METALLIC MATERIAL TRENDS FOR NORTH AMERICAN LIGHT VEHICLES

Richard A. Schultz
Ducker Worldwide
In this presentation we will discuss past, present and future metallic material trends for North American light vehicles. We will concentrate on mild steel, medium and high strength steel, advanced high strength steel, iron, aluminum and magnesium.

We will examine the impact of corporate average fuel economy legislation and other fuel economy regulations on vehicle weight and material trends.

We will examine the value of weight savings compared to other options for reducing light vehicle fuel consumption.
U.S. Light Vehicle Average Inertia Weight

Source: EPA

2006 EPA estimate is 4142 lbs.
Over the past 30-years:

- Production nearly doubled and minivans, SUVs and pickup trucks went from essentially zero to 55 percent of the light vehicle mix
- Fuel economy increased by 60 percent
- Occupant safety improved dramatically
- Horsepower increased by 55 percent
- 0-60 miles per hour time went down 30 percent
- Metallic material content dropped from 81.4 percent to 75.8 percent as plastics and other non metallic materials grew to 24.2 percent of vehicle content
NORTH AMERICAN LIGHT VEHICLE METALLIC MATERIAL TRENDS

- Segmented by Type of Material -
  Calendar Year 1975

Mild Steel 55.9%

Iron 15.0%

Other Metals 3.0%

Aluminum 2.2%

Plastics 4.6%

Other Steels 1.7%

3.6% Medium & Conventional High Strength Steel

*Other Materials 14.0%

*Rubber, coatings, textiles, glass, fuel, other fluids and other organics

3,900 Pounds of Material Content

Source: Ducker Worldwide

www.autosteel.org
- Segmented by Type of Material -

Calendar Year 2005

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Steel</td>
<td>44.0%</td>
</tr>
<tr>
<td>Plastics</td>
<td>8.4%</td>
</tr>
<tr>
<td>Other Metals</td>
<td>3.8%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.2%</td>
</tr>
<tr>
<td>Aluminum</td>
<td>7.7%</td>
</tr>
<tr>
<td>Iron</td>
<td>1.9%</td>
</tr>
<tr>
<td>MHSS, CHSS &amp; Advanced High Strength Steel</td>
<td>10.9%</td>
</tr>
<tr>
<td>Other Steels</td>
<td></td>
</tr>
<tr>
<td>Other Materials</td>
<td>15.8%</td>
</tr>
</tbody>
</table>

3,982 Pounds of Material Content

Source: Ducker Worldwide
Changes in North American Light Vehicle Material Content

- 1975 to 2005 -

Pounds Per Vehicle Increases

- HSS & AHSS: +295
- Other Steels: +11
- Iron: -295
- Aluminum: +223
- Magnesium: +9
- Other Metals: +30
- Plastics: +155

Pounds Per Vehicle Decreases

- Mild Steel: -429

Source: Ducker Worldwide

www.autosteel.org
NORTH AMERICAN LIGHT VEHICLE METALLIC MATERIAL TRENDS

- Segmented by Type of Material -
Calendar Year 2007

Mild Steel: 43.1%
Other Materials: 15.7%
Plastics: 8.4%
Other Metals: 3.7%
Magnesium: 0.2%
Aluminum: 8.1%
Iron: 7.0%
Other Steels: 1.9%
MHSS, CHSS & Advanced High Strength Steel: 11.9%

4,050 Pounds of Material Content

Source: Ducker Worldwide
Light vehicles account for 40 percent of U.S. oil consumption and over one half of this oil is imported.

Light vehicle operation contributes approximately 20 percent of all U.S. carbon dioxide emissions.

New regulations for light trucks have recently been approved and should increase light truck fuel economy by at least 12 percent over the next five years.

