
Mateo St
STOP
2021 Mustang Mach-E

Agenda

1. Product Highlights
2. Structural Development

PRODUCT HIGHLIGHTS

Go Further

The History of the Mach

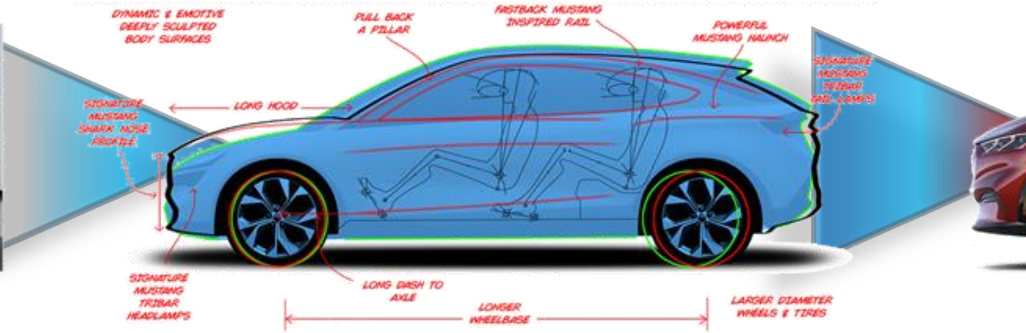
Mach is the definition of speed, a word uttered in the same breath as fighter jets. This word inspired Ford to deliver a performance car that looked like it could break the sound barrier and upped the pony car ante. What they got was the Mustang Mach 1, born in the rebellious ’60s, a time when Mustang was already an icon, but needed a boost for a younger crowd, hungry to tame the open road. More than 50 years after the Mustang turned the industry on its head, a new horse joins the stable sharing the iconic Mach name – and rightfully so.

Mustang Inside and Out

The Mach-E is instantly recognizable as a Mustang thanks to signature elements such as its long powerful hood, rear haunch design, aggressive headlights, and the trademark tri-bar tail lamps. Clever design and engineering delivers surprising rear seat roominess and ample cargo space.

Design Evolution: From Mundane to Mustang

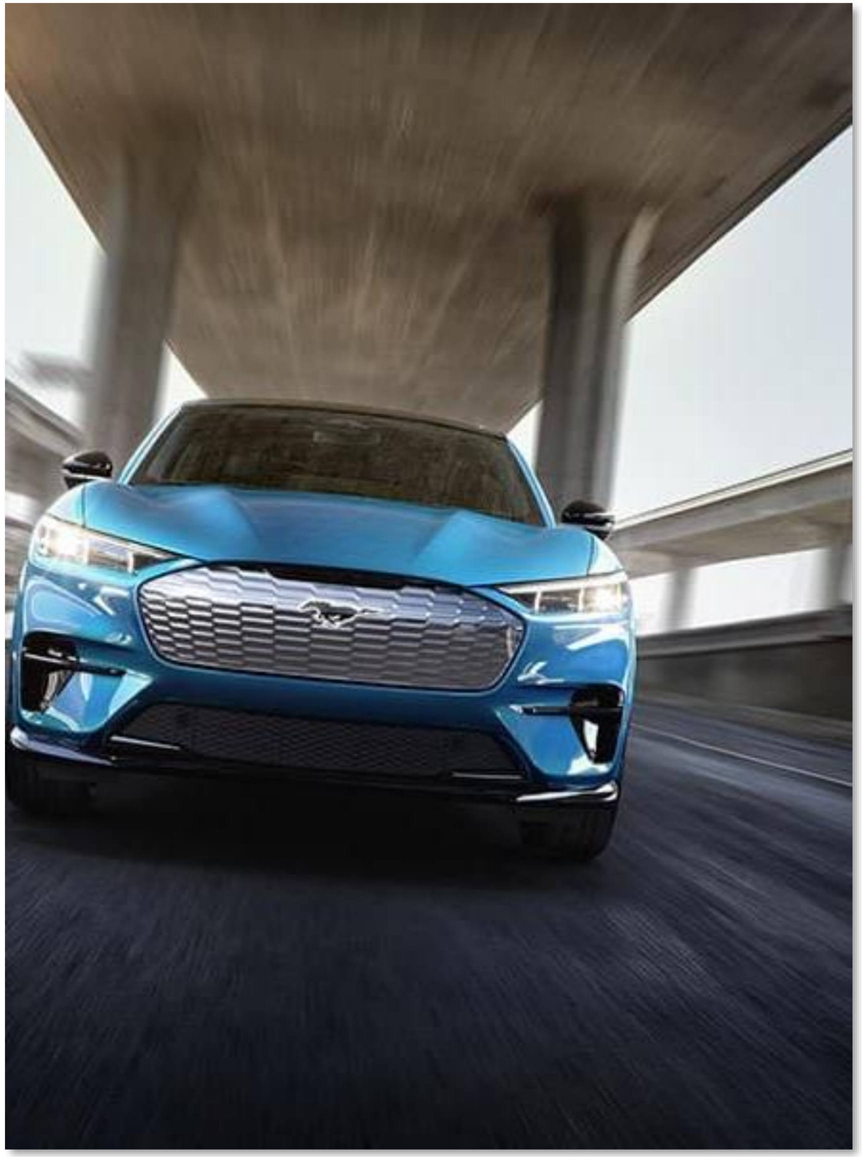
Original BEV Concept



Mustang Mach E

Essential Design Cues Balance Technology with Mustang Heritage

Go Further



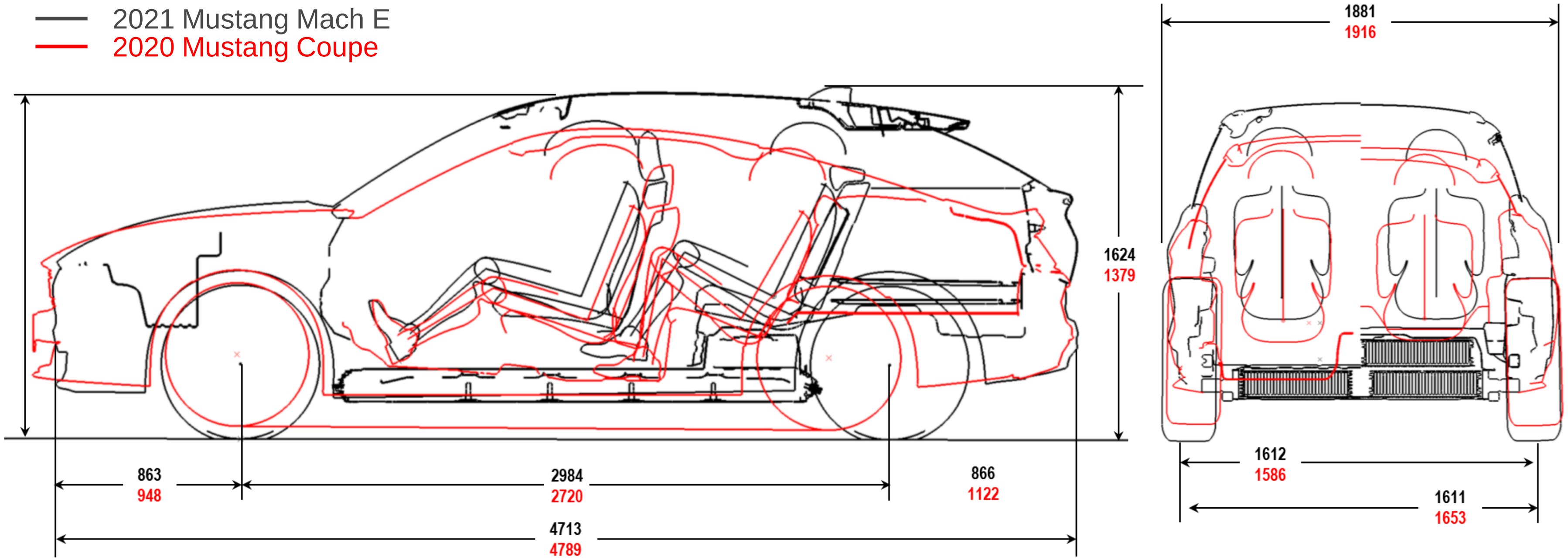
Exhilarating Performance

With the first all-electric member of the Mustang family, Ford harnessed the power of electrification to craft a vehicle that's as exciting to drive as its predecessors while also delivering a new, uniquely tailored experience. There will also be a Mach-E GT targeting 0 to 60 mph in less than 4 seconds, as well and an estimated 342 kW (450 horse power) and 803 Nm (612 ft lbs) of torque.

