Geometry: The Key to Structural Optimization

Fuel Economy Detroit, 3/17/16

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NANOSTEEL

Outline

- Body structure optimization delivers economic fuel efficiency gains across platform design
- Geometry is a key design factor in delivering performance in every function of body structure
  1. Stiffness
  2. Deformation Resistance
  3. Energy Absorption
- Why the combination of strength and geometry wins
- Examples of high strength and formability in NanoSteel sheet

Optimizing Body Structure Has Value

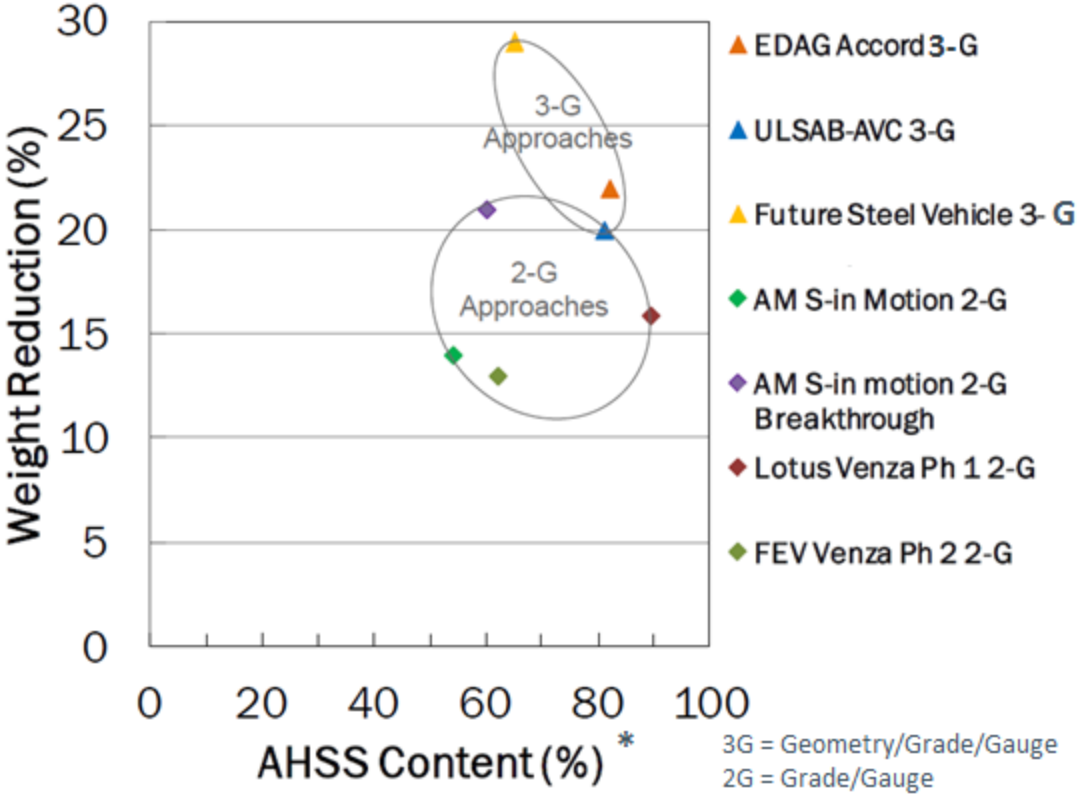
- Body structure optimization
  - Second only to exotic power train adoption for fuel efficiency gains
- Steel brings strongest value to automotive design for body structure optimization

Technology	% Improvement	Cost
EV	68.5	$5,390
PHEV	40.7	$14,517
Hybrid	14.9	$5,810
BIW WR (Aluminum)	11.4	$1,320
BIW WR (AHSS)	7.2	$100
Turbo/Downsize	7.0	$600
Adv. Diesel	5.5	$1,040
Cyl. Deact.	4.7	$244
Var. Valve Timing	3.0	$60
8-Spd DC Trans.	3.9	$304
Cool EGR	3.6	$360

*Citation *1: ArcelorMittal*

Geometry Drives Body Structure Results

- If you consider grade and gauge only, results are not optimized
- Ignoring geometry can overstate or understate the mass reduction potential of the body structure