Passenger car fuel economy officially remains at 27.5 MPG, but there is tremendous pressure to raise the legislated target to at least 30 MPG by 2011. This could be accomplished by taking the control of passenger car fuel economy away from congress and putting it under NHTSA; possibly leading to regulations based on the passenger car’s footprint just like the new regulations for light trucks.
U.S. Light Vehicle Inertia Weight Compared to EPA Model Year Unadjusted Fuel Economy

Source: Ducker Worldwide
Examples of Technology to Improve Fuel Economy

Maximum Increase in Fuel Economy from Each Technology with No Decrease in Vehicle Footprint

<table>
<thead>
<tr>
<th>Technology</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuously Variable Transmission</td>
<td>8.0%</td>
</tr>
<tr>
<td>10% Weight Reduction with Engine Downsize</td>
<td>7.0%</td>
</tr>
<tr>
<td>Idle Off</td>
<td>7.0%</td>
</tr>
<tr>
<td>Cylinder Deactivation</td>
<td>6.0%</td>
</tr>
<tr>
<td>Overhead Cam Engine</td>
<td>5.0%</td>
</tr>
<tr>
<td>Friction Reduction</td>
<td>5.0%</td>
</tr>
<tr>
<td>10% Weight Reduction</td>
<td>3.1%</td>
</tr>
<tr>
<td>Variable Valve Timing</td>
<td>3.0%</td>
</tr>
<tr>
<td>Direct Injection Diesel</td>
<td>35%*</td>
</tr>
<tr>
<td>Hybrid Powertrain</td>
<td>25%*</td>
</tr>
<tr>
<td>Continuously Variable Transmission</td>
<td>8.0%</td>
</tr>
<tr>
<td>10% Weight Reduction with Engine Downsize</td>
<td>7.0%</td>
</tr>
<tr>
<td>Idle Off</td>
<td>7.0%</td>
</tr>
<tr>
<td>Cylinder Deactivation</td>
<td>6.0%</td>
</tr>
<tr>
<td>Overhead Cam Engine</td>
<td>5.0%</td>
</tr>
<tr>
<td>Friction Reduction</td>
<td>5.0%</td>
</tr>
<tr>
<td>10% Weight Reduction</td>
<td>3.1%</td>
</tr>
<tr>
<td>Variable Valve Timing</td>
<td>3.0%</td>
</tr>
<tr>
<td>Direct Injection Diesel</td>
<td>35%*</td>
</tr>
<tr>
<td>Hybrid Powertrain</td>
<td>25%*</td>
</tr>
</tbody>
</table>

EPA estimates that a 14% improvement in fuel economy could be obtained by 2011 from a mix of these technologies at an average implementation cost of less than $2,000.

Source: EPA, FKA and Ducker

*Actual reported increases
Changes in North American Light Vehicle Material Content
2007-2015

319 lbs. of Advanced and other HSS, AL, Mg and plastics will replace 478 pounds of Mild Steel, Iron and other metals for a 33% metallic material weight savings over the next eight years.

Source: Ducker Worldwide
North American Light Vehicle Material Content
Segmented by Type of Material
Calendar Year 2015

Other Materials 650 lbs.
Mild Steel 1,314 lbs. 33.7%
Plastics 364 lbs. 9.3%
Other Metals 145 lbs. 3.7%
Magnesium 22 lbs. 0.6%
Iron 244 lbs. 6.2%
Aluminum 374 lbs. 9.6%
Other Steels 77 lbs. 2.0%
Advanced HSS 403 lbs. 10.3%
Medium and Conventional HSS 315 LBS. 8.0%

3,908 Pounds of Material Content

Source: Ducker Worldwide

Achieving this level of AHSS use will present many challenges.
What is needed for AHSS growth?