Unique Drive Experience

Mustang Mach-E delivers three drive experiences – Whisper, Engaged, and Unbridled – each offering a finely tuned driving dynamics package with a unique sensory experience. Features include custom designed vehicle responsiveness with distinctive steering controls, ambient lighting, sounds tuned for an authentic all electric experience, and dynamic cluster animations that are tied to driving behavior. A new all wheel drive system (eAWD) can apply torque independently to the front and rear axles to deliver impressive acceleration and improved handling over the rear wheel drive model.

Vehicle Dimensions



- Overall Height and Wheelbase increases by 245mm and 264mm respectively to achieve SUV proportions
- Front and rear overhangs were decreased to enable the BEV appearance

Interior Roominess

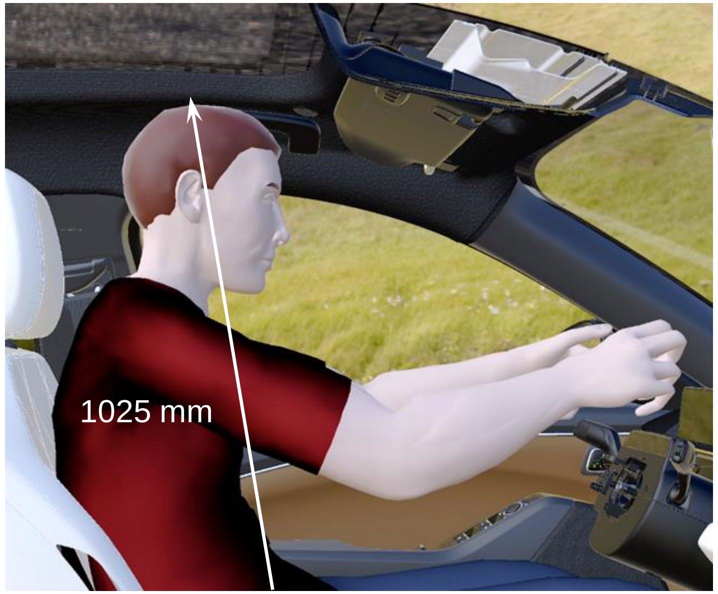
All Interior Dimensions are among the best in class within the BEV / SUV segment

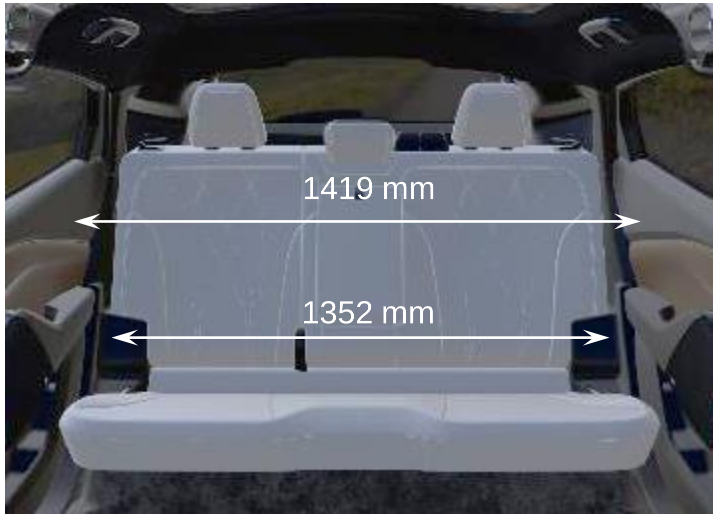
1st Row

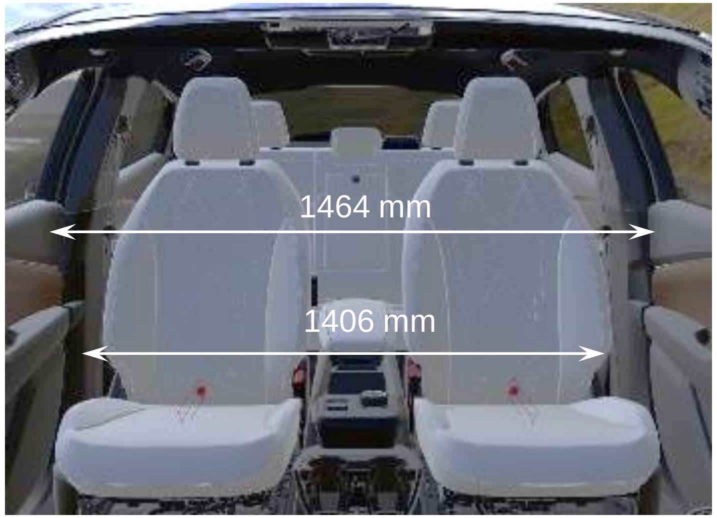
- Shoulder Room= **1464**mm
- Hip Room= **1406**mm
- Head Room w/ Sunroof= **1025**mm

2nd Row

- Couple Distance = 883mm
- Effective Legroom= **967**mm
- Shoulder Room= **1419**mm
- Hip Room= **1352**mm
- Effective Head Room w/ Sunroof= **998**mm
- Knee Clearance= 128mm







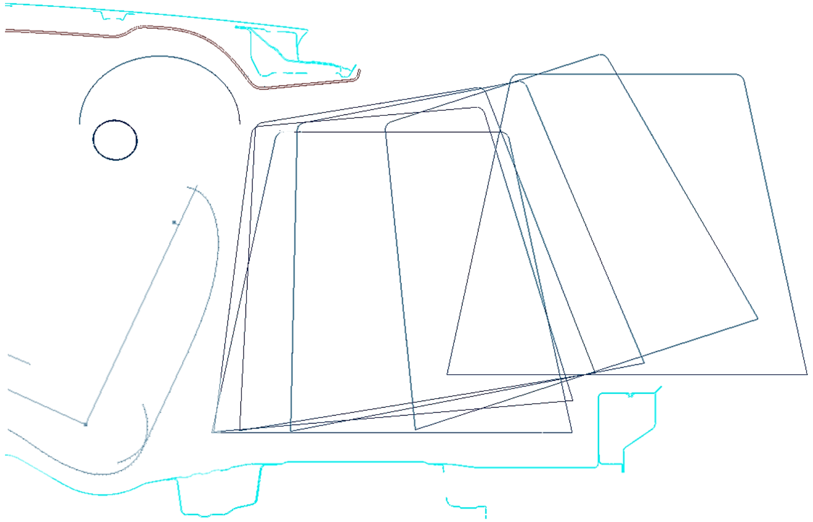
More Space for Your Adventure

Mustang Mach-E can store 83 liter blocks (Europe Measure), 4.7 cubic feet (133 Liters NA Liquid Measure) in the frunk providing enough storage for the equivalent of a carry on bag and several smaller bags. It is also drainable allowing to be packed with ice and serve as a cooler.

The rear cargo area is outfitted with approximately 30 ft^3 of volume behind the 2nd row seat – enough for four 25 in suit cases or three full size golf bags. With the 2nd row seats folded down the cargo volume is increased to almost 60 ft^3.