*Citation *1: ArcelorMittal*

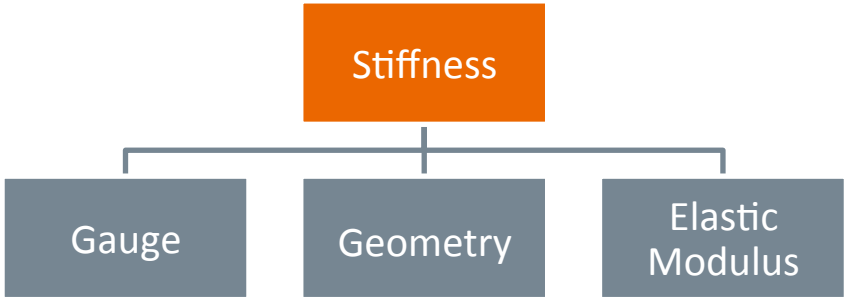
Structure Has Multiple Roles

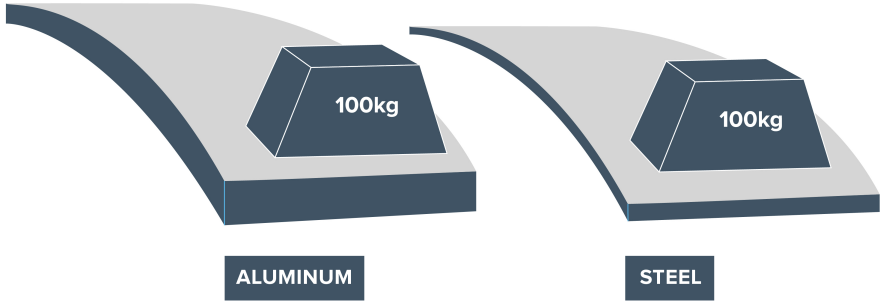
1. Stiffness
(Ride Quality)

2. Deformation Resistance (Strength)

3. Absorb Energy (Crash)

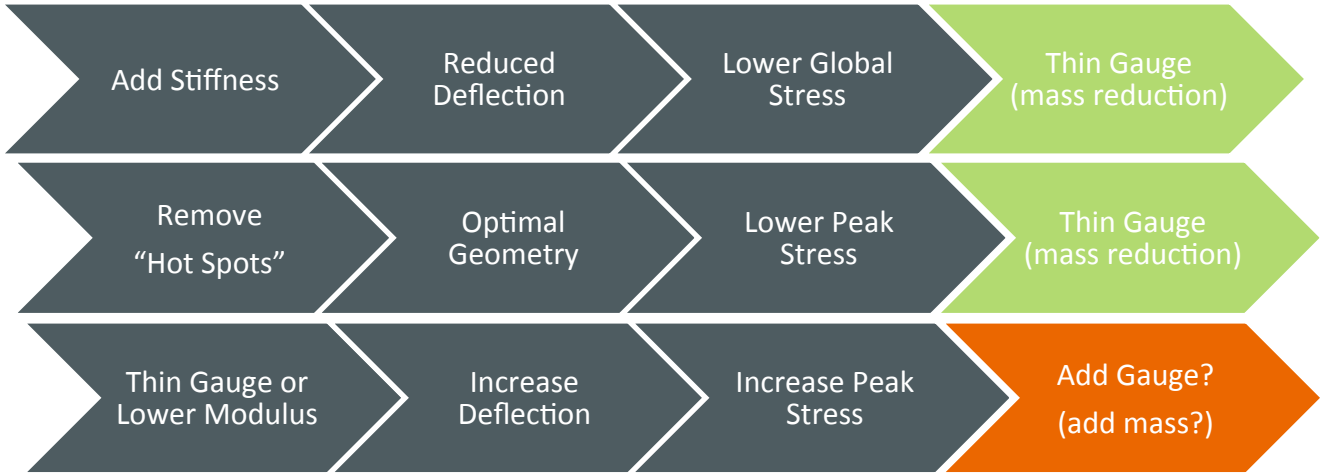
1. Stiffness is Determined by Part Geometry Not Material





Properties	NanoSteel	Aluminum	Titanium	Magnesium
Elastic Modulus (GPa)	204	72	114	41
Density (g/cm^3)	7.78	2.81	4.43	1.82
Specific Modulus ($GPa^* cm^3/g$)	26	26	26	25

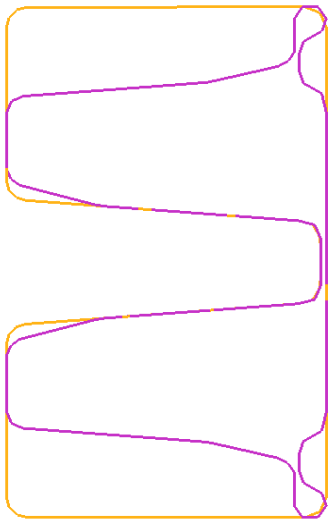
2. Deformation Resistance = Geometry Plus Yield Strength



