LIGHT WEIGHT BODY IN WHITE DESIGN

Shawn Morgans
Global Vehicle Architecture Manager
Ford Motor Company

Society of Automotive Analysts
2017 Automotive Light Weighting Summit

September 25th, 2017

Go Further

Agenda:

- Drivers for Light Weight BIW
- Light Weight Design Mindset
- The Future

Go Further

Sustainability – Clear Technology Priorities

Technology
Leadership Commitments

Drive green.

SUSTAINABILITY "GREEN"

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

Drive safe.

SAFETY "SAFE"

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

Drive smart.

DESIGN "SMART"

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

Drive quality.

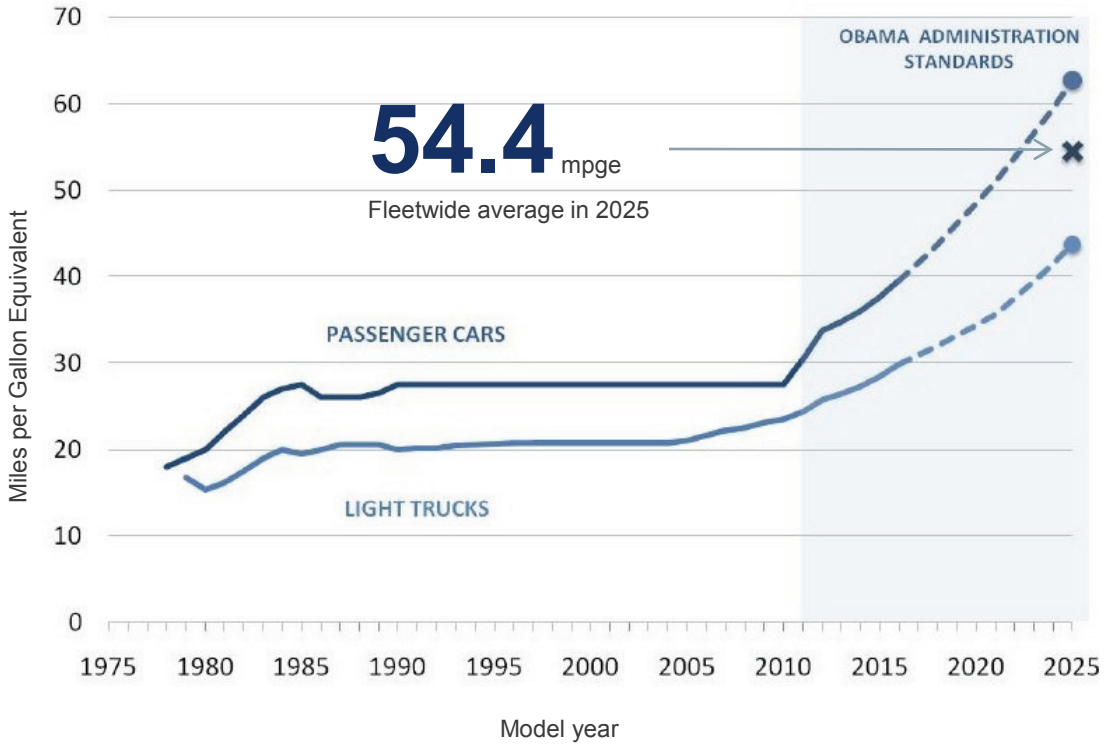
LEADERSHIP FOUNDATION "QUALITY"

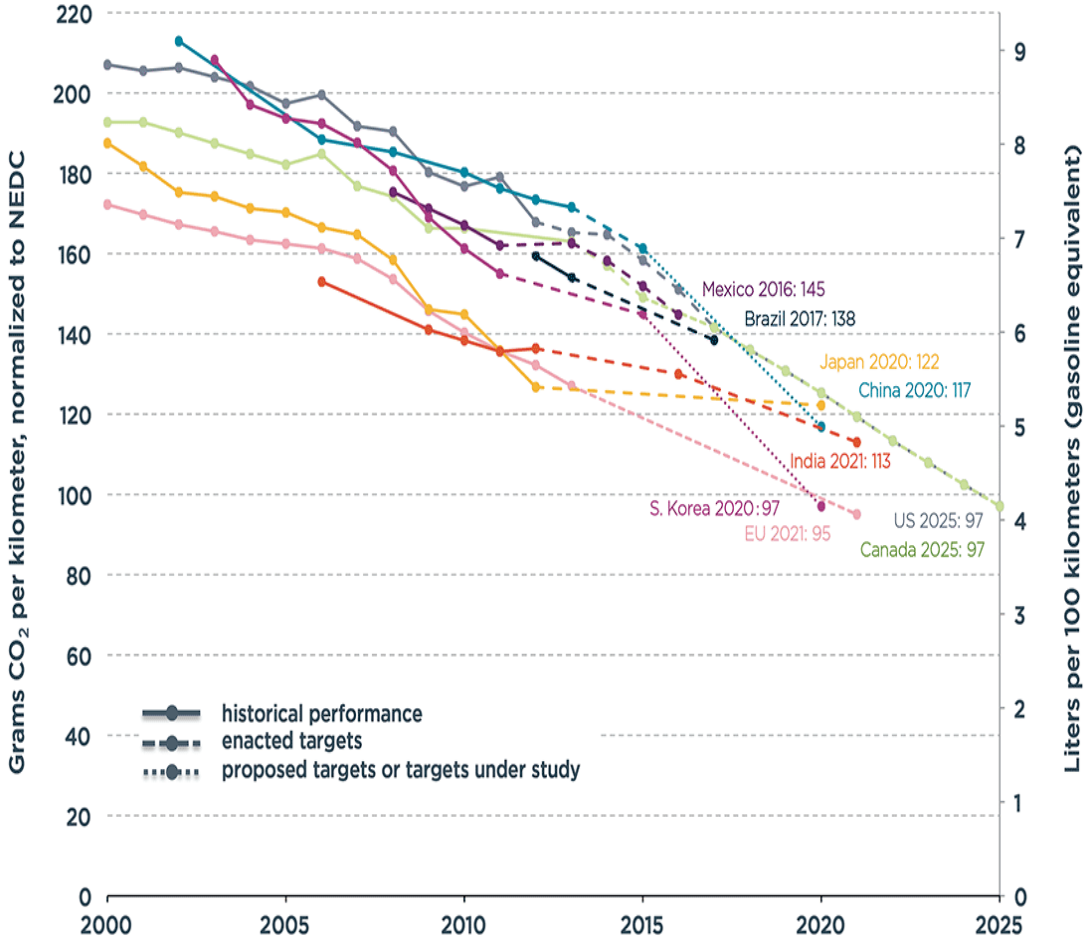
Our **leadership commitments** around **Quality, Green, Safe and Smart** consistently guide our product development team priorities every day

Go Further

Fuel Efficiency Targets

Light-Duty Vehicle Fuel Economy Standards, 1978 - 2025

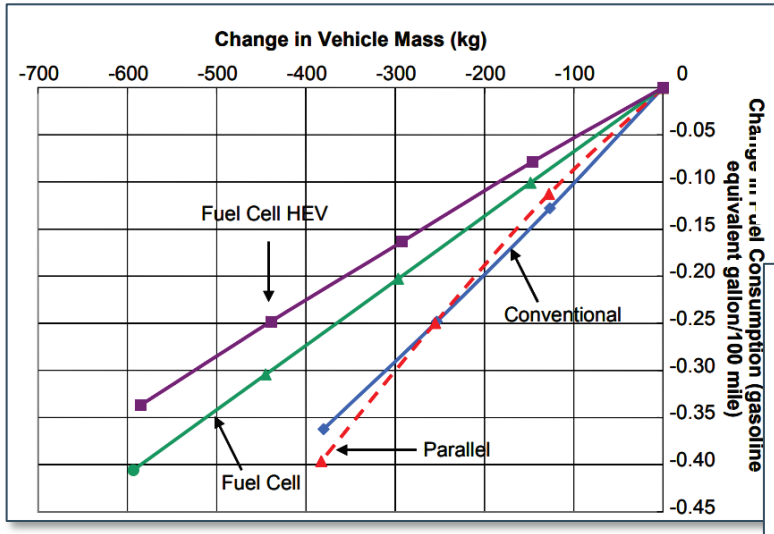




Source: Green Technology, 2011.

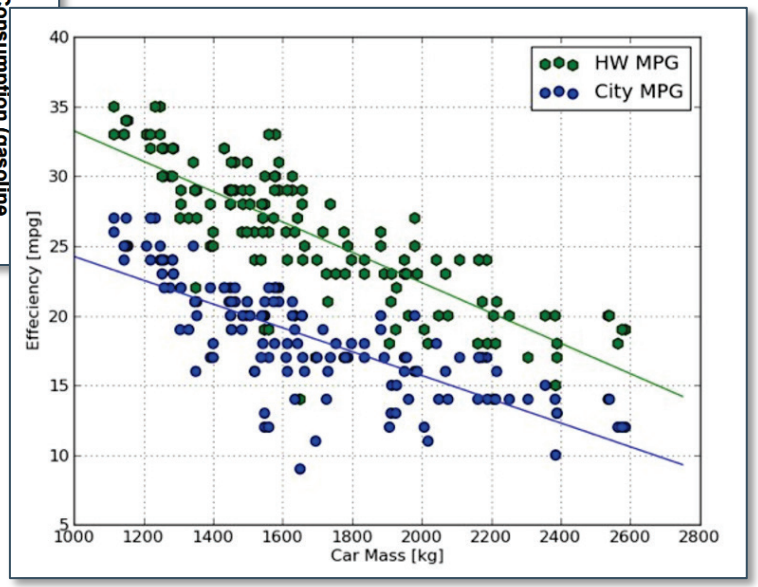
Go Further

Impact of Vehicle Mass on Fuel Economy

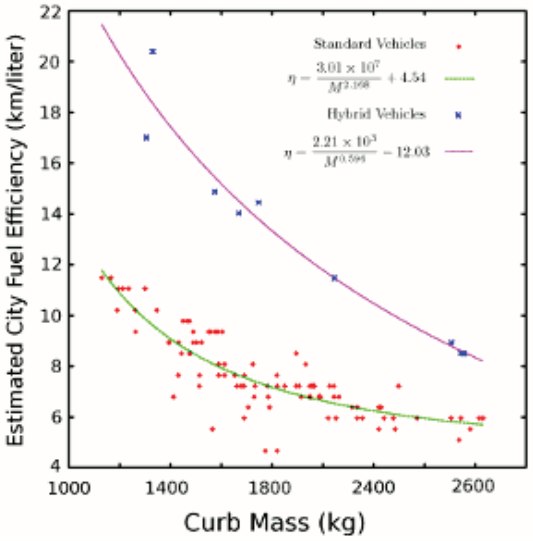


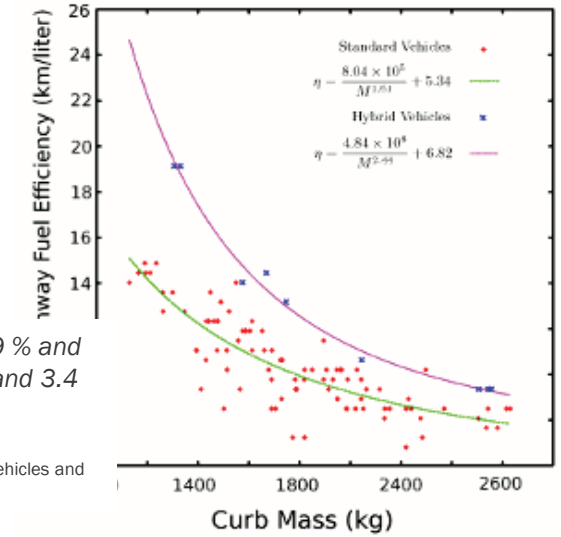
Fuel Economy Sensitivity to Vehicle Mass for Advanced Vehicle Powertrains
S. Pagerit, P. Sharer, A. Rousseau