Go Further

More Space for The Whole Family



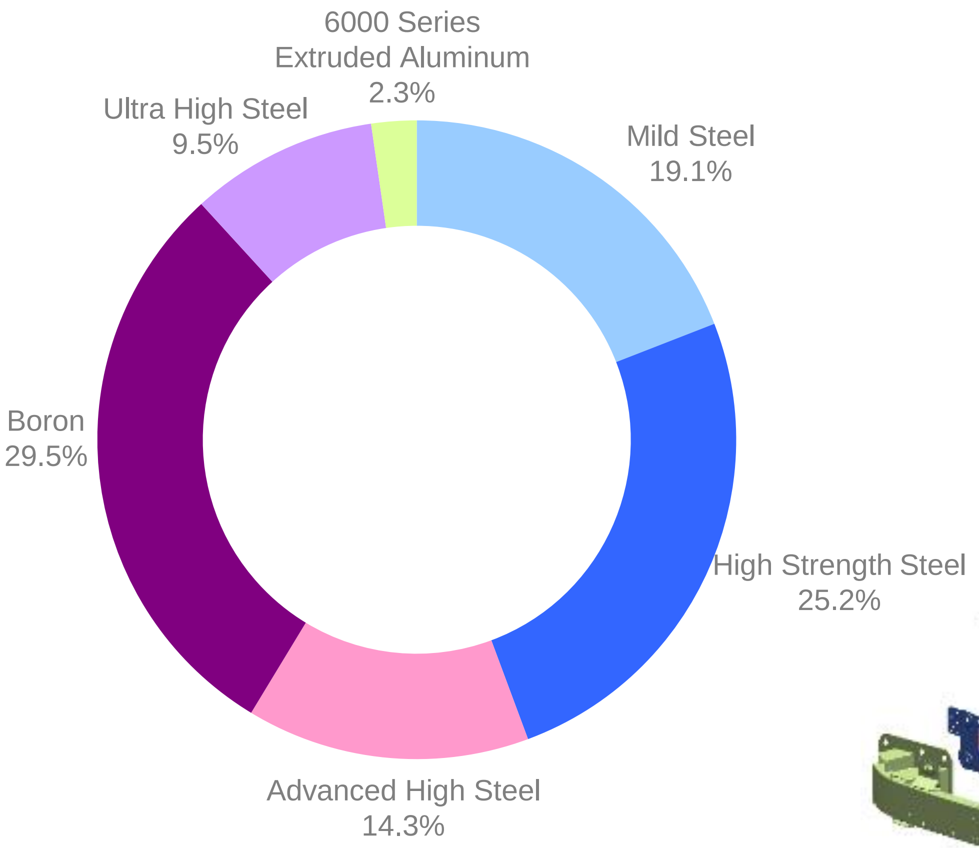
Family and Furry Friends Fit and Ride Comfortably in the Mach-E

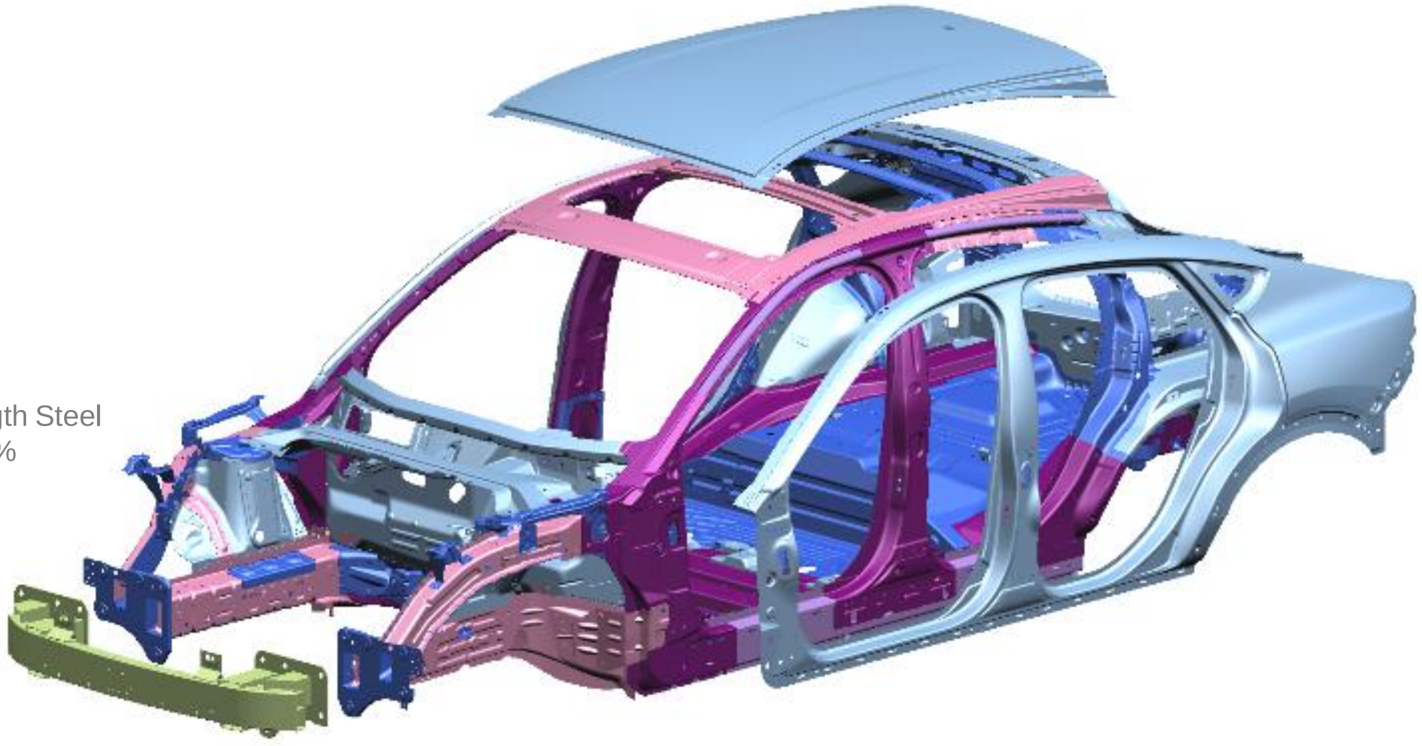
- Packaged to fit European target dog crate through rear opening and provide great head space for rear occupant
- The roof execution allows surprising cargo capability and rear occupant headroom in rear without sacrificing Mustang profile