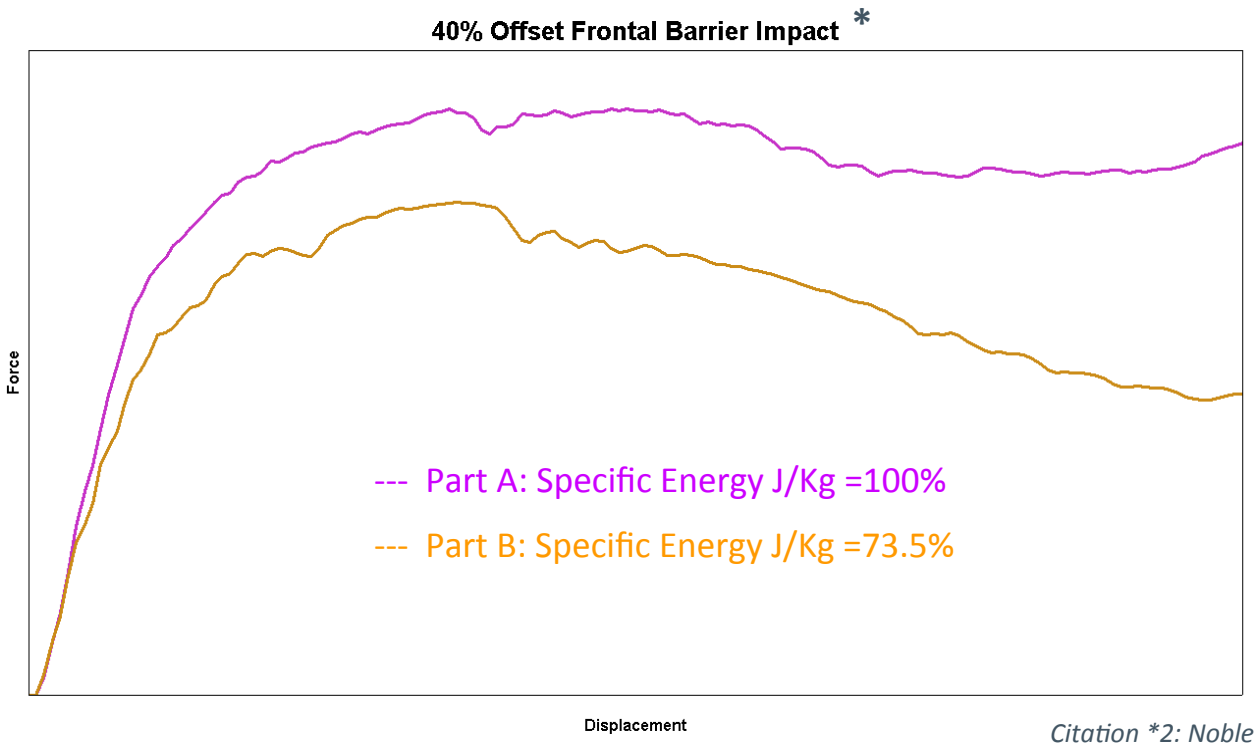
Properties	NanoSteel	Aluminum	Titanium	Magnesium
Yield Strength (MPa)	400-1200	435	114	41
Elongation (%)	55-28	13	14	10

3. Energy Absorption is Primarily Dependent On Geometry

High Elastic Capacity → Absorb During Crush → Even Absorption → Thin Gauge (mass reduction)



Cross section of the bumper

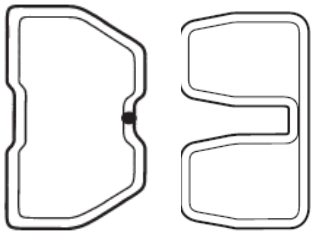


*Citation *2: Noble Industries*

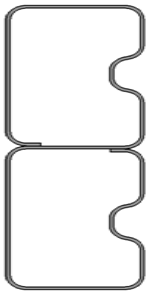
Properties	NanoSteel	Aluminum	Titanium	Magnesium
Ultimate Strength (MPa)	1180-1700	505	980	245
Elongation (%)	55-28	13	14	10

What Can Geometry + Strength Achieve?