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

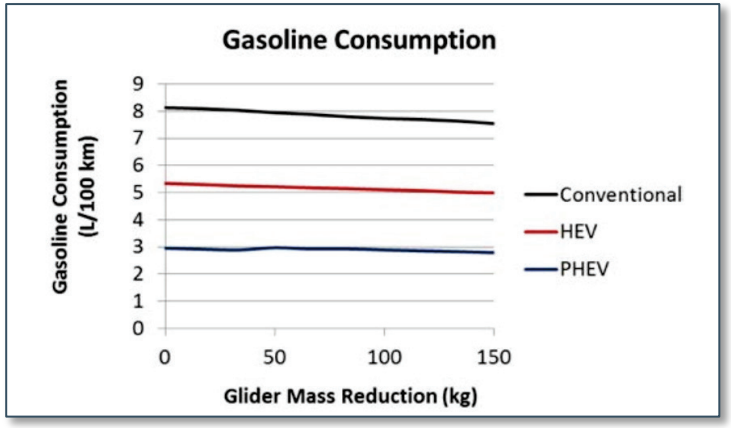


Rhett Allain - Wired





Gas Guzzler Weights
Andrew Danowitz



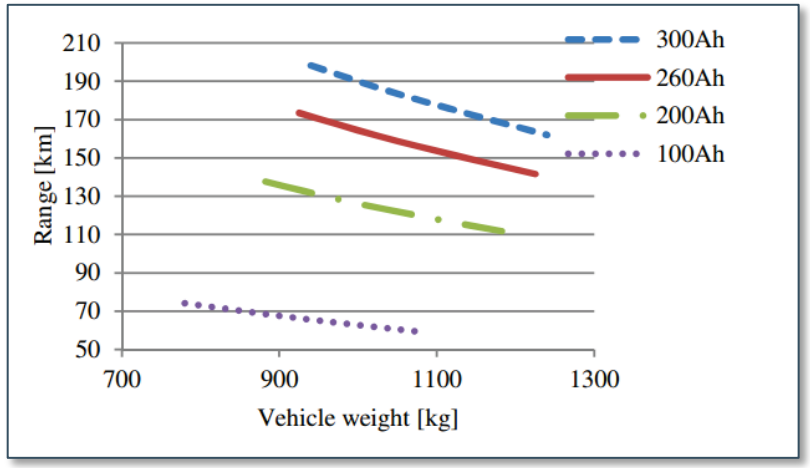
Lightweighting Impacts on Fuel Economy, Cost, and Component Losses; Aaron David Brooker, Jacob Ward, Lijuan Wang

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

Diesel engine Determination of Weight Elasticity of Fuel Economy for Conventional ICE Vehicles, Hybrid Vehicles and Fuel Cell Vehicles Forschungsgesellschaft Kraftfahrwesen mbH Aachen Body Department

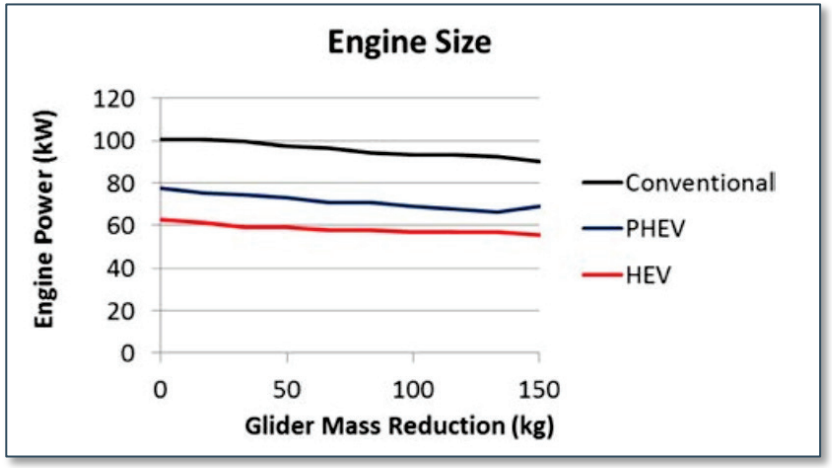
Go Further

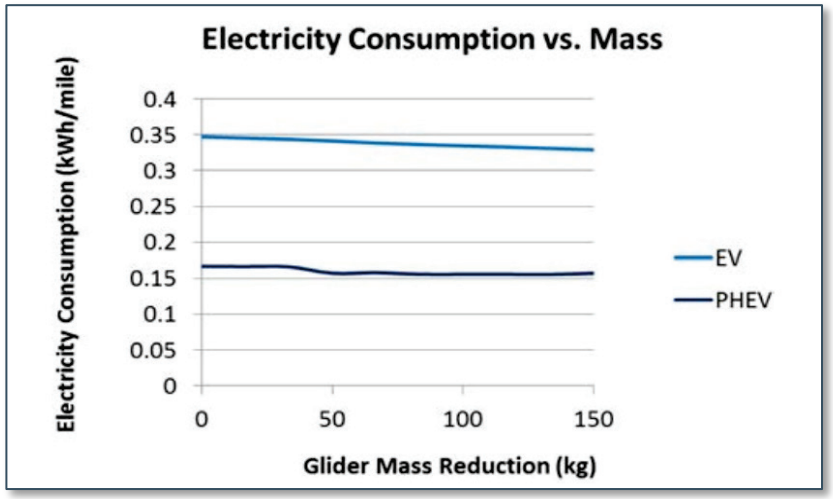
Electric Vehicle & Mass



Analysis of Parameters Influencing Electric Vehicle Range;
Martin Mruzek*, Igor Gajdáč, Ľuboš Kučera, Dalibor Barta

A similar relationship between power required or range and vehicle mass exists for electric vehicles