- Enabling Technologies
  - Welding AHSS
  - Stamping AHSS
  - Modeling with AHSS
- New Steel Product Development
  - New steel grades with even higher strength and formability than current AHSS grades at little or no increase in cost

Source: U.S. Steel
2007 Body and Closure Steel Content by Type

**Total Body on Frame**
- HSS: 34.6%
- Advanced HSS: 5.3%
- Mild Steel: 60.1%

977 Pounds

**Total Unibody**
- Advanced HSS: 12.4%
- Mild Steel: 51.5%
- HSS: 36.1%

769 Pounds

**Total**
- Advanced HSS: 9.3%
- Mild Steel: 55.2%
- HSS: 35.5%

847 Pounds

*Source: Ducker Worldwide*
NORTH AMERICAN
LIGHT VEHICLE METALLIC MATERIAL TRENDS

2007 Body and Closure Steel Content by Type

GMC Acadia
- Mild Steel: 24%
- CHSS: 23%
- Medium HSS: 34%
- BH: 10%
- Dual Phase: 13%
- Other AHSS: 9%
- Total: 930 lbs.

DCX M Class
- Mild Steel: 45%
- CHSS: 23%
- Medium HSS: 10%
- BH: 5%
- Dual Phase: 15%
- Other AHSS: 2%
- Total: 969 lbs.

Ford Expedition
- Mild Steel: 45%
- CHSS: 14%
- Medium HSS: 20%
- BH: 5%
- Dual Phase: 15%
- Other AHSS: 1%
- Total: 1080 lbs.

Nissan Altima
- Mild Steel: 45%
- CHSS: 20%
- Medium HSS: 13%
- BH: 13%
- Dual Phase: 7%
- Other AHSS: 10%
- Total: 700 lbs.

Toyota Tundra
- Mild Steel: 40%
- CHSS: 15%
- Medium HSS: 15%
- BH: 10%
- Dual Phase: 28%
- Other AHSS: 7%
- Total: 968 lbs.

Honda CR-V
- Mild Steel: 45%
- CHSS: 28%
- Medium HSS: 10%
- BH: 8%
- Dual Phase: 7%
- Other AHSS: 10%
- Total: 717 lbs.
2015 Advanced High Strength Steel Content
Per Light Vehicle

Body and Closures
70%
278 lbs.

Suspensions
16%
66 lbs.

Bumper and Intrusion Beams
9%
38 lbs.

Wheels, Seats and other components
5%
21 lbs.

Total AHSS = 403 Pounds Per Vehicle

Source: Ducker Worldwide
2015 Light Vehicle Aluminum Content Segmented by Application

- **Engines**: 37.4%
- **Driveline**: 17.9%
- **Wheels**: 14.7%
- **HVAC**: 8.5%
- **Body, Bumper & Closures**: 5.5%
- **Chassis, Steering & Suspension**: 10.0%
- **Brakes & Other Components**: 6.0%

21 lbs. of aluminum per vehicle for body, bumper and closures in 2015, 2.5 times today’s amount.

Power train applications will represent over 55% of the aluminum content in 2015.

Source: Ducker Worldwide

374 Pounds Per Vehicle
To achieve 22 lbs. of Mg per vehicle, magnesium will have to economically solve the problem of elevated temperature creep.

Source: Ducker Worldwide
NORTH AMERICAN LIGHT VEHICLE METALLIC MATERIAL TRENDS

Body and Closure Metallic Material Content by Type

### 2007

- Advanced HSS: 9.5%
- Con. HSS: 12.7%
- Medium HSS: 15.8%
- Bake Hardenable: 6.6%
- Mild Steel: 54.6%

**Total: 850 Pounds**

### 2015

- Advanced HSS: 2.5%
- Conventional HSS: 10.2%
- Bake Hardenable and Medium HSS: 23.5%
- Aluminum & Magnesium: 29.0%

**Total: 800 Pounds with an Equal Footprint to 2007**

*Source: Ducker Worldwide*
## North American Light Vehicle Material Content Per in Pounds