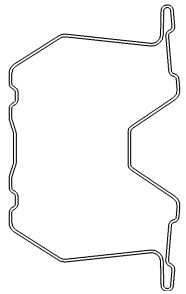
M190/120XF
weight savings: 25 -30%
Typical Roll Formed Section



Shape Corp. Monoleg M190 *
weight savings: 5 -10%
Typical Roll Formed Section
(7003 Alum. Parity)

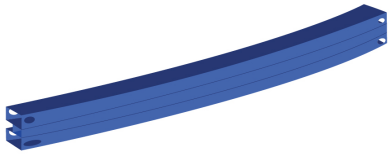


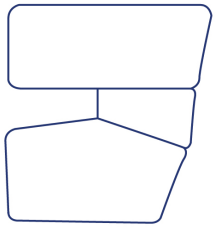
Usibor
weight savings: 30%
Best in Class
A-tech Variable Section

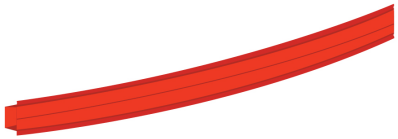


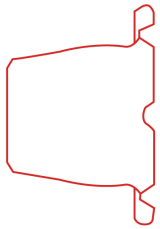
*Citation *3: SMDI and Shape Corp.*

Aluminum + Steel Bumper Comparison: Geometry Plus Strength Wins









Aluminum Rear Bumper

Material = Al 7000 series
Thickness = 2.5~6.0mm
System mass = 8.80kg

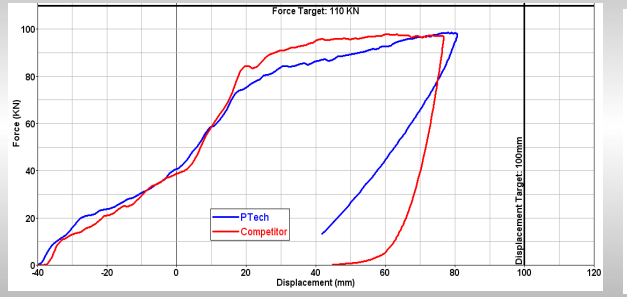
Steel can achieve 29% weight reduction in comparison to aluminum with identical performance

P-Tech® Rear Bumper

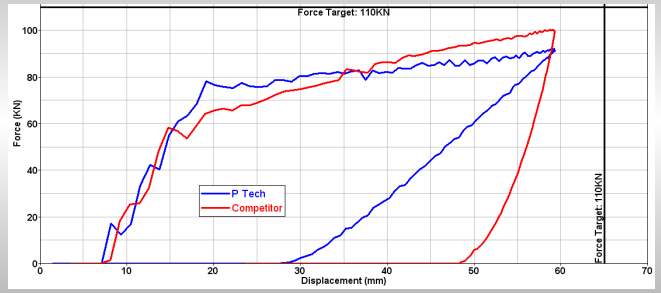
Material = Usibor1500
Thickness = 1.4mm
System mass = 6.24kg