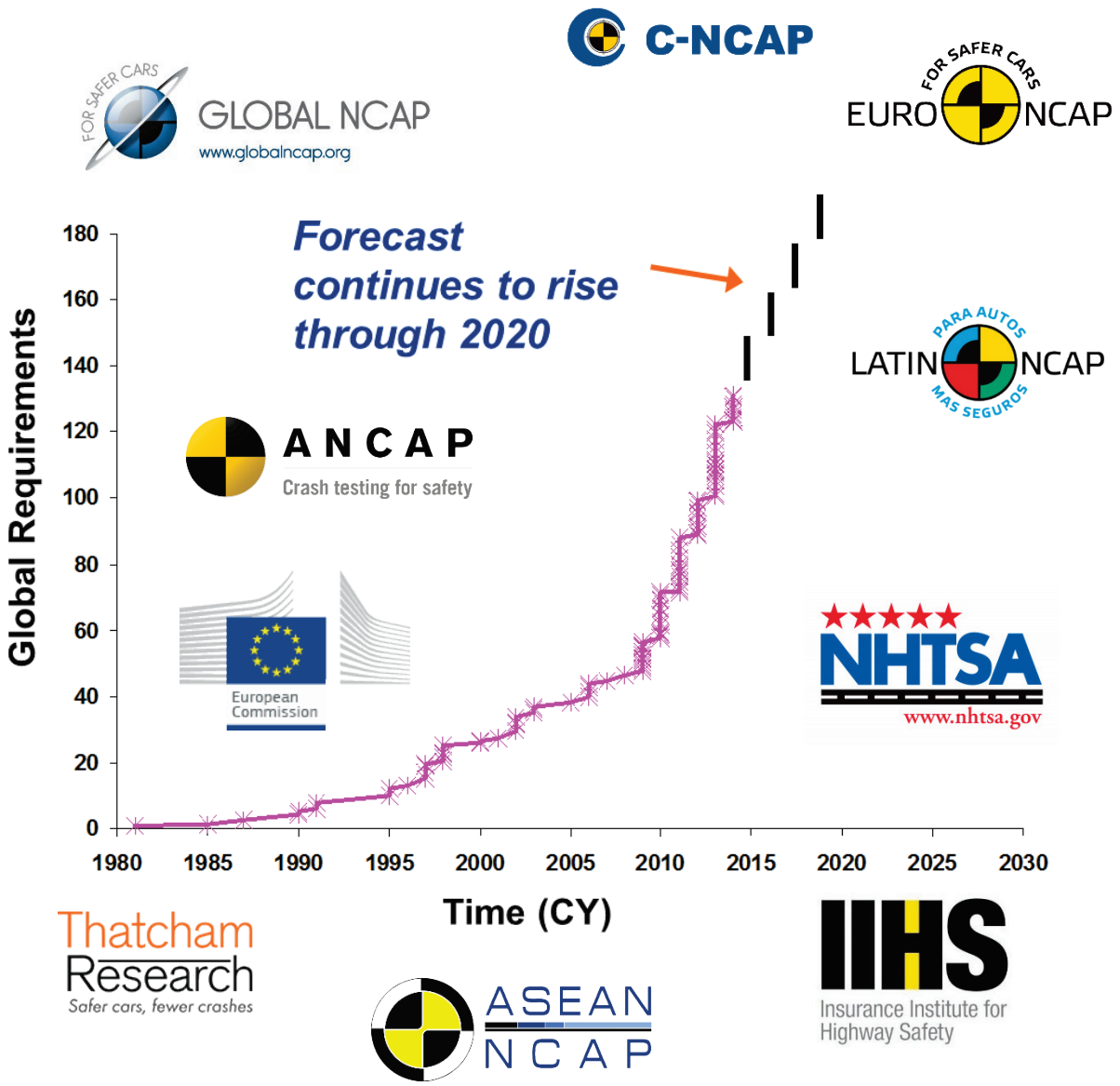


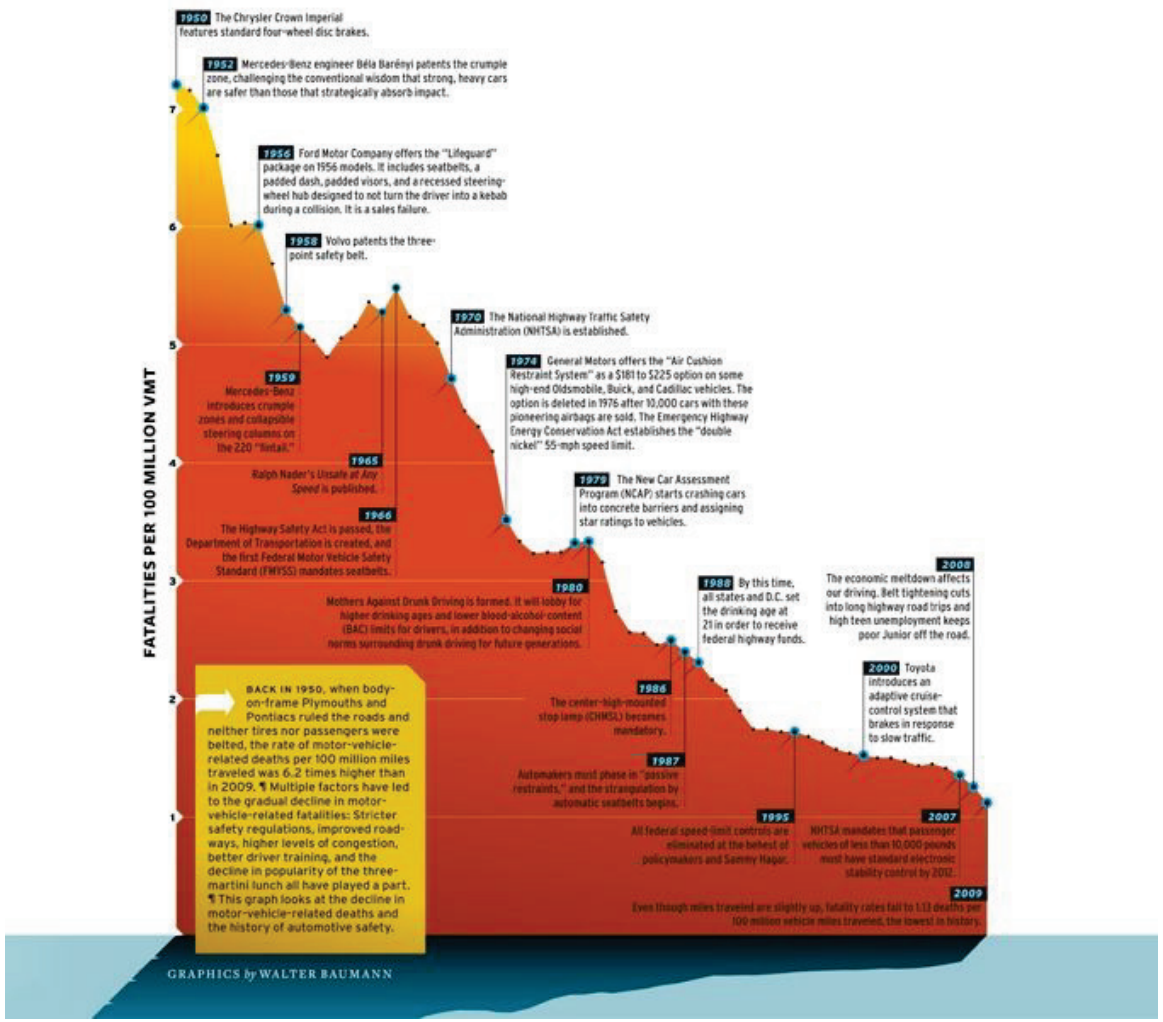


Lightweighting Impacts on Fuel Economy, Cost, and Component Losses; Aaron David Brooker, Jacob Ward, Lijuan Wang

Go Further

Regulation Changes





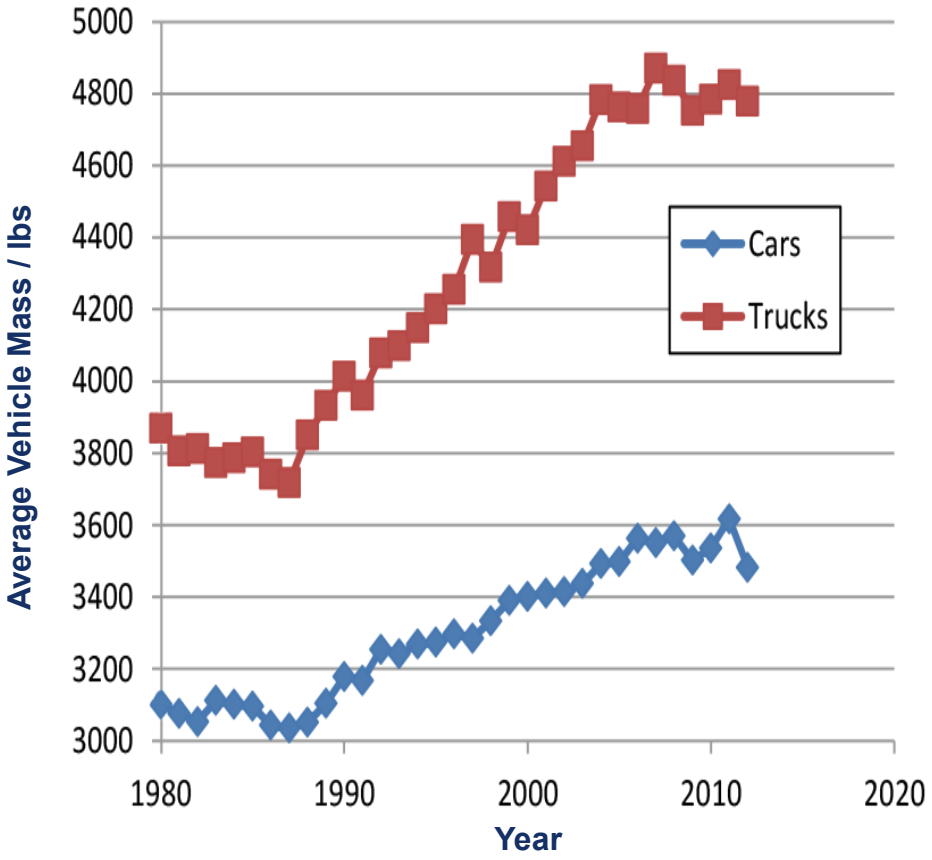
Ford
Go Further

Average Vehicle Mass 1980-2012 (NA)

