LIGHT WEIGHT BODY IN WHITE DESIGN

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Global Vehicle Architecture Manager
Ford Motor Company

Society of Automotive Analysts
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Agenda:
• Drivers for Light Weight BIW
• Light Weight Design Mindset
• The Future
Sustainability – Clear Technology Priorities

Technology Leadership Commitments

- **SUSTAINABILITY “GREEN”**
  - Leadership in fuel economy with every new or significantly refreshed entry
  - More renewable, recycled materials
  - Vehicle light weighting

- **SAFETY “SAFE”**
  - Leadership safety technology / feature content
  - Achieve public domain targets and 3rd party recommended buys
  - Breakthrough features for family safety

- **DESIGN “SMART”**
  - Design leadership on each new program
  - Leadership in interior comfort / convenience, infotainment technology
  - Global platforms with right proportions
  - Improve emotional appeal

**LEADERSHIP FOUNDATION “QUALITY”**

Our leadership commitments around Quality, Green, Safe and Smart consistently guide our product development team priorities every day.
Fuel Efficiency Targets


54.4 mpge
Fleetwide average in 2025

Source: Green Technology, 2011.
The EPA says that for every 100 pounds taken out of the vehicle, the fuel economy is increased by 1-2 percent.

10% mass reduction without powertrain re-sizing saves fuel between 1.9% and 3.2% in conventional vehicles with gasoline engine and between 2.6% and 3.4% with diesel engines.
A similar relationship between power required or range and vehicle mass exists for electric vehicles.
Regulation Changes

Forecast continues to rise through 2020

Global Requirements

Time (CY)


0 20 40 60 80 100 120 140 160

GlobalNCAP

ANCAP

C-NCAP

EURO NCAP

LATIN NCAP

NHTSA

Thatcham Research

IIHS

ASEAN NCAP

Go Further

Ford

www.globalncap.org

www.iihs.org

www.aseanncap.org

www.nhtsa.gov
Since 1998, the average vehicle mass has increased by...

- **17 lbs/yr** for cars
- **42 lbs/yr** for trucks
• Mass of Ford Sedan BIWs are on a decreasing trend
• From 2007 to 2017 there was a reduction of 17% in average BIW mass
• "Snap Shot of the Industry" shows the average trending down 12.5% over the same time
Safety regulations and need for weight reduction have driven the need for higher strength steels.

- Increase of up to 104% in the Average Yield Strength of Ford BIWs since 2008.
Topology Optimization

- Mass savings starts at the early in the design phase by insuring that the optimal load paths are defined
- Establishing the ideal load paths allow energy transfer through the structure with the minimum amount of material and material strength

**Three application of Topology:**
1. Full Vehicle – focus on defining the overall load path strategy based on vehicle level load conditions
2. System – develop geometry to address specific loads within a given system
3. Component – insure the geometry at the component level is optimized to the local events
Section Design

- Engineers need to ensure that the material used is fully utilized.
- Designing simple sections does not define efficiency.
- Minor changes to the design can lead to mass reduction.

Seat Cross Member Example

<table>
<thead>
<tr>
<th>Section Name</th>
<th>Crush Load Capacities (kN)</th>
<th>Moment Capacities (kN-mm)</th>
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<tbody>
<tr>
<td></td>
<td>Fcrt</td>
<td>MmaxY-</td>
</tr>
<tr>
<td>Cross Member</td>
<td>78.8</td>
<td>2944</td>
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<tr>
<td>Beaded Cross Member</td>
<td>84</td>
<td>3198</td>
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</table>
Forming Processes and Geometry

- Utilize all available forming processes to:
  - Enable the utilization of the highest strength materials available
  - Improve the geometric properties of a given part
  - End goal of achieving reduced cost and mass required to achieve a given level of performance

- Current focus is on Hot Stamping, Roll Forming, and Hydro-Forming
Hydro-Forming Evolution

- **Stampede Steel**
  - 31 parts
  - 20 bends
  - -31% weight
  - Front-End Super Duty

- **First Hydroform Steel**
  - 18 parts
  - 12 bends
  - -59% weight
  - Front-End F-150