STRUCTURAL DEVELOPMENT

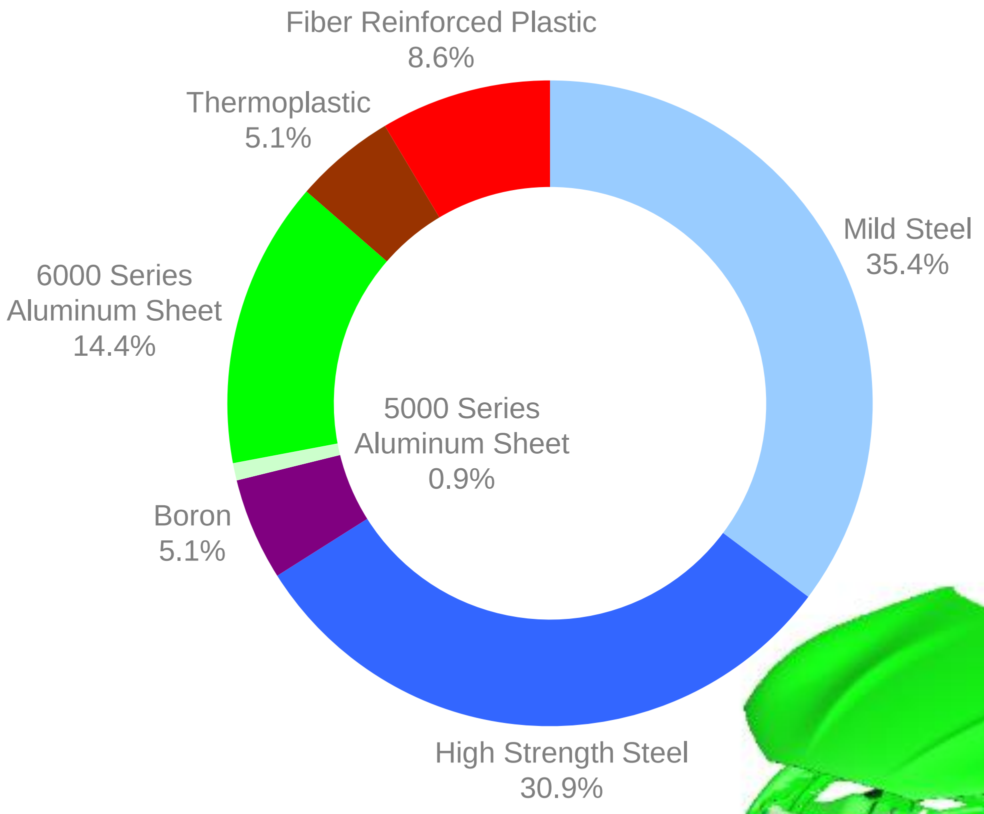
Go Further

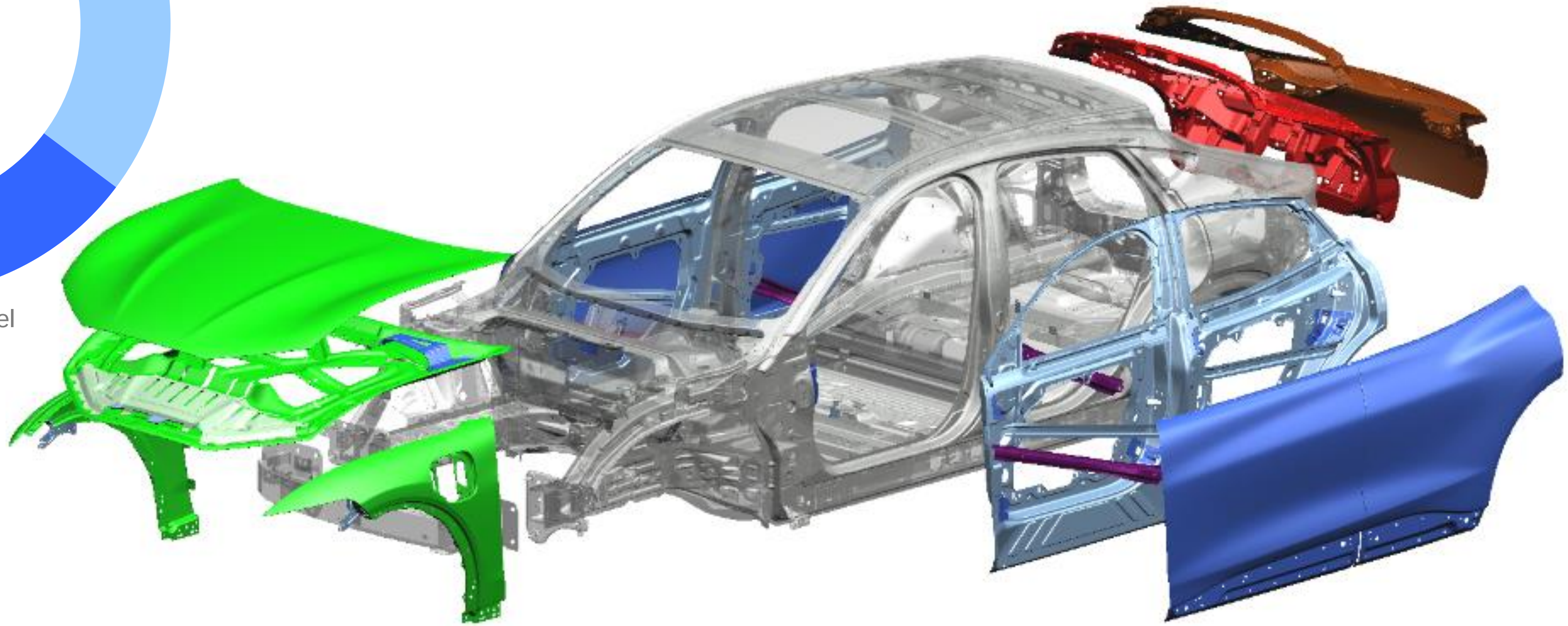
BIW Material





Closures Material



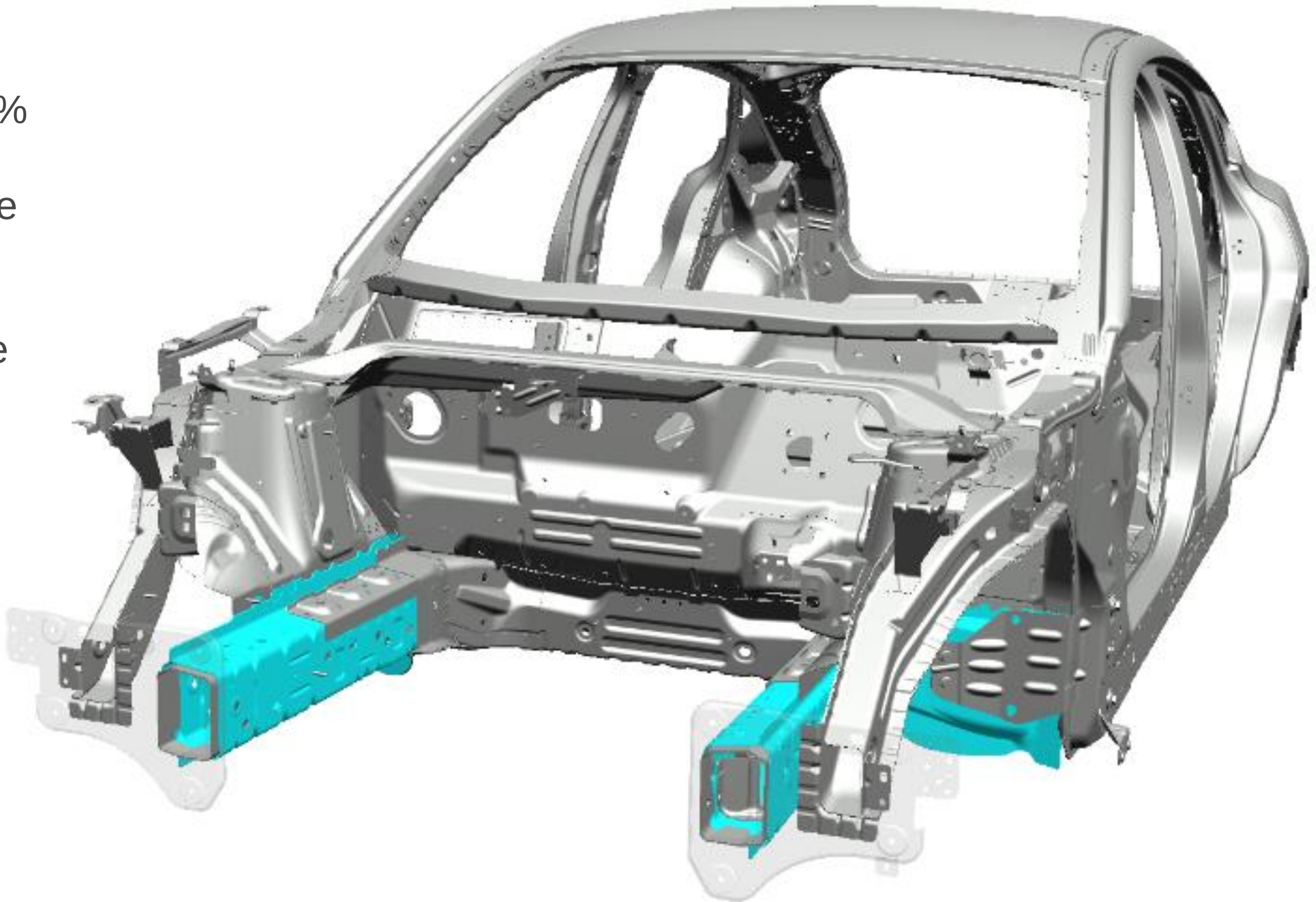


Energy Management of BEV – Frontal Structure

The transition from an ICE to a BE powertrain results in a 36% increase in vehicle test mass and energy input into the structure.

Achieving the proportions of a BEV yielded a 10% reduction in the allowable crush space of the frontal structure when compared to a comparable ICE vehicle

These two factors result in a 53% increase in the loads needed to be managed by the front rails.