Since 1998,
the average vehicle mass has **increased** by…

17 lbs /yr for cars

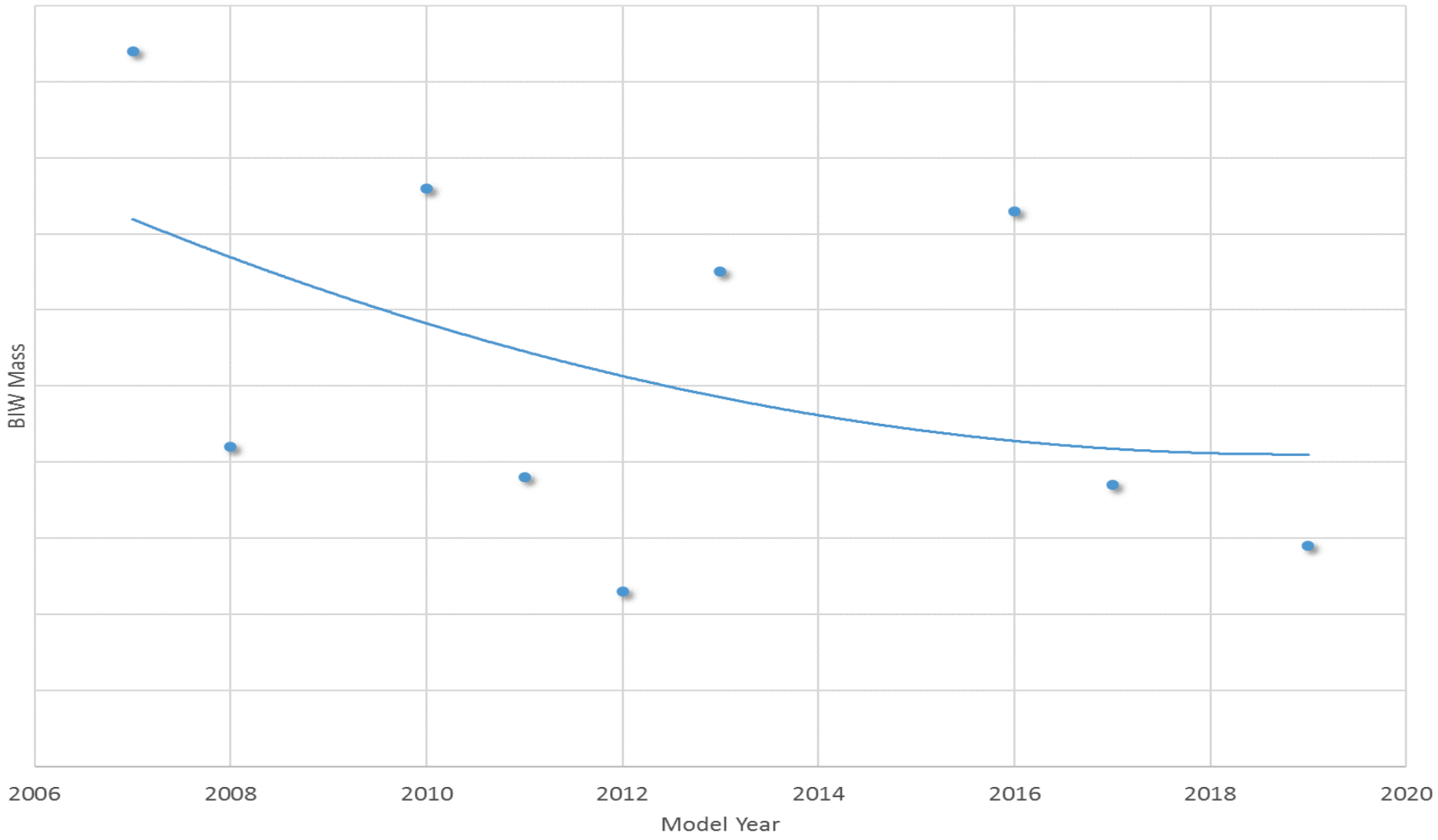
42 lbs /yr for trucks



Go Further

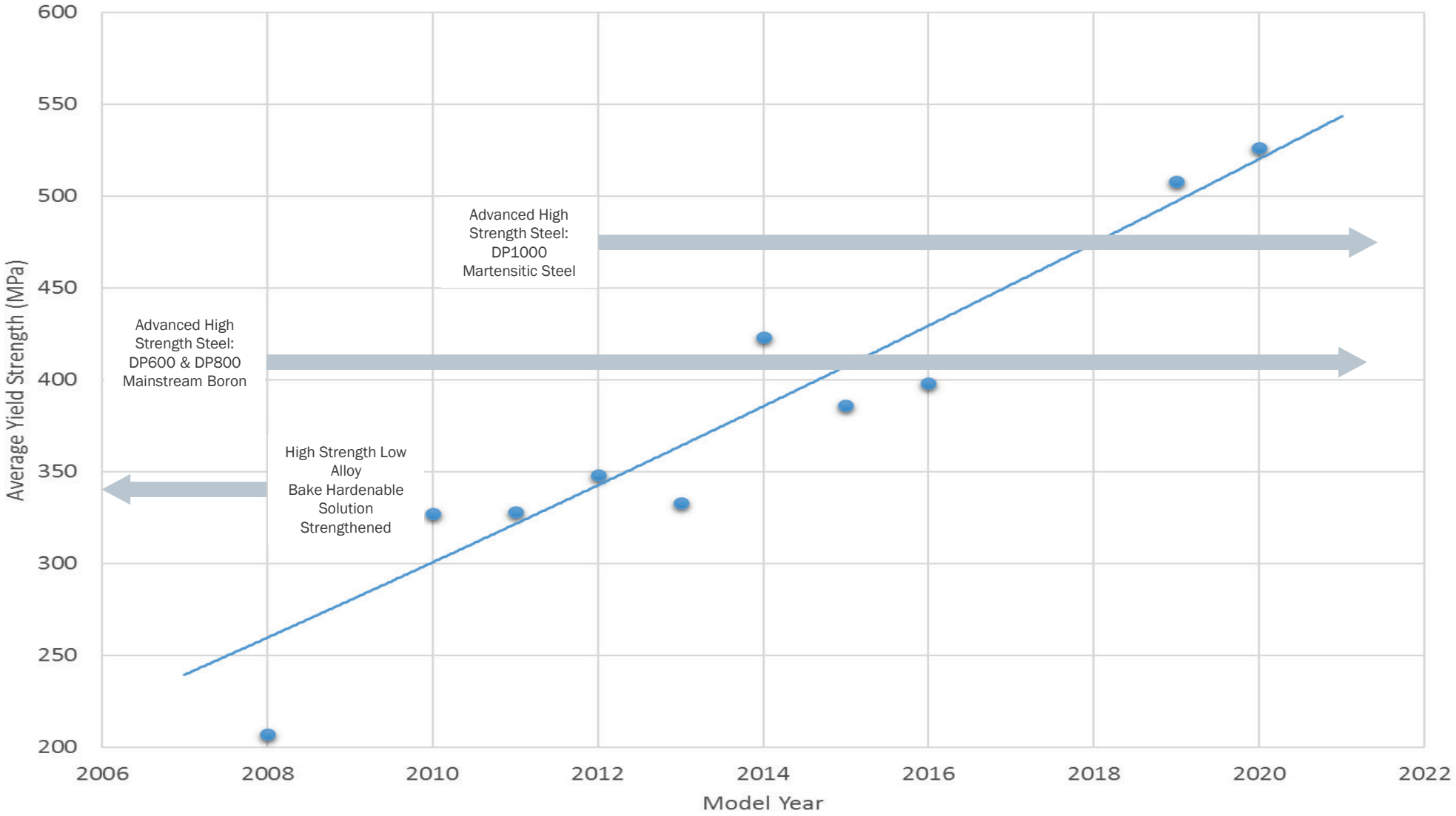
BIW Mass Trend

- 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



Go Further

Average Yield Strength



- 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

Go Further

Topology Optimization

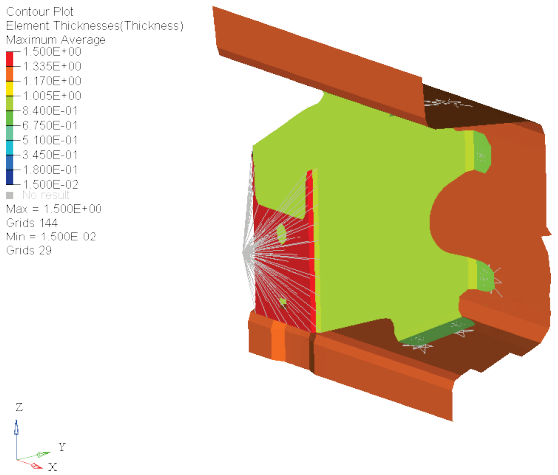
- Mass savings starts at the early in the design phase by insuring that the optimal load paths are defined
- Establishing the ideal load paths allow energy transfer through the structure with the minimum amount of material and material strength

Three application of Topology:

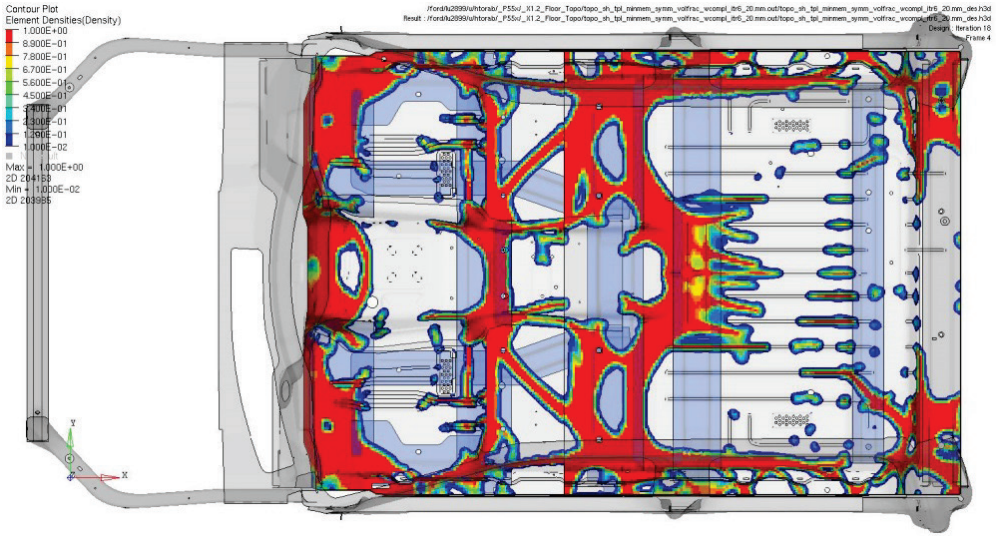
1. Full Vehicle – focus on defining the overall load path strategy based on vehicle level load conditions
2. System – develop geometry to address specific loads within a given system
3. Component – insure the geometry at the component level is optimized to the local events

Full Vehicle

Component Level



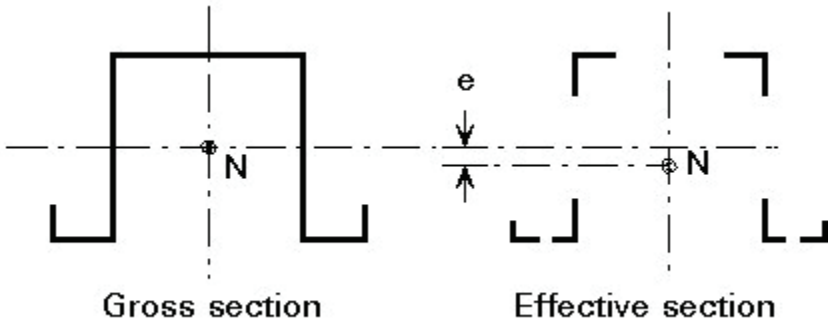
System Level



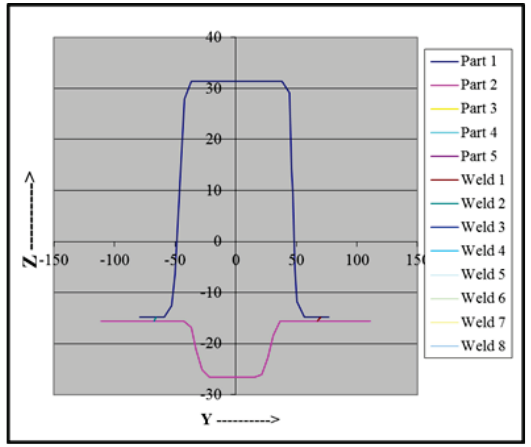
Go Further

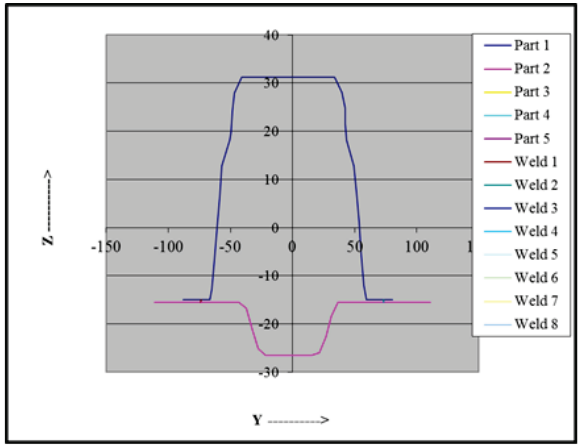
Section Design

- Engineers needs to insure 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





Section Name	Crush Load Capacities (kN)	Moment Capacities (kN-mm)	
	Fcrit	MmaxY-	Mmax Y+
Cross Member	78.8	2944	1350
Beaded Cross Member	84	3198	1739

