROPOSITION (Varied by OEM and platform)

• Fuel Economy
  
  Consumer demand
  CAFE

  • Mass reduction vs. acceleration (powertrain selection)
  • Weight balance (50/50 or C of G or Yaw moment)
  • Inertia class
  • Enabling of low stored energy, or hybrid vehicles
CAFE 2017-25 Regulation

54.5 MPGe (equivalent)
   credits (7 – 9 MPG)
47 MPG (pre-credits)

Weight reduction assumption
overcame safety concerns
400 Lbs. avg. (10-20%)
achieves 2-3 MPG gain

Maintained “Footprint “ basis
Consumers Driving Improvements

**Buyer Behavior**
Percentage of consumers willing to pay more for fuel-efficiency

- 65% of consumers: Fuel Economy is the #1 factor in buying decision!

**Regulation Change**
US Corporate Average Fuel Economy (MPG)

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
<th>2016</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points</td>
<td>27.2</td>
<td>35.5</td>
<td>54.5</td>
</tr>
</tbody>
</table>

- +29% points
- +31%
- +100%

Sources: Consumer Reports, Ducker Worldwide 2011, Aluminum Association, Alcoa analysis

40 Years of Uninterrupted Aluminum Growth
Weight Reduction = \[\uparrow\] Fuel Economy

<table>
<thead>
<tr>
<th></th>
<th>Passenger Vehicle</th>
<th>Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base Engine</td>
<td>Downsize Engine</td>
</tr>
<tr>
<td>Gasoline</td>
<td>3.3 %</td>
<td>6.5 %</td>
</tr>
<tr>
<td>Diesel</td>
<td>3.9 %</td>
<td>6.3%</td>
</tr>
<tr>
<td>PEV</td>
<td>6.3 % *</td>
<td></td>
</tr>
<tr>
<td>PHEV</td>
<td>6.3 % *</td>
<td></td>
</tr>
</tbody>
</table>

* - Power consumption

Source: Ricardo Consulting Engineers
Automotive Mass Reduction Facts
(Independent of Material Choice)

- Achieving 2025 objectives will take **all** available technologies
  - Powertrain
  - Mass
  - Aero
  - Rolling resistance

- Mass reduction **additive** to other FE improvements
  - Including: Diesel, Hybrid, Electric, Aero, Tires...

- **10%** vehicle mass reduction = **6.5%** fuel economy improvement

- Significant gains achievable (+ **1.5 – 5.0 MPG @ 45 MPG**)

- OEM’s: “Mass reduction **critical** to achieving 2025 objectives”
Aluminum Association
Aluminum in 2012 North American Light Vehicles

Executive Summary

August 18, 2011
Automotive Aluminum Today

Average 2012 Vehicle:
343 Lbs. (9%) Aluminum

Source: Ducker Worldwide 2011
Aluminum Use in Vehicles Accelerating

40 Years of Un-interrupted Growth

Source: Ducker Worldwide 2011
Nearly 90% of aluminum content is in these four components -

- Heat Exchangers
- Engines
- Transmissions
- Wheels

Source: Ducker Worldwide 2011
Body - Largest Remaining Mass Reduction Opportunity

- **Aluminum penetration continues**
- **Potential future mass savings with steel are diminishing**
  - Advanced steels
- **Aluminum is the logical next step**
  - Al Closures, Steel BIW
  - Al Closures, Steel/Aluminum BIW
  - Al Closures, Aluminum/Steel BIW
By 2017 over 20% of aluminum content –
Body, bumper and closure components

Source: Ducker Worldwide 2011
Automotive Material Distribution – 2012:2025

Source: Ducker Worldwide 2011
Aluminum Today

Land Rover Range Rover
World’s First All-Aluminum SUV

All-aluminum unibody
- 39 percent lighter than outgoing steel body
- Total vehicle weight savings of 926 lbs.
- Significant enhancements in performance, agility, fuel economy, CO2 emissions

Tesla Model S

World Car of the Year - Automobile Magazine’s Car of the Year

All-electric vehicle relies on an all-aluminum body to save weight, allowing it to go farther while producing zero emissions and offering rapid acceleration and nimble performance.