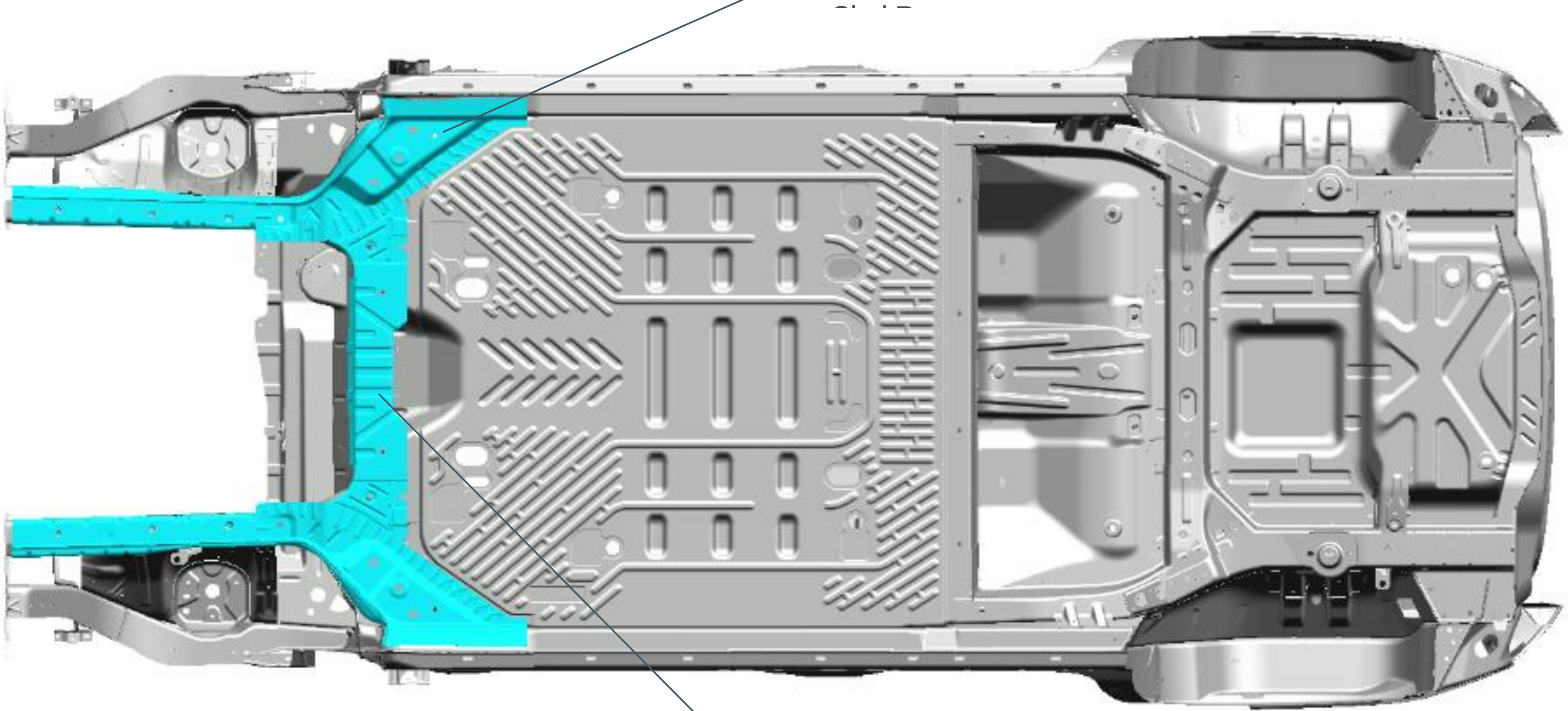


- Increased rail section
- Increased rail gauges
- No stress risers due to tire clearance at full turn or other package related issues
- Improved robustness of the upper load path

Energy Management of BEV – Frontal Structure

Typical ICE powertrain provides area for multiple load paths to provide back up to the front structure

Introduction of the battery pack requires the frontal loads to be managed through the torque box only

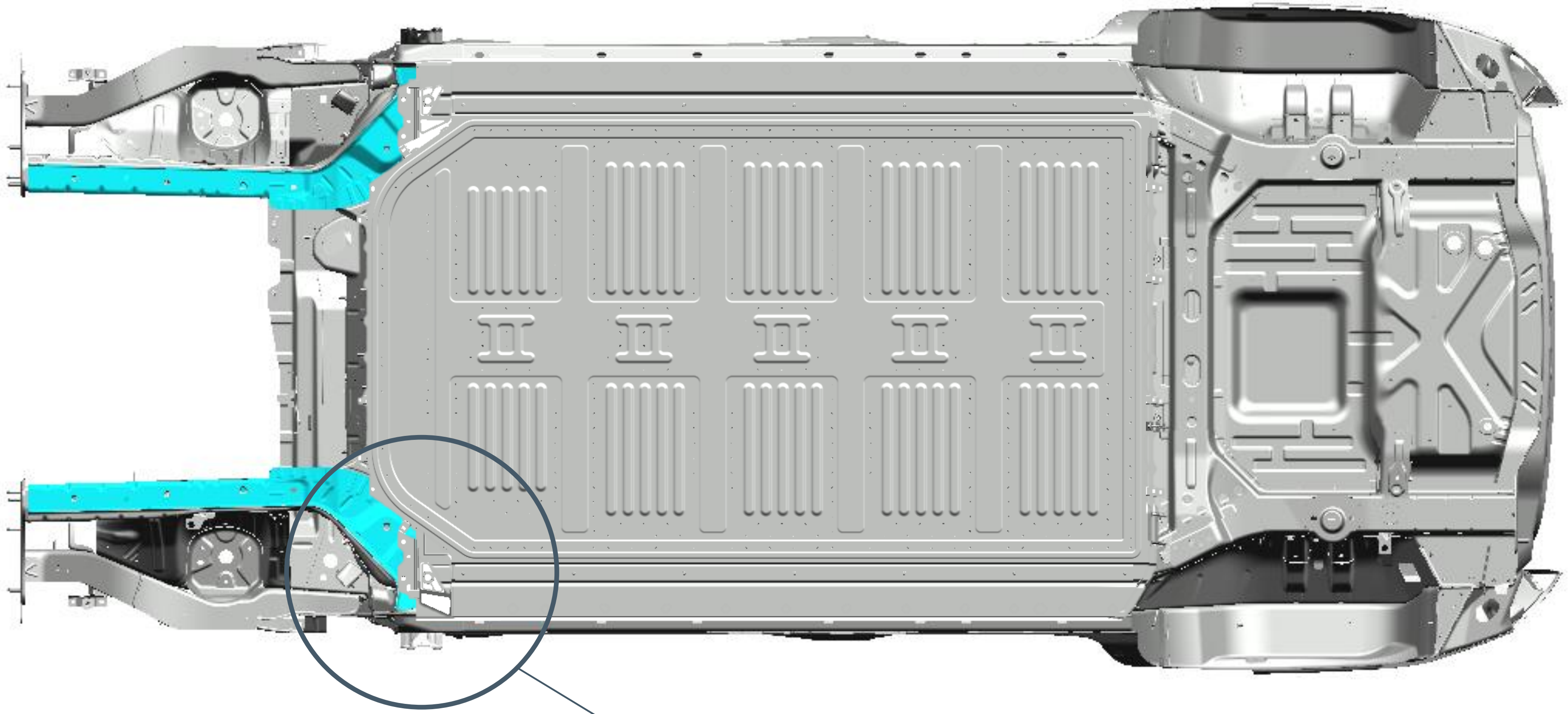


Tunnel Runner

Strong dash cross member added to manage compressive loads from the rail and bending loads from the powertrain.