- **First Aluminum Hydroform**
  - 6 parts
  - 6 bends
  - -59% weight
  - Front-End Super Duty/Expedition
Replacement of complex stampings with a tubular structure enables:
- The use of higher strength steel within a reduced package
- Increased vehicle performance
- Reduced package requirement

Concept initiated on F-150 and proliferated across vehicle lines

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Material</th>
<th>Mass Savings</th>
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</thead>
<tbody>
<tr>
<td>F-150</td>
<td>DP800</td>
<td>6.1 kg</td>
</tr>
<tr>
<td>Fusion</td>
<td>DP1000</td>
<td>4.2 kg</td>
</tr>
<tr>
<td>Mustang</td>
<td>DP1000</td>
<td>3.9 kg</td>
</tr>
<tr>
<td>Continental</td>
<td>DP1000</td>
<td>4.5 kg</td>
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<tr>
<td>F-150</td>
<td>6000 Series</td>
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</tr>
<tr>
<td>Expedition</td>
<td>6000 Series</td>
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</table>
Closed section concept was extended to the B-Pillar for the Fusion enabling:

- Elimination of large press hardened parts
- Use of AHSS
- Reduced intrusion during side impact
- 6 kg mass reduction
Tailored Material Thickness

Press Hardened Steel Center Hinge Pillar Reinforcement used to provide the necessary performance for Roof Strength and Side Impact Events.

Tailor Rolled Blank introduced to place gage where needed to meet the performance requirements and provide mass savings.

Mass savings of 1.2 kg achieved over the conventional approach.
Tailored Material Properties

- Rails were shortened for donor vehicle to provide correct vehicle proportions
- Mass of the vehicle increased over the donor vehicle

Typical mechanical properties:
- Hard area: $R_m = 1450$ Mpa, $R_e = 1100$ Mpa, $\varepsilon_{(A5)} > 6\%$
- “Soft” area: $R_m = 550$ Mpa, $R_e = 400$ Mpa, $\varepsilon_{(A5)} > 20\%$
Ford developed a novel Post Form Heat Treatment (PFHT) cycle for 6XXX sheet alloy (Industry-first) that results in:
- 66% increase in Yield Strength
- 6% increase in Ultimate Strength

PFHT is used to strengthen sheet parts for yield-limited applications

14 stamped parts undergo the PFHT operation
Extrusions

Advantages Afforded by Extrusions:
• Freedom to place material where you need it
• Addition of internal ribs / reinforcements to improve the effectiveness of the design section
• Closed section without discrete connection points

Case Study: Front Header

Part Reduction: 3 to 1
Mass Reduction: 2.9 kg

1 Additional geometry changes achieved through bending and hydro-forming processes
Developments in steel related to 3rd Generation Advanced High Strength Steel offer opportunities:

- Increased Yield Strength allows for gauge reduction of strength driven parts
- Yield Strength increased combined with improved ductility offer opportunities to optimize parts requiring energy absorption
An industry wide shift from stamped shock towers to cast aluminum components has begun.

5-7 Stampings welded into one assembly with welds nuts and studs

1 Casting

**Expected benefits:**
- Reduced component mass
- Increase local and vehicle level stiffness
- Improved dimensional accuracy through part integration
- Efficient attachment integration – elimination of brackets.
Mixed Material BIW

The Original
- Wood Structural Frames
- Aluminum Hood
- Steel Panels

Now...

The Future...
- Steel
- Aluminum
- Hot Stamping

Material split
Percent

<table>
<thead>
<tr>
<th>Material</th>
<th>2010</th>
<th>2030</th>
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<tr>
<td>Aviation</td>
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<tr>
<td>Glass fiber</td>
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<td>6</td>
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<tr>
<td>Magnesium</td>
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<td>16</td>
</tr>
<tr>
<td>Steel (&lt; 500 MPa)</td>
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<td>64</td>
</tr>
<tr>
<td>Other non-lightweight</td>
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<td>11.5</td>
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<table>
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1. HSS, aluminum, magnesium, plastics (beyond current use), glass/carbon fiber
2. High-strength steel (> 500 MPa)
3. Mainly other metals, glass, rubber, interior parts for automotive, etc.

SOURCE: McKinsey