*Citation *2: Noble Industries*

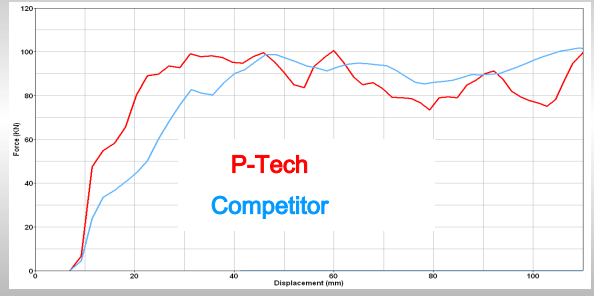
IIHS C/L Curved Barrier Impact



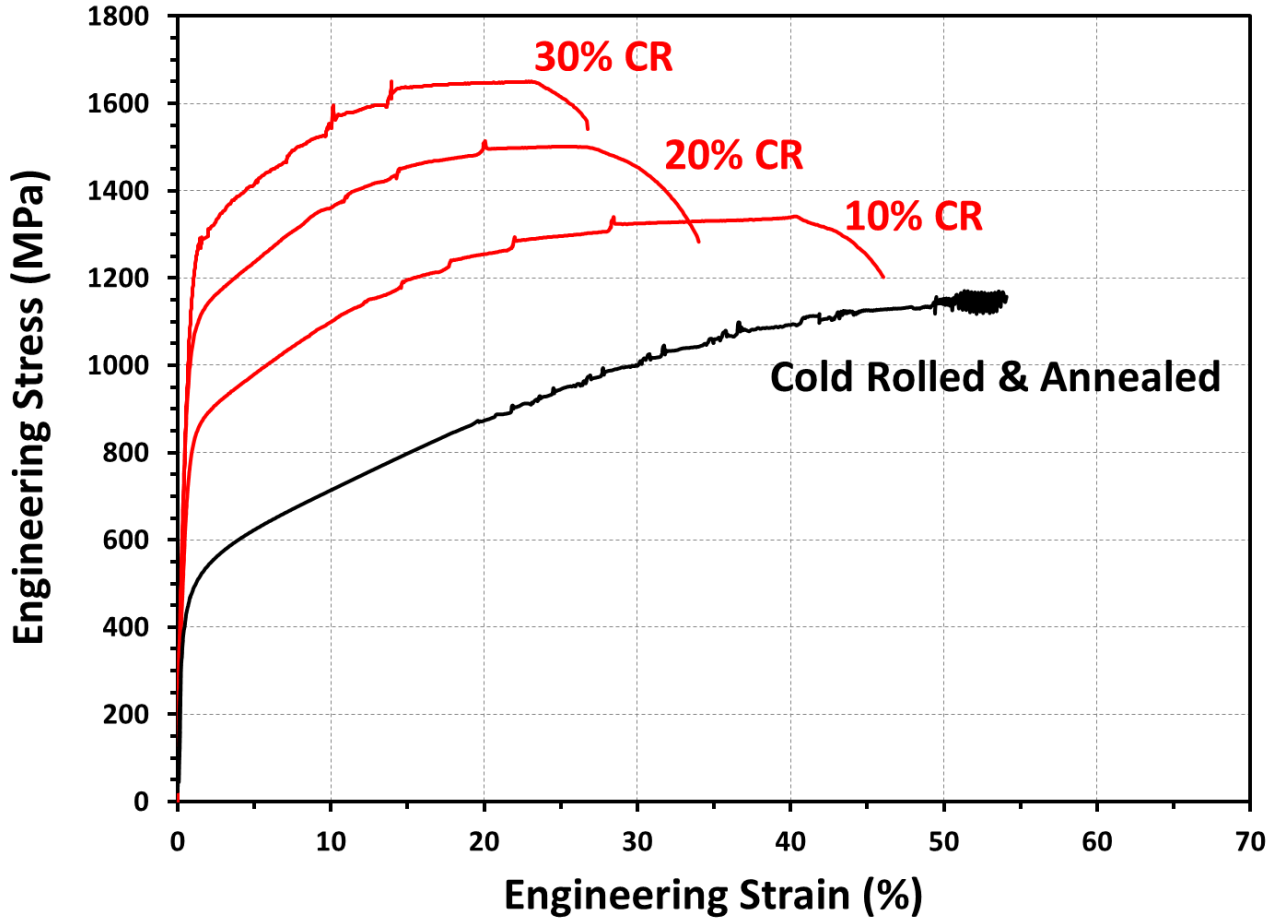
CMVSS 215 Flat Barrier Impact



AZT Danner 0^0 & AZT Danner 10^0



NanoSteel First Alloy Properties

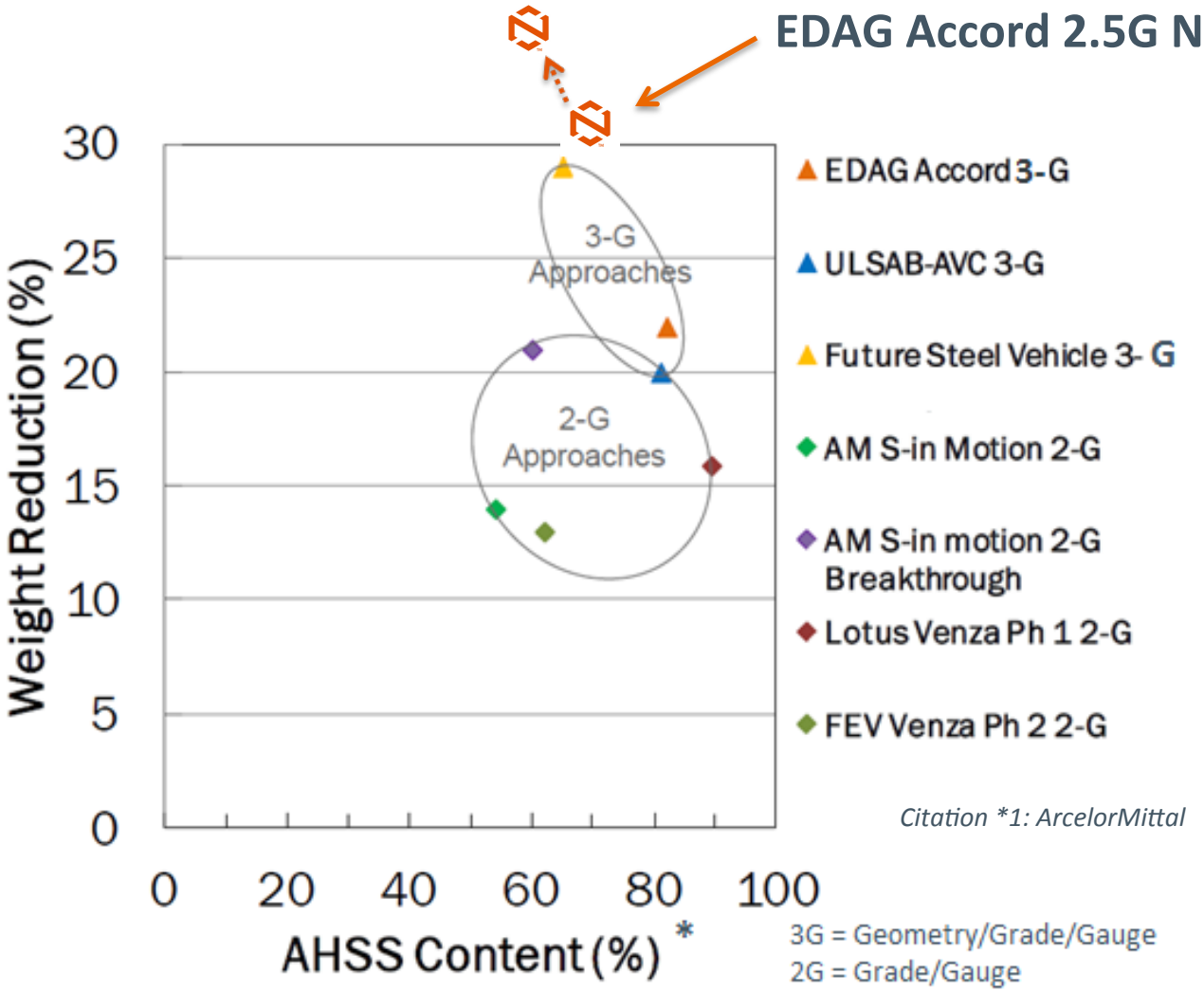


Geometry Freedom with Ultra High Strength is Achievable without Hot Stamping

NanoSteel = Cold Formability + Ultra High Strength

Bendability and biaxial strain substantially beyond current 3rd generation Advanced High Strength Steels

Geometric Freedom Drives Results



Conclusion

- Use of AHSS is the most cost effective way to increase fuel efficiency
- Geometry is the key design factor in every role of body structure
  1. Stiffness
     - Is material independent
  2. Deformation Resistance
     - Thin structures require complex geometries to distribute load
  3. Energy Absorption
     - Geometry dictates performance in both elastic and plastic regions
- Its not just about price, complex geometry with the strength of AHSS is a clear choice for body structure

Citations

- *Citation 1* ArcelorMittal 'On the Role of Body-in-White Weight Reduction in the Attainment of the 2012-2025 US EPA/NHTSA Fuel Economy Mandate, GDIS Presentation, Dr. Blake Zuidema, May 2013*
- *Citation 2* Noble Industries, Ltd. 'Highly Engineered Structural Solutions for the 21st Century Autobody' GDIS Presentation, Steven Jansen, (Vikstrom,T; McKune,P; Palanisamy, K; Kozak, R; Contributors) 2008, Noble Industries, Ltd. 'The P-tech Process and Applications' General Sales Presentation, Noble Advanced Technologies, (FEA Analysis Contributor, Introtech Inc., Himat Taank) 2008*
- *Citation 3* SMDI 'Steel Bumper Systems for Passenger Vehicles and Light Trucks, Fifth Edition, May 2013, and Shape Corp, 'Next Generation of Roll Formed Bumper Beams,' GDIS, T. Johnson, J. Matecki, B. Oxley 2013*

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