Energy Management of BEV – Frontal Structure

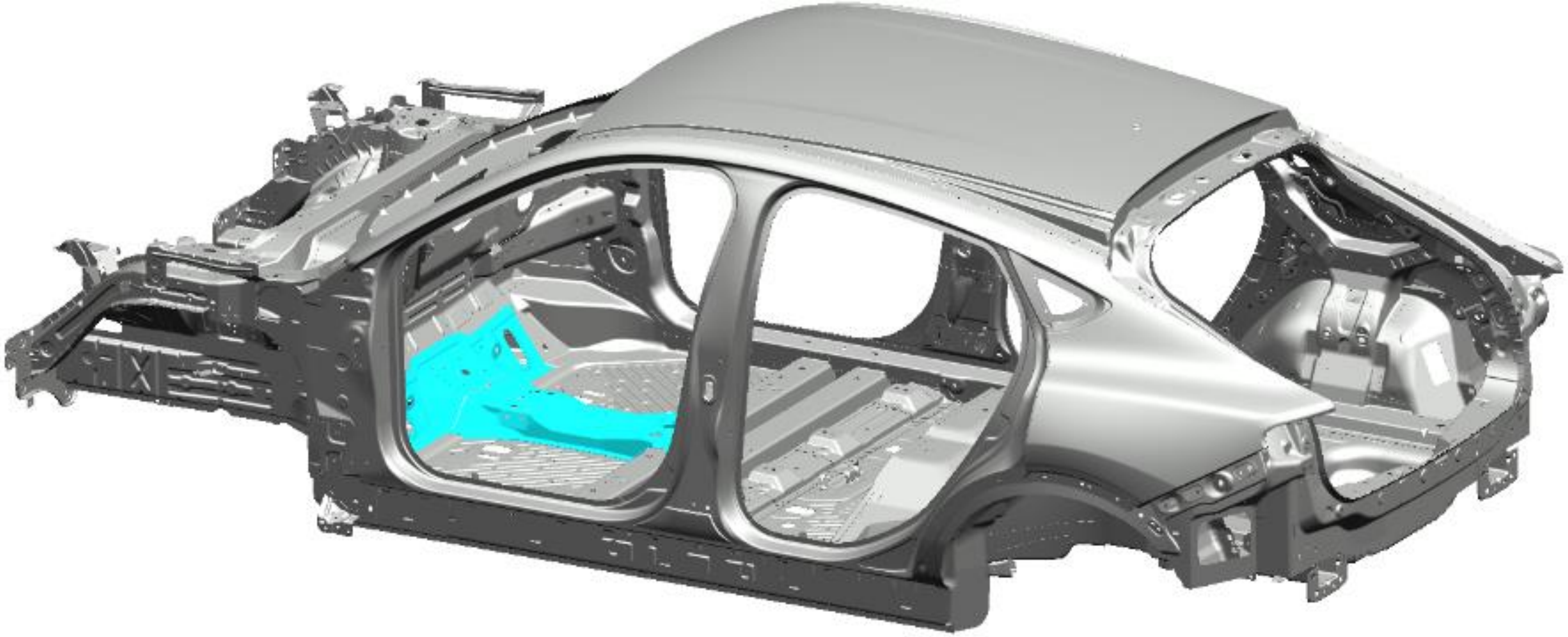
Initial battery concept was developed to maximize energy density leading to a rectangular shape. The square corners of the pack required the torque box to manage the loads at a true 90º corner, resulting in high mass and cost



Chamfering the front corners of the pack enabled the torque box to make a smoother transition between the rail and the rocker improving the structural efficiency

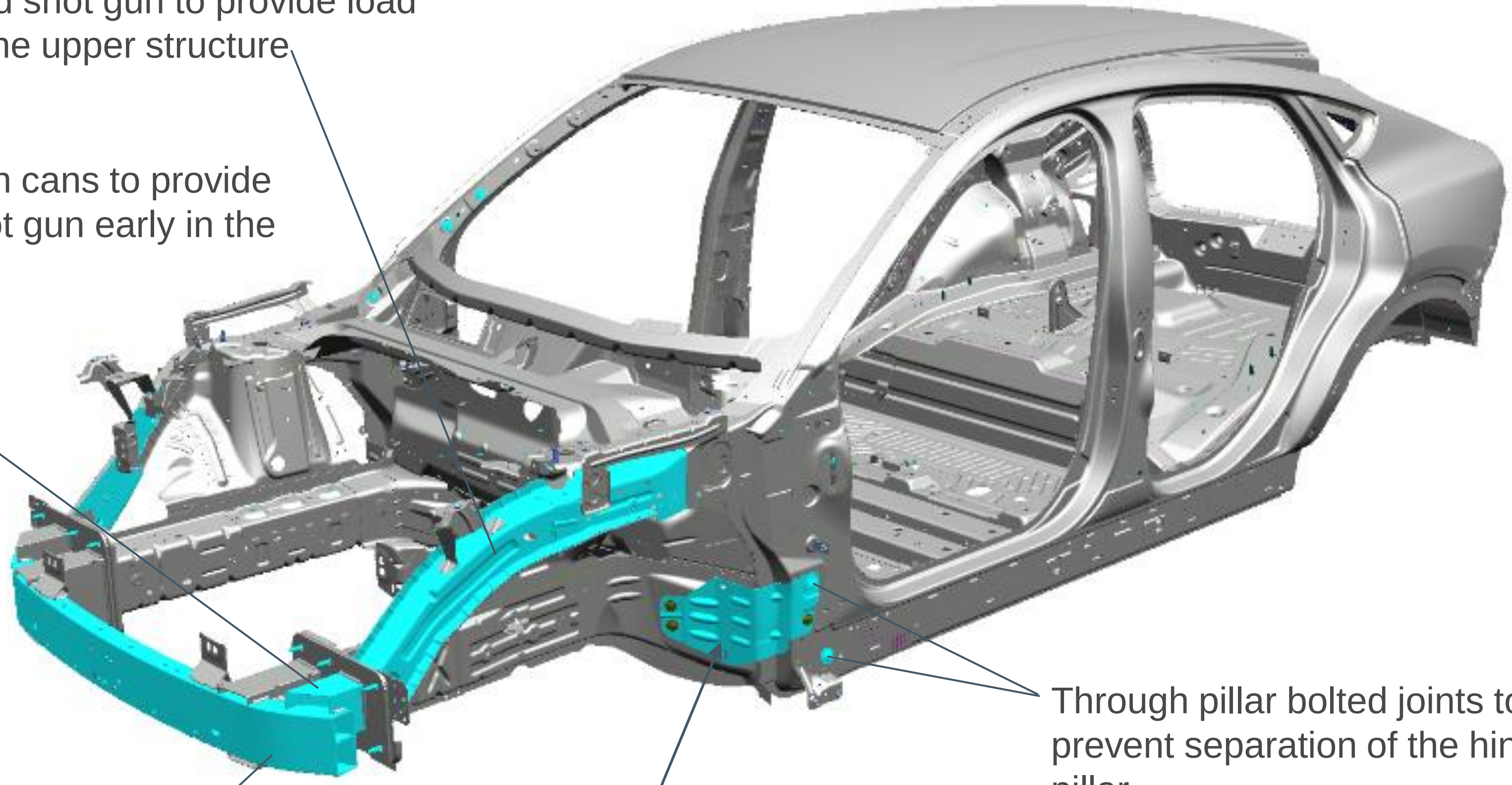
Energy Management of BEV – Frontal Structure

BEV allowed for the introduction of a flat floor, but the area under the console is utilized to provide support to the dash cross member under severe load conditions



Energy Management of BEV – Frontal Structure

Additional mass also increases the loads input into the BIW during the Small Offset Barrier protocol.