<table>
<thead>
<tr>
<th>Material Type</th>
<th>1975</th>
<th>2005</th>
<th>2007</th>
<th>2015</th>
<th>Change From 1975 to 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Steel</td>
<td>2,180</td>
<td>1,751</td>
<td>1,748</td>
<td>1,314</td>
<td>Down 866 lbs.</td>
</tr>
<tr>
<td>High Strength Steel</td>
<td>140</td>
<td>324</td>
<td>334</td>
<td>315</td>
<td>Up 175 lbs.</td>
</tr>
<tr>
<td>Advanced HSS</td>
<td>--</td>
<td>111</td>
<td>149</td>
<td>403</td>
<td>Up 403 lbs.</td>
</tr>
<tr>
<td>Other Steels</td>
<td>65</td>
<td>76</td>
<td>76</td>
<td>77</td>
<td>Up 12 lbs.</td>
</tr>
<tr>
<td>Iron</td>
<td>585</td>
<td>290</td>
<td>284</td>
<td>244</td>
<td>Down 341 lbs.</td>
</tr>
<tr>
<td>Aluminum</td>
<td>84</td>
<td>307</td>
<td>327</td>
<td>374</td>
<td>Up 290 lbs.</td>
</tr>
<tr>
<td>Magnesium</td>
<td>--</td>
<td>9</td>
<td>9</td>
<td>22</td>
<td>Up 22 lbs.</td>
</tr>
<tr>
<td>Other Metals</td>
<td>120</td>
<td>150</td>
<td>149</td>
<td>145</td>
<td>Up 25 lbs.</td>
</tr>
<tr>
<td>Plastic/Composites</td>
<td>180</td>
<td>335</td>
<td>340</td>
<td>364</td>
<td>Up 184 lbs.</td>
</tr>
<tr>
<td>Other Materials</td>
<td>546</td>
<td>629</td>
<td>634</td>
<td>650</td>
<td>Up 104 lbs.</td>
</tr>
<tr>
<td><strong>Total Pounds</strong></td>
<td>3,900</td>
<td>3,982</td>
<td>4,050</td>
<td>3,908*</td>
<td>Up 8 lbs.</td>
</tr>
</tbody>
</table>

* Same vehicle mix and average footprint as 2007

Source: Ducker Worldwide
North American Light Vehicle Steel Content By Type

1975
- Stainless and Other Steels: 91.0%
- HSS: 5.9%
- Mild Steel*: 3.1%
- Mild Steel: 2,385 Pounds

2007
- Stainless and Other Steels: 75.8%
- AHSS: 14.7%
- HSS: 6.2%
- Mild Steel*: 3.3%
- Mild Steel: 2,307 Pounds

2015
- Stainless and Other Steels: 14.9%
- AHSS: 62.3%
- HSS: 19.1%
- Mild Steel*: 3.7%
- Mild Steel: 2,109 Pounds

*Mild steel has a tensile strength of 270 Mpa or less in this analysis

Note: Total steel weights per light vehicle are plus or minus 100 pounds. Medium and heavy trucks would add as much as 250 pounds to the overall average steel content per vehicle in North America if they were included in the calculations.
Conclusions

• Advanced high strength steels will grow at a 14 percent CAGR and reach over 400 pounds per vehicle by 2015

• Advanced high strength steels in the body structure will increase from 11 percent of the body weight today to 40 percent of the body weight by 2015

• The total amount of steel content per light vehicle will decline from 2,300 pounds in 2007 to 2,100 pounds in 2015, as Advanced High Strength Steels replace other steels to save weight and improve performance

• Aluminum and magnesium will only increase from seven pounds per vehicle in the body and closures today to 20 pounds in the body and closures by 2015
Conclusions

• Vehicle weights are likely to decrease by only four percent by 2015 with no significant change in vehicle interior volume or average footprint over the next eight years.

• A variety of technologies including weight savings are likely to improve fuel economy by at least 12 percent by 2015 while maintaining or improving vehicle performance.

• Changes in the mix of materials will be used primarily to improve vehicle performance and increase content with only a small contribution to improving fuel economy (less than 2 percent of the fuel savings out of 12 percent is likely to come from material substitution).
Thank you for your attention!
Dick Schultz - Project Consultant
Ducker Worldwide
1250 Maplelawn Drive
Troy, MI
248-644-0086 or 724-940 9018
richards@ducker.com