Go Further

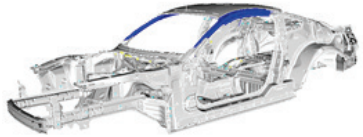
Forming Processes and Geometry

- 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

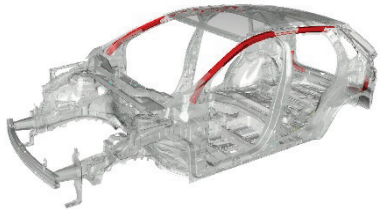
Hydro-Forming

F-Series: Front End and Body Side

Fusion: A-Pillar / Roof Rail & B-Pillar

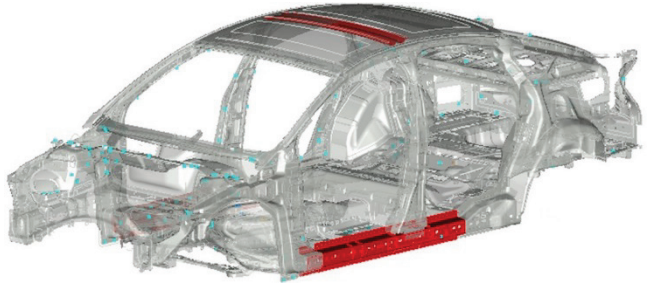


Mustang: A-Pillar / Roof Rail

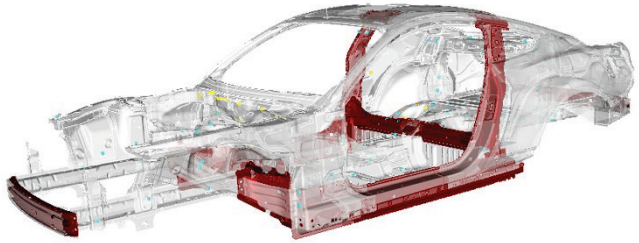


Edge: A-Pillar / Roof Rail & D-Pillar

Roll Forming

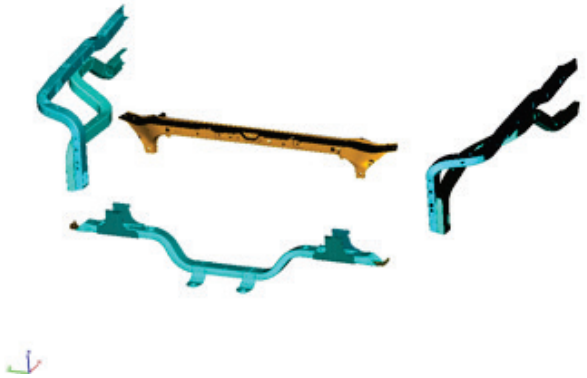


Hot Stamping



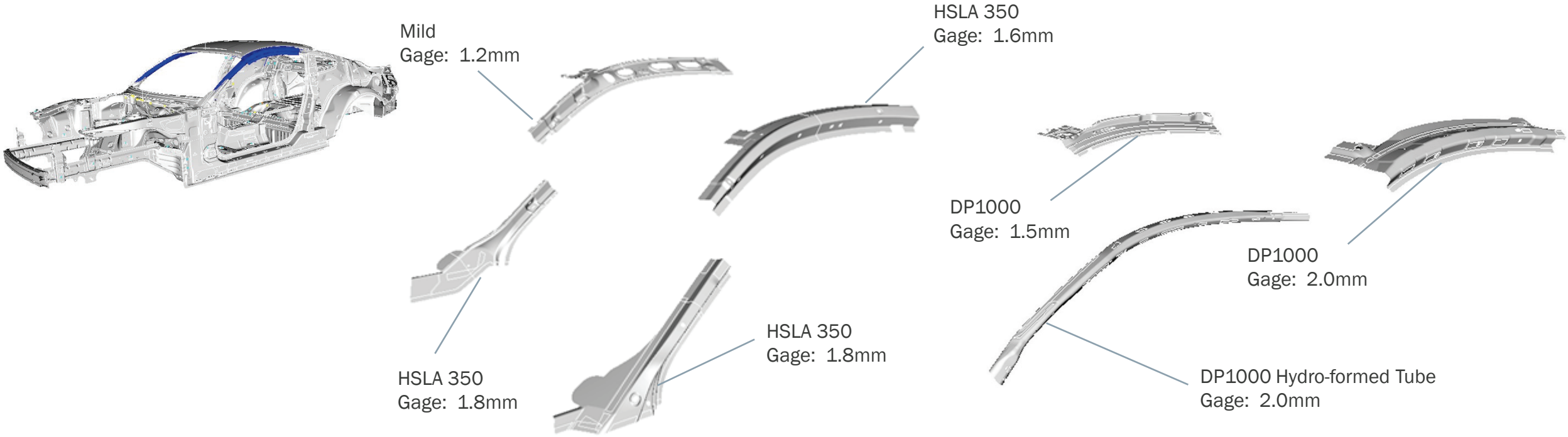
Go Further

Hydro-Forming Evolution

STAMPED STEEL	FIRST HYDROFORM STEEL	FIRST ALUMINUM HYDROFORM
		
31 PARTS	**18** PARTS | **20** BENDS | **-31%** WEIGHT	**12** PARTS | **6** BENDS | **-59%** WEIGHT
FRONT-END SUPER DUTY	FRONT-END SUPER DUTY/EXPEDITION	FRONT-END F-150

Go Further

A-Pillar / Roof Rail: Closed Section Design



2014 Mustang

2015 Mustang

Vehicle	Material	Mass Savings
F-150	DP800	6.1 kg
Fusion	DP1000	4.2 kg
Mustang	DP1000	3.9 kg
Continental	DP1000	4.5 kg
F-150	6000 Series	
Expedition	6000 Series	

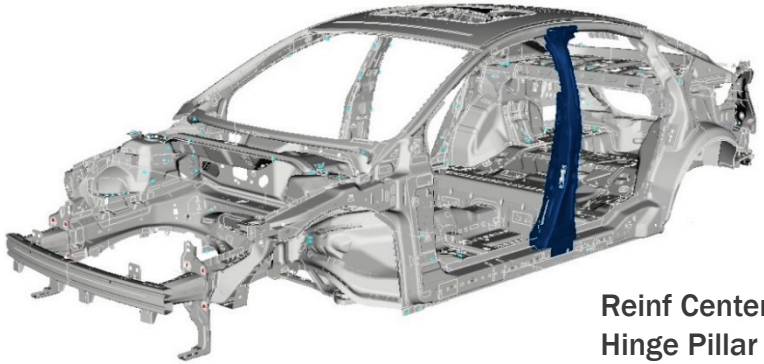
Replacement of complex stampings with a tubular structure enables:

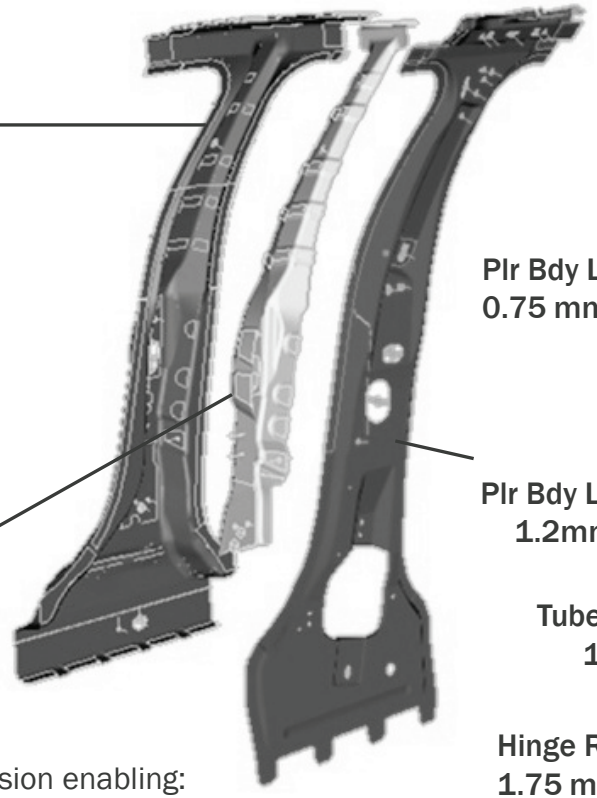
- The use of higher strength steel within a reduced package
- Increased vehicle performance
- Reduced package requirement

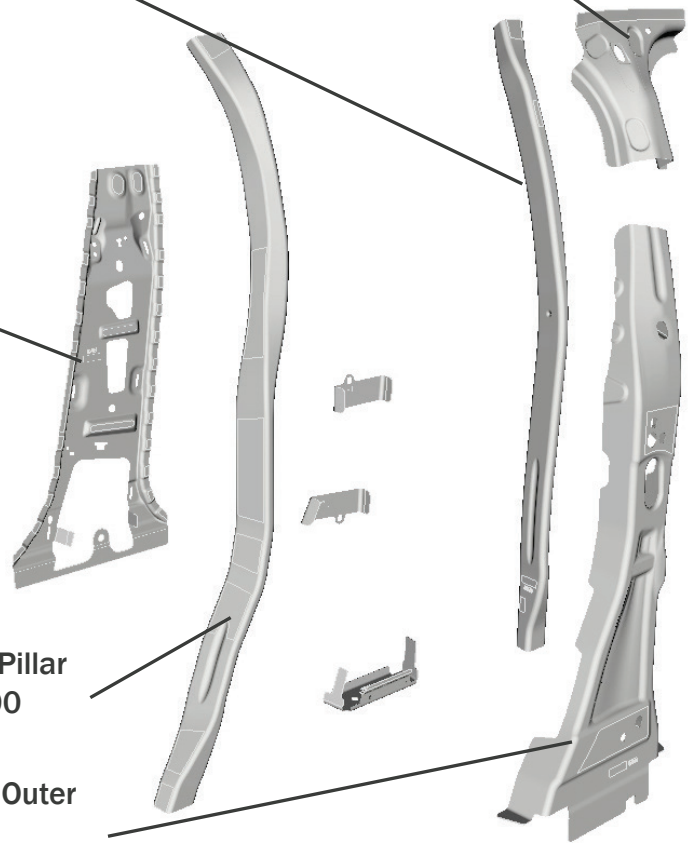
Concept initiated on F-150 and proliferated across vehicle lines

Go Further

B-Pillar: Closed Section Design





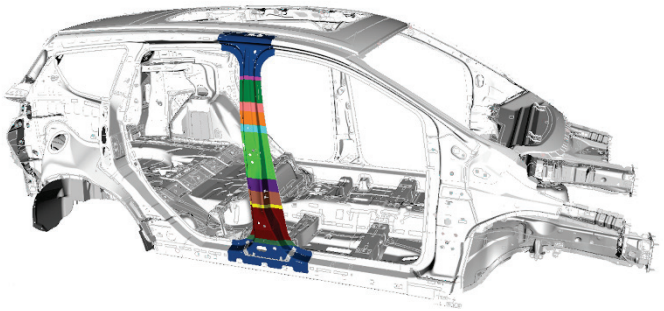


Closed section concept was extended to the B-Pillar for the Fusion enabling:

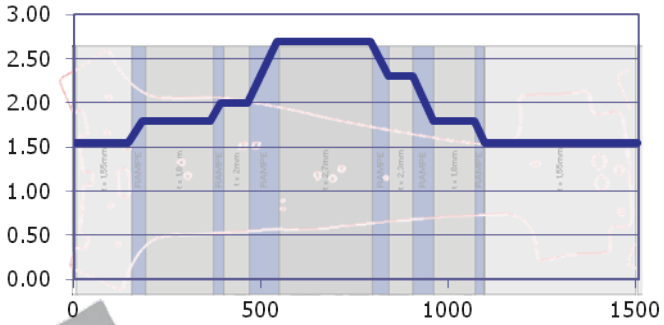
- Elimination of large press hardened parts
- Use of AHSS
- Reduced intrusion during side impact
- 6 kg mass reduction