Extended shot gun to provide load path to the upper structure

Added outboard crush cans to provide a load path to the shot gun early in the event

Through pillar bolted joints to prevent separation of the hinge pillar

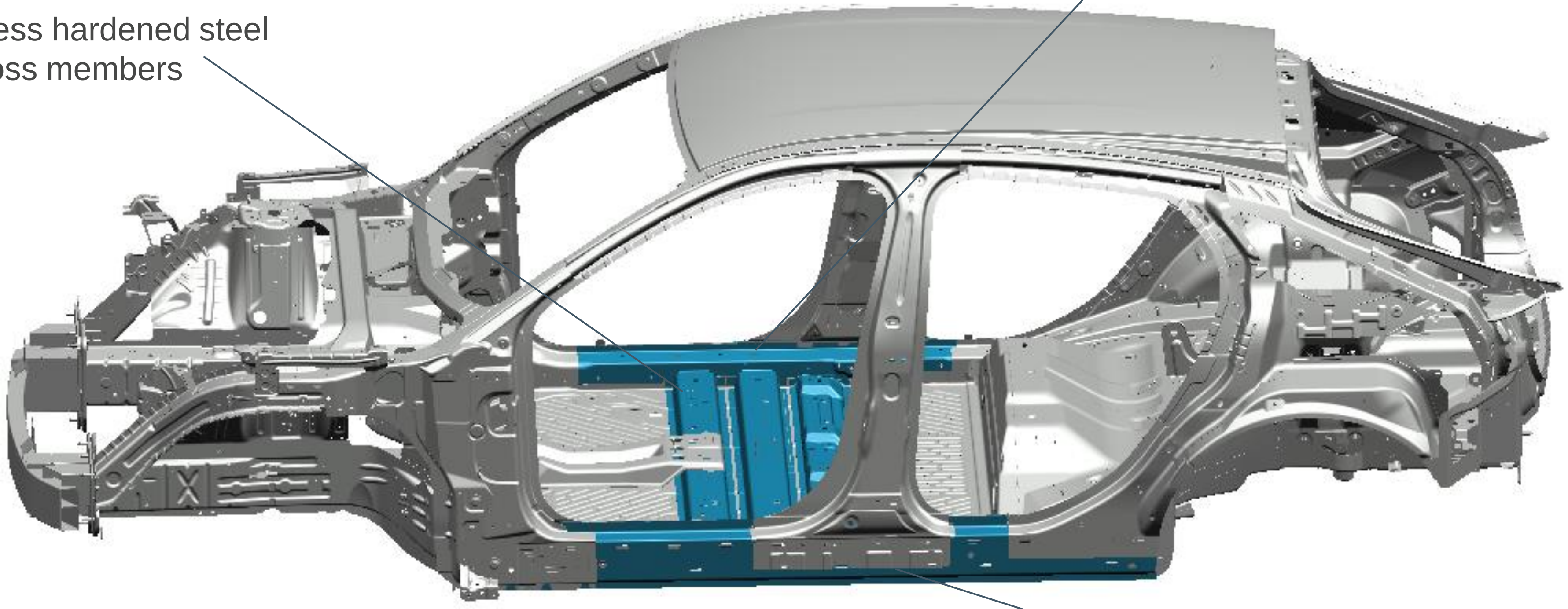
Extended the bumper beam in Y direction to engage with the barrier

Added bolt on reinforcement to enhance the load capacity of the hinge pillar

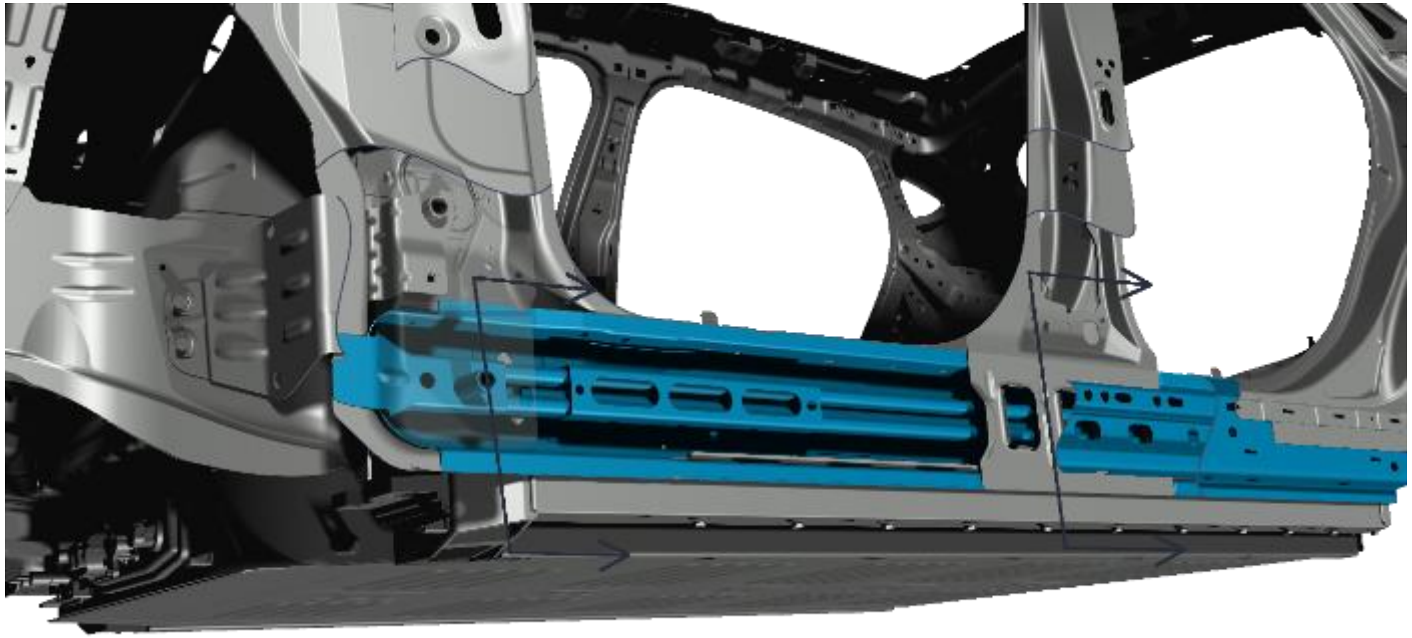
Go Further

Energy Management of BEV – Side Structure

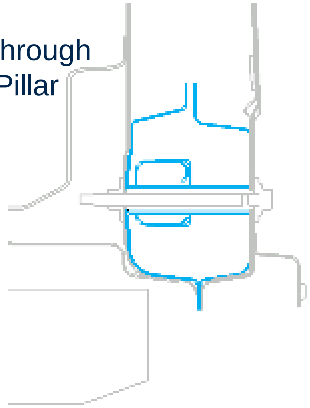
Energy from the pole and barrier during a side event must be absorbed before there is intrusion into the battery case. This results in a reduction of available crush space by a factor of 2 when compared to an ICE vehicle. This coupled with the increased mass results in an increase in the load from the pole of 350kN



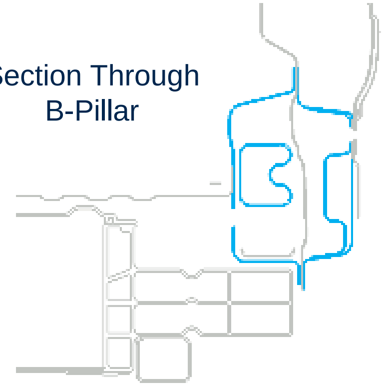
Multi-piece AHSS Roll Form Rocker Tuned to Handle BEV Loads



Section Through
Hinge-Pillar



Section Through
B-Pillar



3-Piece Martensitic Roll Form

- M1500-M1700 MPa for smaller sections
- Thru-bolts at front joint tie components together to create solid node for Small Overlap modes
- Extended to the leading edge of the hinge pillar section for early engagement