High volume, all aluminum cars and trucks will enter the marketplace
Laser Welding Opportunities – Auto Body Aluminum
Objectives:

- Mass Reduction – 20%
- Retain: Size, Functionality, Safety (5 Star), NVH, Performance
- Proven Toyota body structure
- Cost increase < 10%
- Materials and process available and practical 2017

Source: EDAG
Crossover SUV (MMV) Mass Reduction

FEV/EDAG Venza MMV
Mass Reduction by System

- 313 Kg (18%)
**Crossover SUV (MMV)**


<table>
<thead>
<tr>
<th>MASS REDUCTION BY MATERIAL</th>
<th>KG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel (HSS/AHSS) 57% BIW</td>
<td>54</td>
</tr>
<tr>
<td>BIW, Bumper, Wheels</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>53</td>
</tr>
<tr>
<td>Closures, Transmission, Arms, Knuckles, Hubs, Calipers</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>37</td>
</tr>
<tr>
<td>Sub-frame, Seating, IP Beam, Engine</td>
<td></td>
</tr>
<tr>
<td>Plastics</td>
<td>38</td>
</tr>
<tr>
<td>Interior/Exterior trim (MuCell, PolyOne)</td>
<td></td>
</tr>
<tr>
<td>Downsizing</td>
<td>96</td>
</tr>
<tr>
<td>Engine/Trans, Fluids, Brakes, Exhaust</td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>35</td>
</tr>
<tr>
<td>Park Brake, Seats, Trans, Window reg.</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td>313</td>
</tr>
</tbody>
</table>

Crossover SUV (MMV)

Baseline Venza
- Steel: 59%
- Aluminum: 9%
- Glass: 3%
- Plastics: 9%
- Iron: 8%
- Mg: 0%
- All Other: 12%

Total Mass: 1,711 Kg

Venza MMV
- Steel: 57%
- Aluminum: 14%
- Glass: 3%
- Plastics: 9%
- Iron: 3%
- Mg: 3%
- All Other: 11%

Total Mass: 1,399 Kg

18% Mass Reduction

Source: EDAG/EPA
COST

Total LSV cost: $148 reduction

Premium costs – HSS/AHSS (BIW), aluminum (closure panels) and magnesium (castings). Offset by mass driven cost reductions in other vehicle systems.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Cost</th>
<th>Net $/Kg Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIW: 50% HSS/Aluminum</td>
<td>-54 Kg</td>
<td>+ $ 136</td>
</tr>
<tr>
<td>Closures: Aluminum</td>
<td>- 17 Kg</td>
<td>+ $ 91</td>
</tr>
<tr>
<td>Rest of Vehicle</td>
<td>- 241 Kg</td>
<td>- $ 375</td>
</tr>
<tr>
<td>Total Vehicle</td>
<td>- 313 Kg</td>
<td>- $ 148</td>
</tr>
</tbody>
</table>
Crossover SUV (MMV)

FINDINGS

• Reduced mass mid-size sedan can meet all design objectives: size, functionality, safety, NVH, performance

• **18% (313 Kg) mass reduction** – achievable MMV
  — advanced steel – BIW
  — aluminum – closures, chassis, suspension, brakes
  — Magnesium – seats, sub-frame, cradle, IP beam

• **FE impact: +3.1 MPG fuel economy**
  (from 27 to 30.1 MPG)

• Estimated **cost impact: -$148 (reduction)**
SUV Aluminum BIW Concept Study

January 23, 2013
AIV Crossover SUV

Objectives:

- Maximum Practical Mass Reduction – Aluminum Intensive Body
- Retain: Size
  - Functionality
  - Safety (5 Star)
  - NVH
  - Performance
- Proven Toyota body structure
- Cost increase: TBD
- Materials and process available and practical 2017

Source: EDAG
# AIV Crossover SUV Body

<table>
<thead>
<tr>
<th>AIV Body Mass Reductions</th>
<th>Baseline</th>
<th>AIV</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIW</td>
<td>378 Kg</td>
<td>220 Kg</td>
<td>162 Kg</td>
</tr>
<tr>
<td>Doors</td>
<td>96 Kg</td>
<td>67 Kg</td>
<td>28 Kg</td>
</tr>
<tr>
<td>Hood</td>
<td>18 Kg</td>
<td>10 Kg</td>
<td>8 Kg</td>
</tr>
<tr>
<td>Hatch</td>
<td>15 Kg</td>
<td>8 Kg</td>
<td>7 Kg</td>
</tr>
<tr>
<td>Fenders</td>
<td>7 Kg</td>
<td>5 Kg</td>
<td>2 Kg</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>514 Kg</strong></td>
<td><strong>310 Kg</strong></td>
<td><strong>208 kg (40 %)</strong></td>
</tr>
</tbody>
</table>
## AIV Crossover SUV – Materials Summary