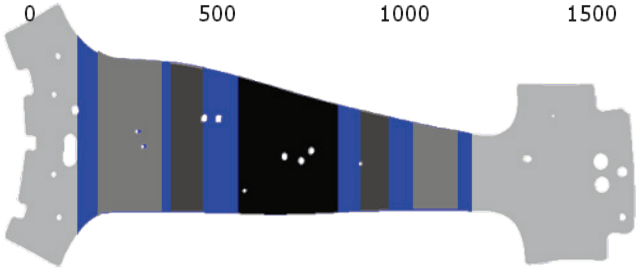
Go Further

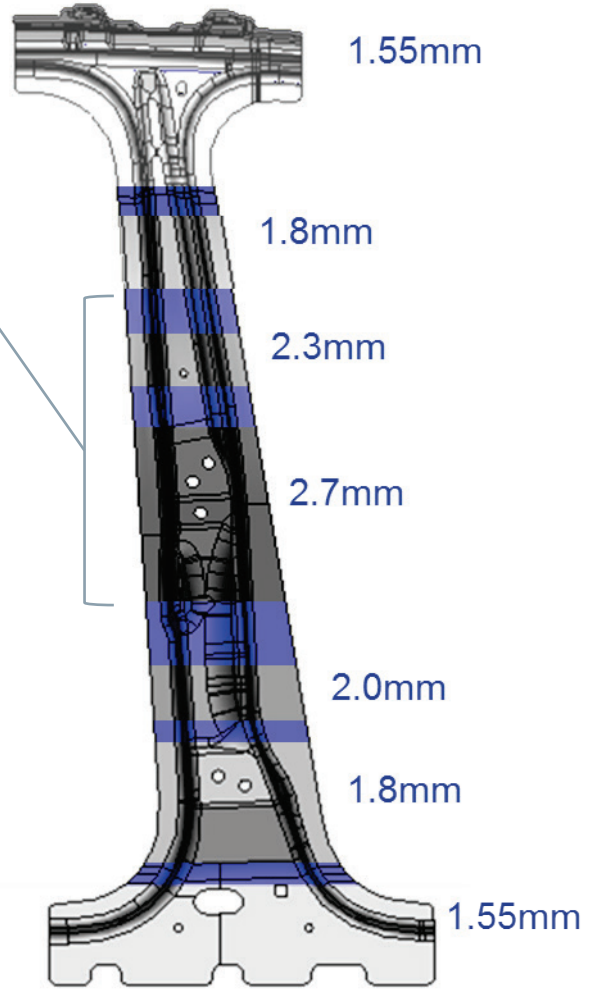
Tailored Material Thickness



Variation of gauge allowed for the elimination of the B-Pillar Reinforcement







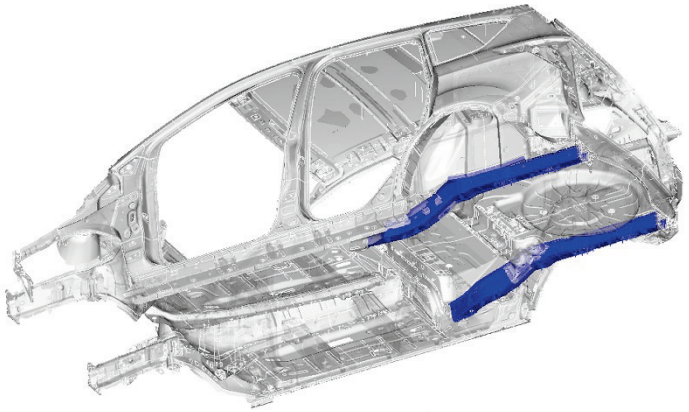
Press Hardened Steel Center Hinge Pillar Reinforcement used to provide the necessary performance for Roof Strength and Side Impact Events

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

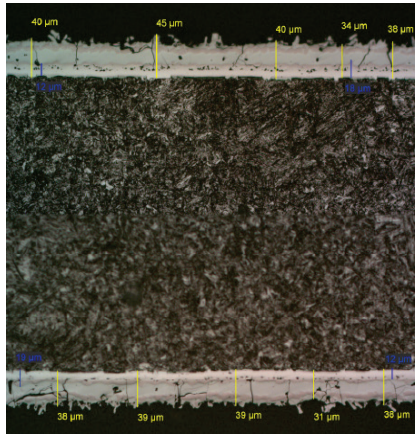
Mass savings of 1.2 kg achieved over the conventional approach

Go Further

Tailored Material Properties



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

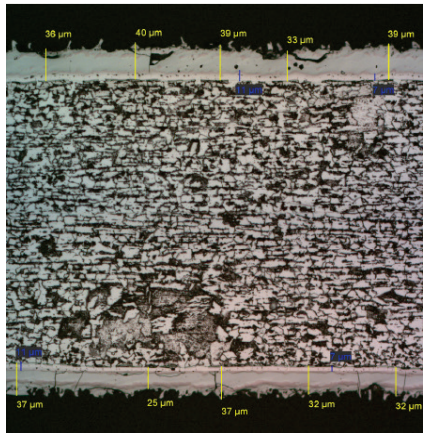


Hard area

Typical mechanical properties:
R_m = 1450 Mpa
R_e = 1100 Mpa
$\varepsilon_{(A5)}$ > 6%

Transition zone from soft to hard area

Typical mechanical properties:
R_m = 550 Mpa
R_e = 400 Mpa
$\varepsilon_{(A5)}$ > 20%

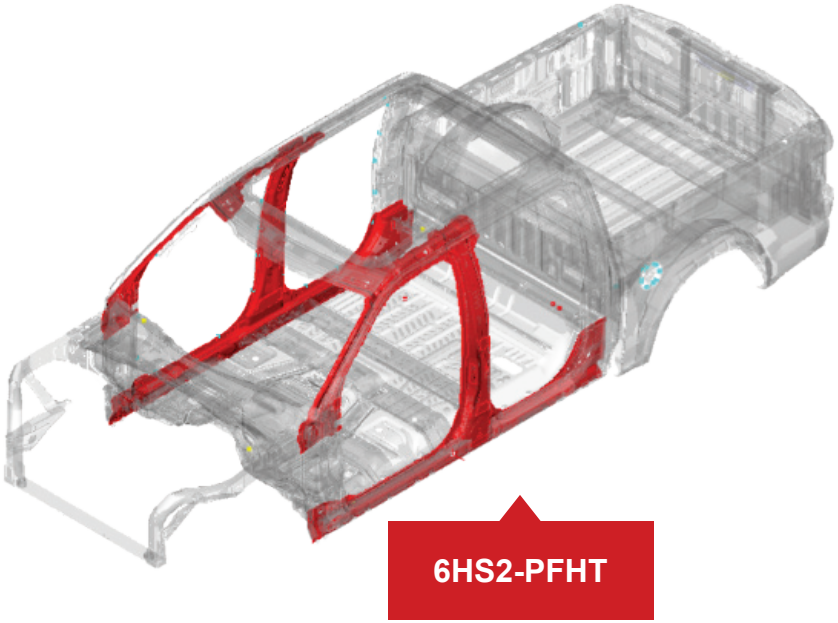


“Soft”

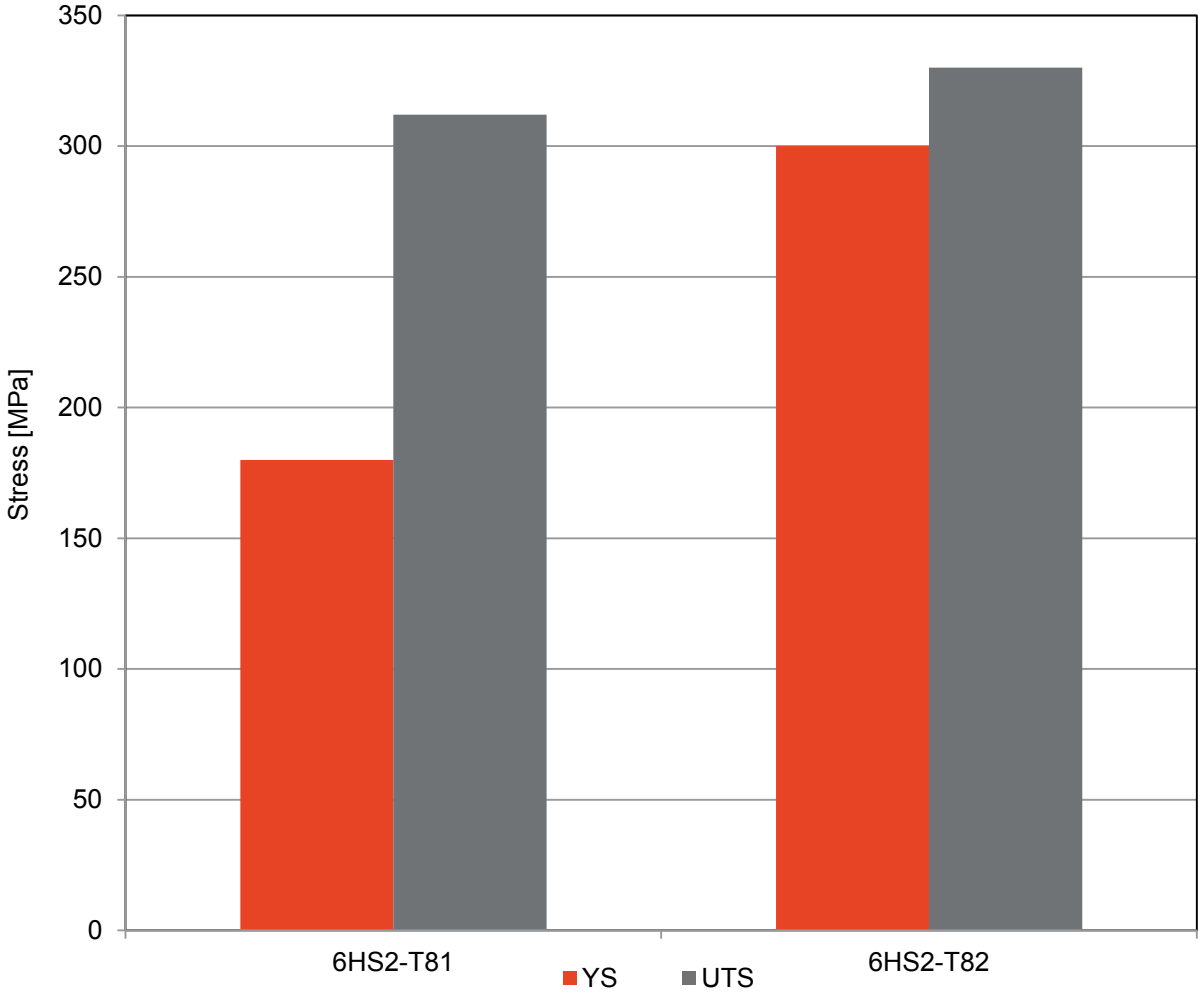
Go Further

Aluminum: Post Form Heat Treatment

- Ford developed a novel Post Form Heat Treatment (PFHT) cycle for 6XXX sheet alloy (Industry-first) that results in a:
  - 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



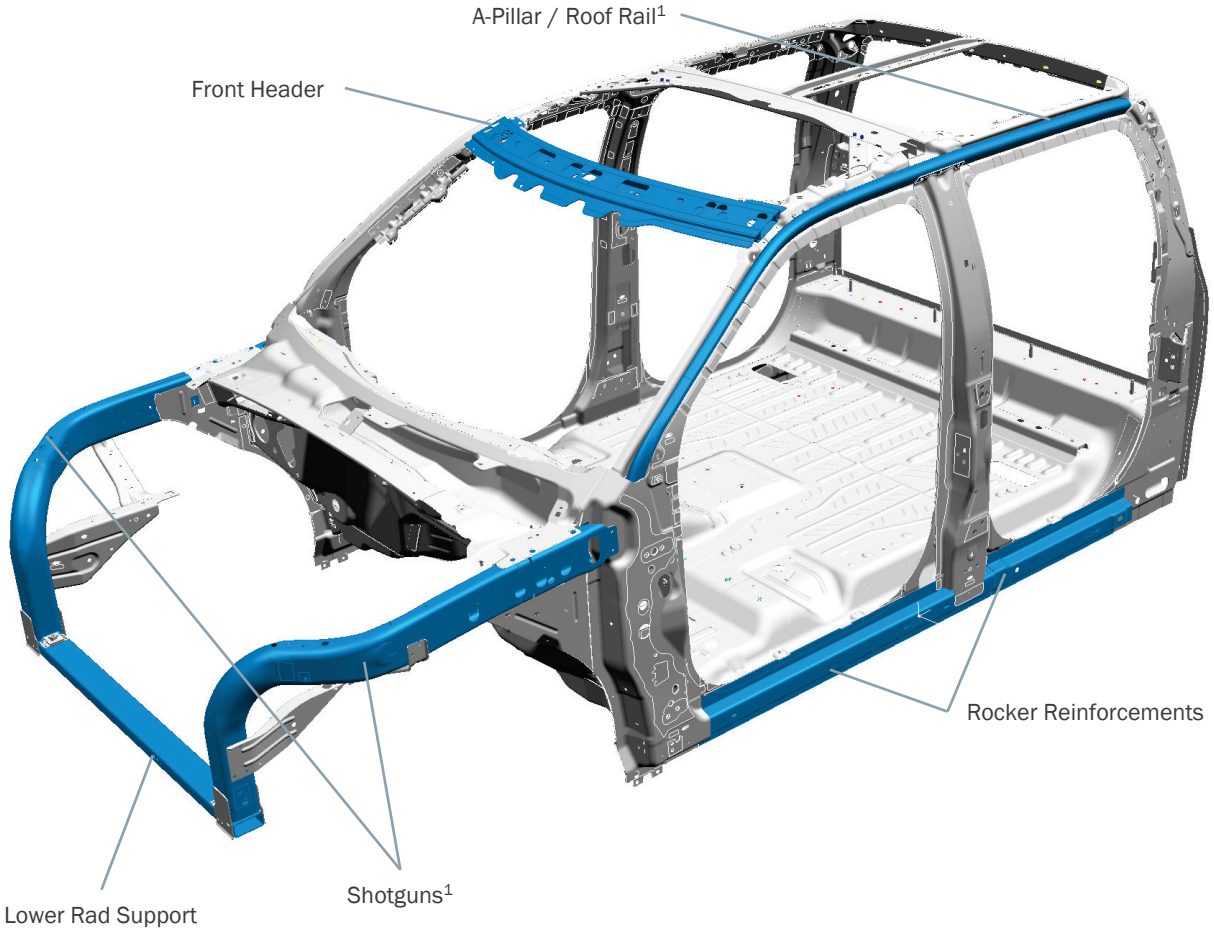
PFHT Process



Go Further

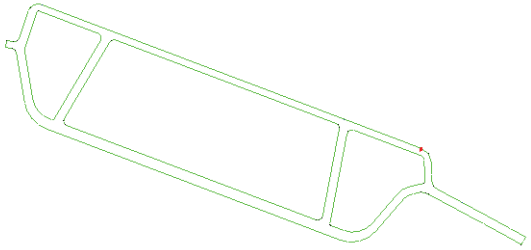
Extrusions

Extruded Applications on the F-150



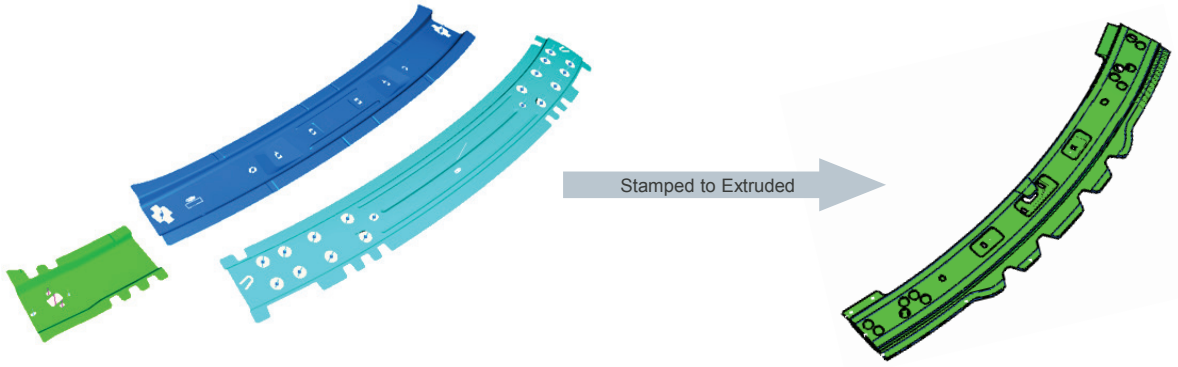
Advantages Afforded by Extrusions:

- 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



Front Header Section

Case Study: Front Header

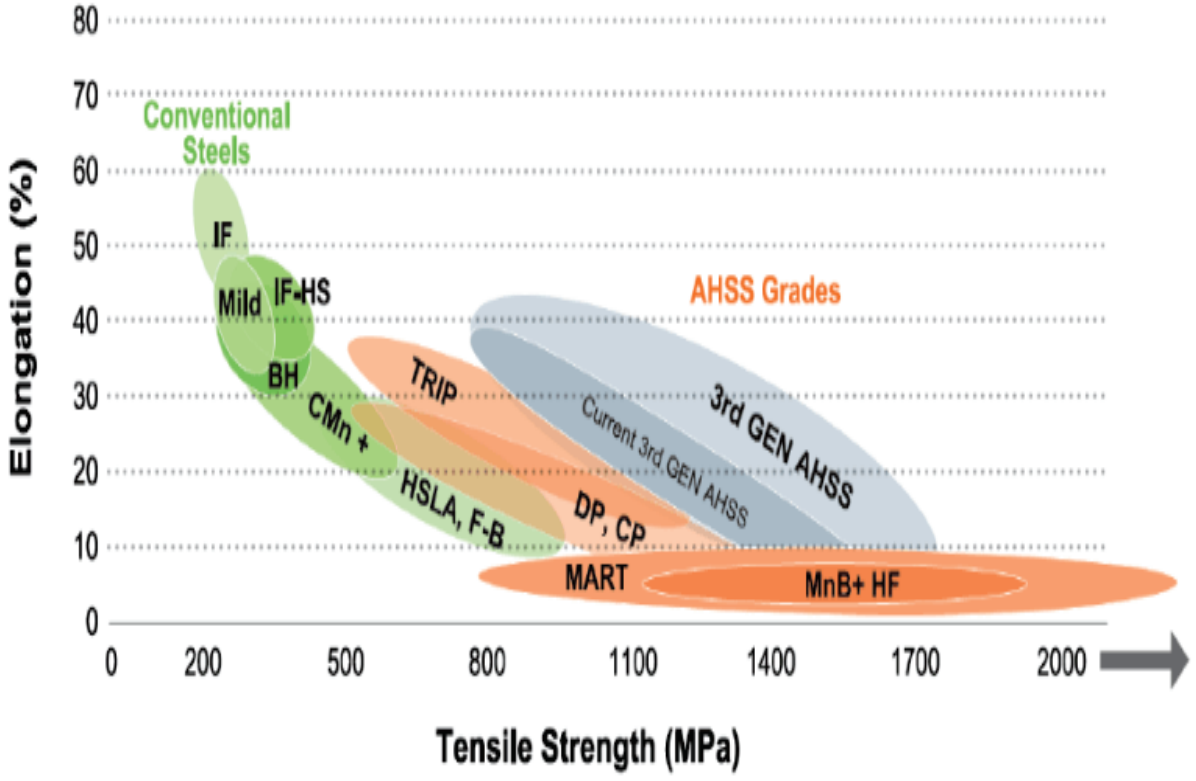


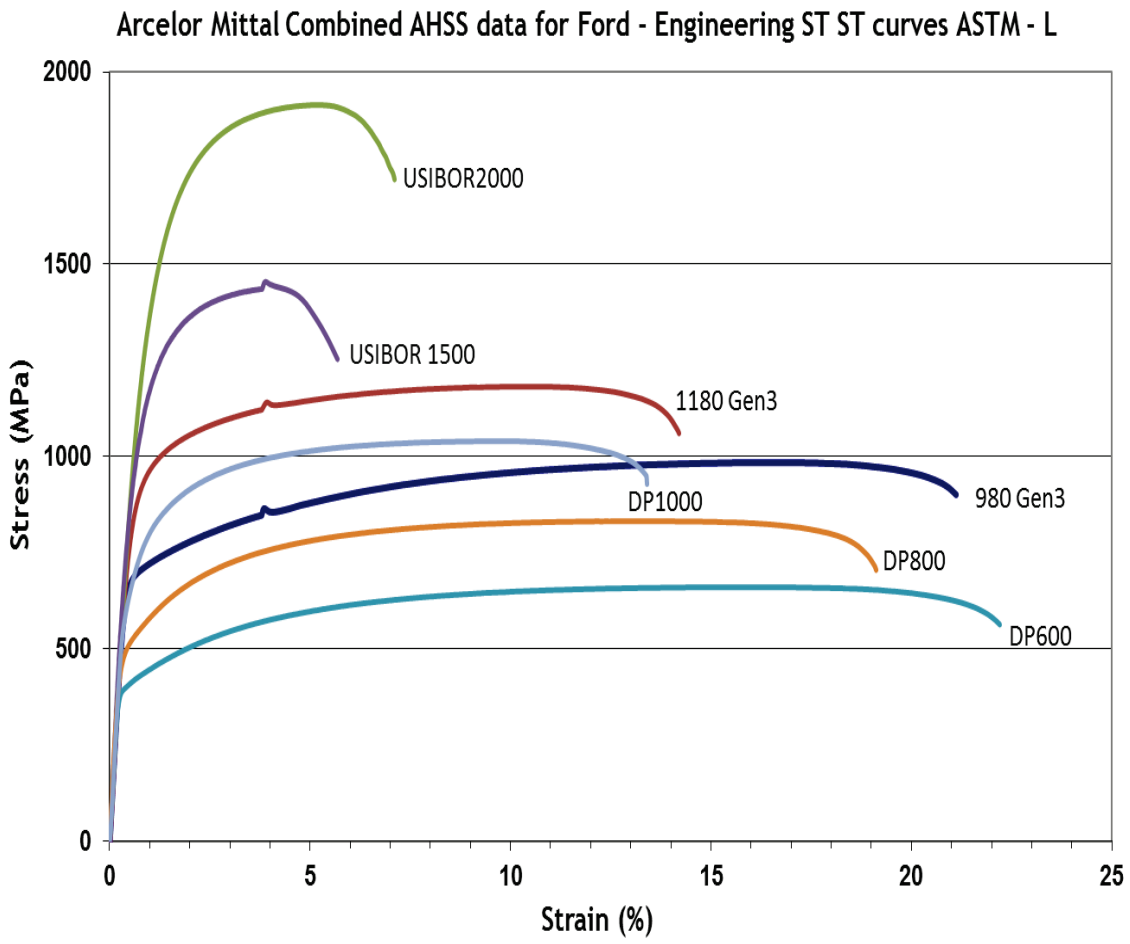
Part Reduction: 3 to 1
Mass Reduction: 2.9 kg