<table>
<thead>
<tr>
<th>MASS REDUCTION BY MATERIAL</th>
<th>With FEV/EDAG LW Venza non-body content</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aluminum</strong></td>
<td></td>
<td>242 Kg</td>
</tr>
<tr>
<td>BIW, Closures, Cradle, Sub-frame, Knuckles, Calipers</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Magnesium</strong></td>
<td></td>
<td>37 Kg</td>
</tr>
<tr>
<td>Sub-frame, Seating, IP Beam, Engine</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plastics</strong></td>
<td></td>
<td>38 Kg</td>
</tr>
<tr>
<td>Interior/Exterior trim (MuCell, PolyOne)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Downsizing</strong></td>
<td></td>
<td>117 Kg</td>
</tr>
<tr>
<td>Engine/Trans, Fluids, Brakes, Exhaust</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td></td>
<td>35 Kg</td>
</tr>
<tr>
<td>Park Brake, Seats, Trans, Window reg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td></td>
<td><strong>476 Kg</strong></td>
</tr>
</tbody>
</table>
AIV Crossover SUV Materials

Baseline SUV
- Steel: 59%
- Aluminum: 9%
- Plastics: 9%
- Iron: 8%
- Mg: 0%
- Glass: 3%
- All Other: 12%
Total Mass: 1,711 Kg

28% Mass Reduction

AIV SUV
- Steel: 30%
- Aluminum: 37%
- Plastics: 10%
- Iron: 4%
- Mg: 4%
- Glass: 3%
- All Other: 12%
Total Mass: 1,237 Kg
COST

Total AIV cost increase: $534

Premium costs – Aluminum (BIW, closure panels) and magnesium (castings). Partially offset by mass driven cost reductions in other vehicle systems.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Cost</th>
<th>Net $/Kg Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIW: Aluminum</td>
<td>-162 Kg</td>
<td>+$789</td>
</tr>
<tr>
<td>Closures: Aluminum</td>
<td>-44 Kg</td>
<td>+$135</td>
</tr>
<tr>
<td>Rest of Vehicle</td>
<td>-263 Kg</td>
<td>-$389</td>
</tr>
<tr>
<td>Total Vehicle</td>
<td>-476 Kg</td>
<td>+$534</td>
</tr>
</tbody>
</table>
FINDINGS

• Aluminum intensive mid-size cross-over SUV can meet all design objectives: size, functionality, safety, NVH, performance

• 28% (476 Kg) total mass reduction – achievable MMV
  — aluminum – BIW, closures, chassis, suspension, brakes

• FE impact: +4.8 MPG fuel economy
  (from 27 to 31.8 MPG)

• Estimated cost impact: +$534 ($1.12/Kg)
Emerging Opportunities – Auto Aluminum

Market Needs / OSP Opportunities

-- Capable aluminum processors needed --
Automotive aluminum content is expected to increase ~60% by 2025

Aluminum pounds per U.S. light vehicle

Source: Ducker August 2011, Aluminum Association Transportation Group
Aluminum cast and mill products shipments for N.A. light vehicles expected to double by 2025

Source: Ducker August 2011, IHS
~5x aluminum flat rolled products content growth expected

Historic Applications
- heat exchangers
- closure panels

Future Applications
- closure panels
- body in white

Aluminum pounds per U.S. light vehicle

Source: Ducker August 2011, Aluminum Association Transportation Group
Aluminum **extrusion** content expected to maintain the historic 4% CAGR

**Historic Applications**
- brake systems
- heat exchangers

**Future Applications**
- body in white
- crash management

Aluminum pounds per U.S. light vehicle

**Historic**
- 2012: 27 pounds

**Future**
- 2025: 48 pounds

**Growth**
- 4.5% CAGR

Source: Ducker August 2011, Aluminum Association Transportation Group
OSP - Automotive Aluminum Considerations

Aluminum Sheet/Extrusion

Material Management
- lighter – easier to move
- water spotting - avoid moisture
  transit, storage (precipitation, condensation)
- damageability - dent, scratch
  “soft” tempers (T4 vs. T6)

Slitting/Blanking
- “Slivers” - tool design

Inventory “SHRINKAGE”

Tailor welded blanks
  Value proposition

Extrusion: Precision cutting (0.2 mm), Miter cutting, Punching
Market Needs – OSP Opportunities

The Value Proposition: Cost Savings (Auto Body)

*Material Utilization (blanking recovery)*

*Value: 3-4X value of steel TWB*

Greatest opportunity:
- Tailor welded blanks
- Blank optimization
- Gauge optimization
- Laser welding
- Friction stir welding
- Avoid heat-affected-zone (HAZ)
Aluminum Sheet & Extrusion Processing

OPC Industry Opportunity
- Significant Growth Potential
- Accommodate characteristics of aluminum

- **Demand Driver:** VALUE PROPOSITION (COST, COST, COST)
  (Must be technical success)

  Material cost
  Processing cost
  System cost
Thank You!

www.DriveAluminum.org
@DriveAluminum