[1] Additional geometry changes achieved through bending and hydro-forming processes

Go Further

New Materials – 3RD Generation Advanced High Strength Steel





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

Go Further

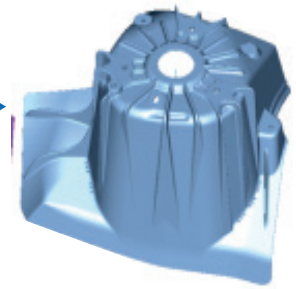
Structural Castings

An industry wide shift from stamped shock towers to cast aluminum components has begun.

Typical Steel Design

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

Die Cast Design

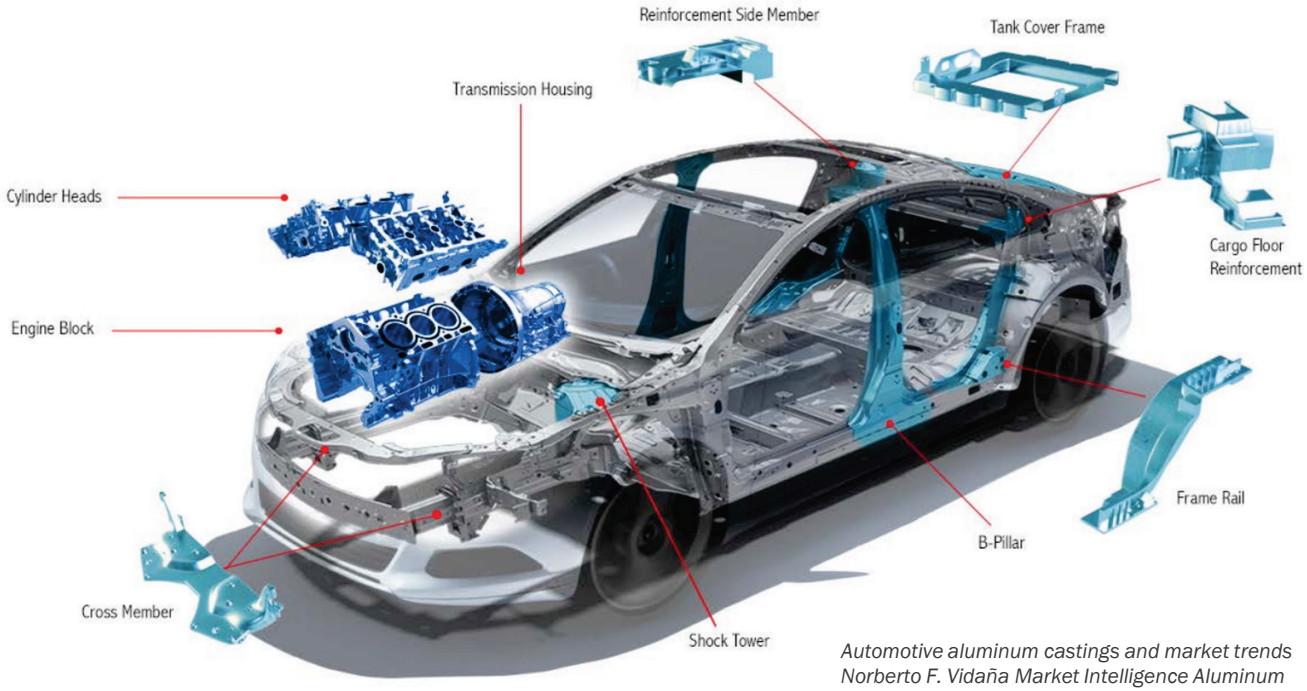


1 Casting

Expected benefits:

- Reduced component mass
- Increase local and vehicle level stiffness
- improved dimensional accuracy through part integration
- Efficient attachment integration – elimination of brackets.

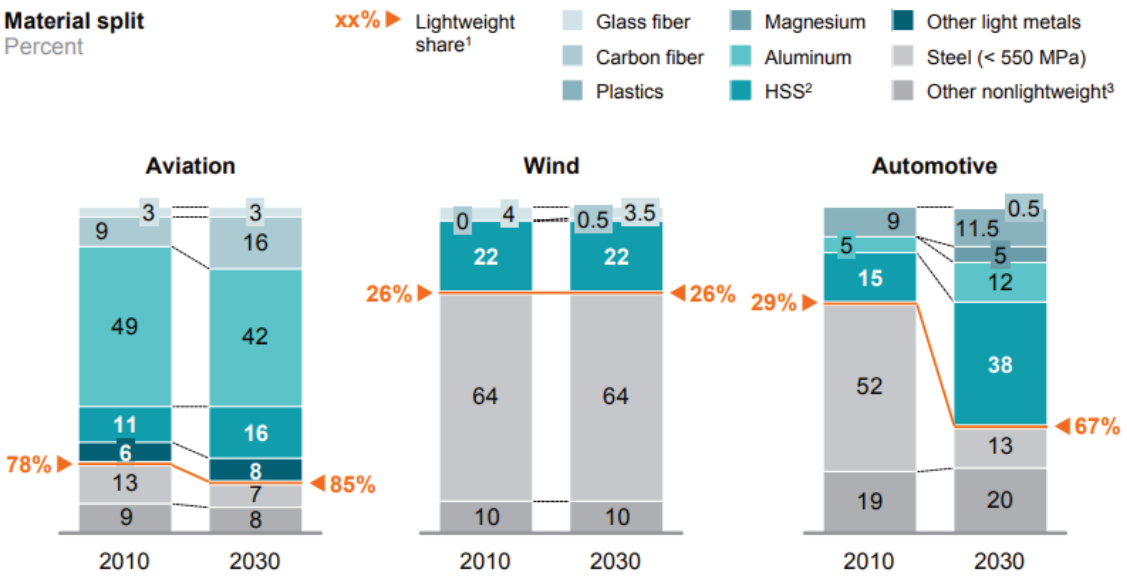
Going forward . . .



Automotive aluminum castings and market trends
Norberto F. Vidaña Market Intelligence Aluminum

Go Further

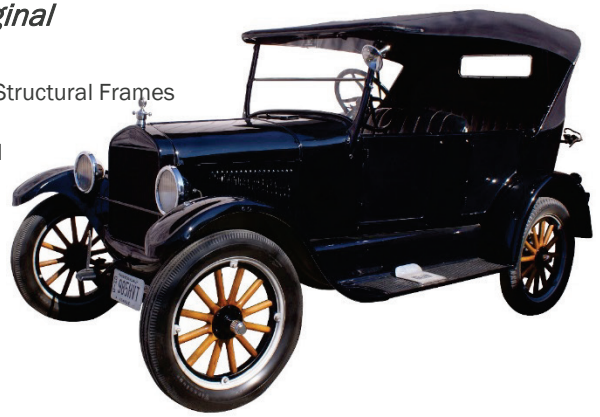
Mixed Material BIW



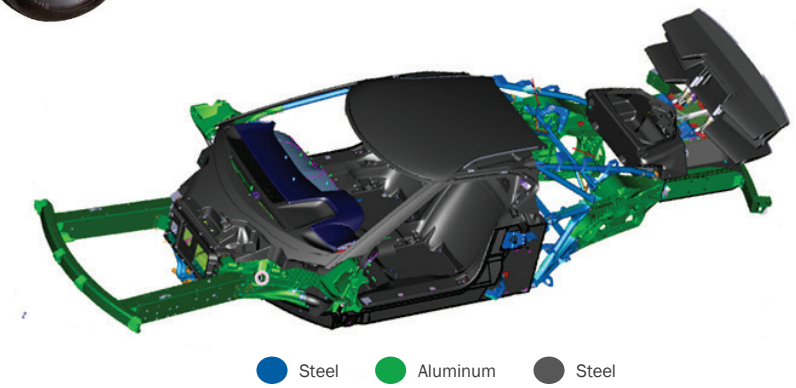
1 HSS, aluminum, magnesium, plastics (beyond current use), glass/carbon fiber
2 High-strength steel (> 550 MPa)
3 Mainly other metals, glass, fluids, interior parts for automotive, etc.

SOURCE: McKinsey

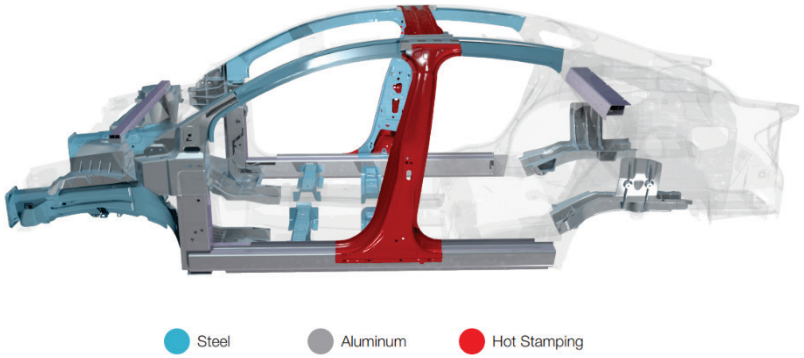
The Original



Now . . .



The Future . . .



Go Further


THANK YOU
Ford
Go Further