Dual Purpose Design

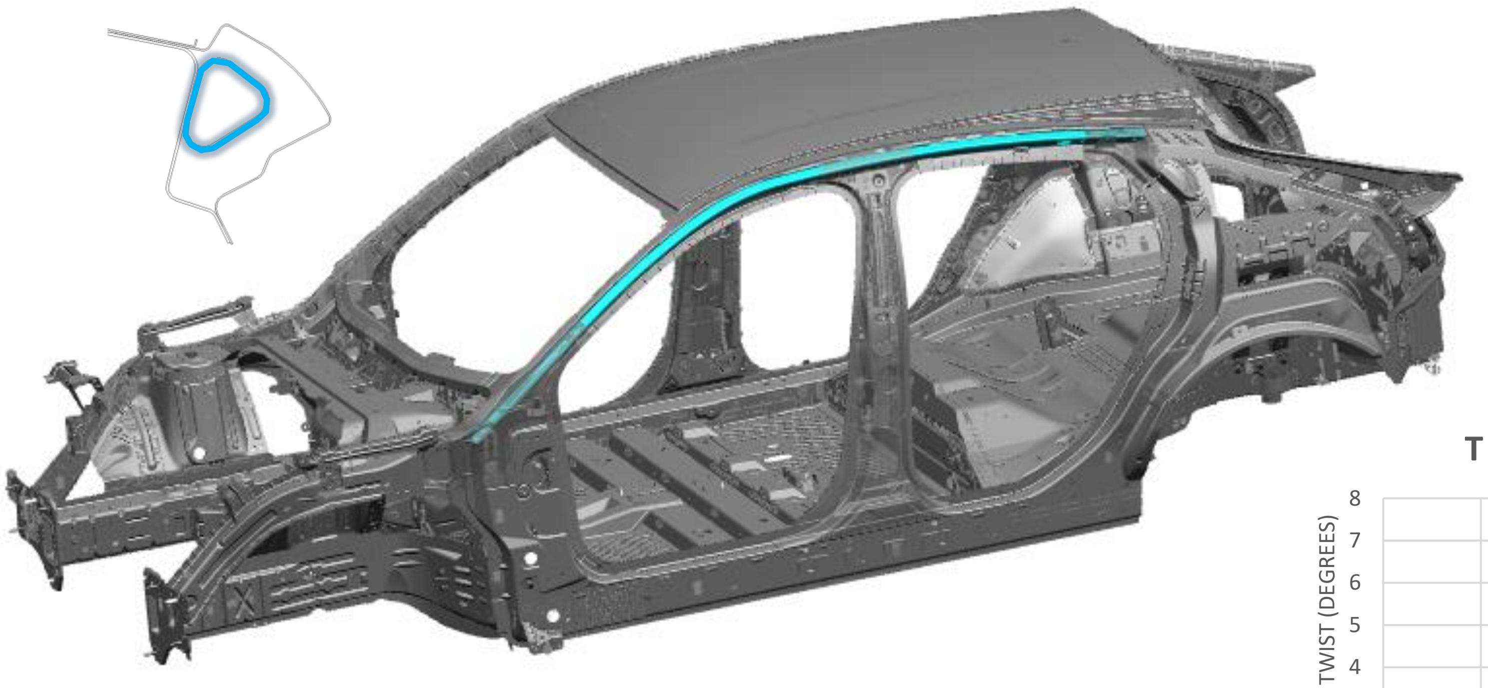
- Continuous side impact coverage AND stability for Front SORB Modes ~$50/veh savings & Equivalent weight/performance vs Extruded AL
- Multipiece steel construction allowed for traditional welding in Body shops while still offering numerous tuning options that work in concert with bolt on battery tray structure to optimize energy absorption

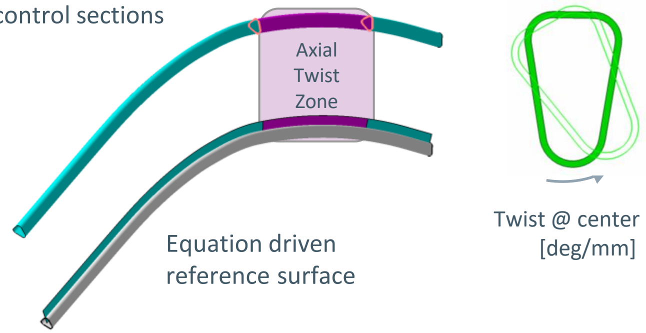
Split Design Advantages

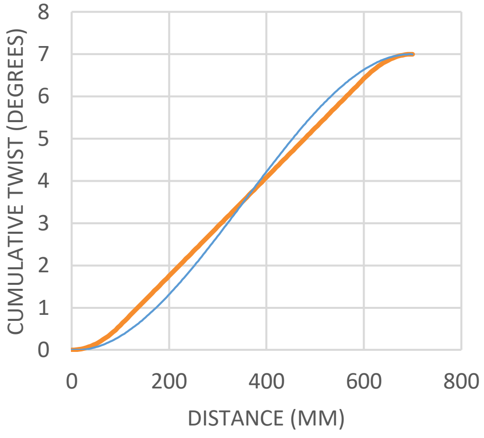
- 3-piece design allows for B-pillar pass thru.
- Split Geometry designed to collapse together in side modes to maximize energy absorption

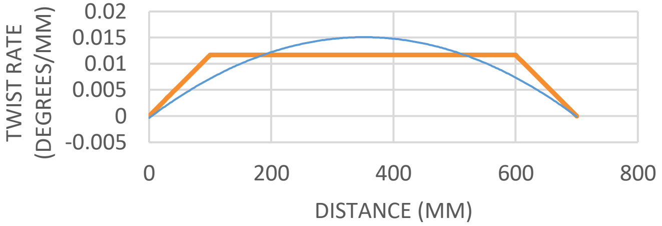
Energy Management of BEV – A-pillar & Roof Rail

Ford's unique 3D roll-formed design applies a M1700 tube throughout the A-pillar and Roof Rail structure for consistent AHSS strength and package efficiency.







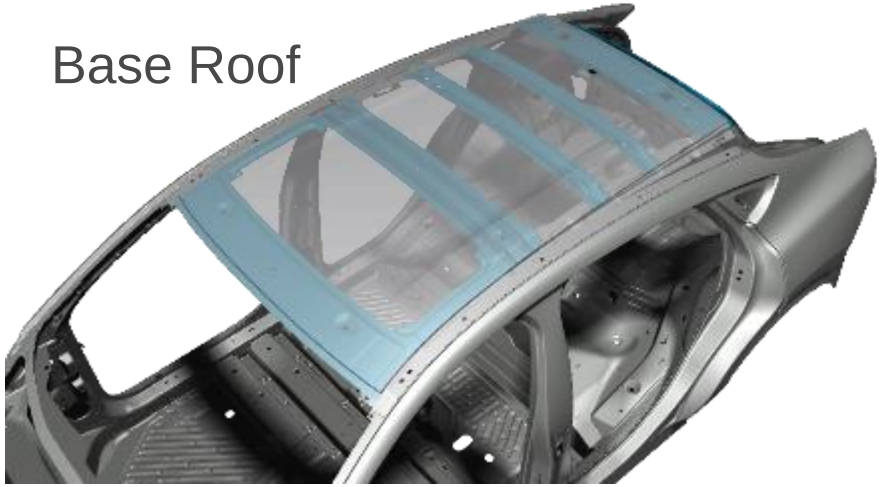


A-pillar & Roof Rail Structure

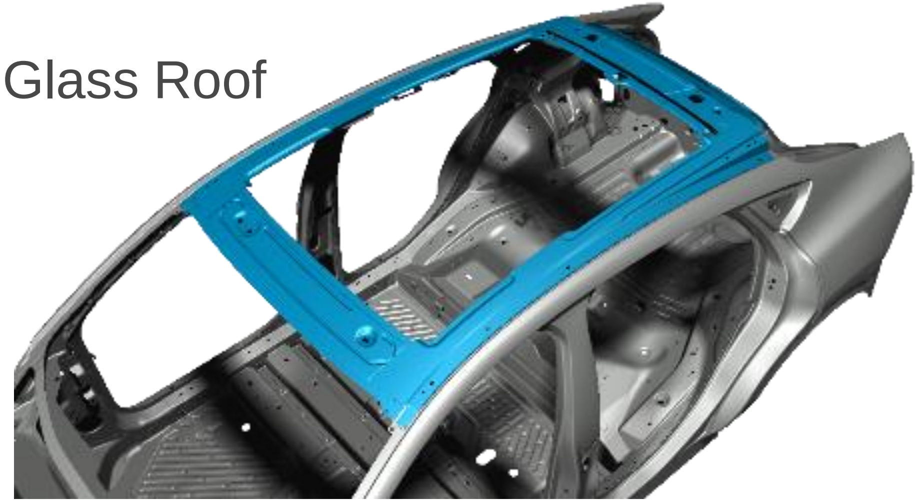
- Smooth, constantly varying twist rate from prior design method using loft control sections developed for hydroforming was difficult for the 3D roll form machine controller to reproduce
- New method utilizes an equation driven reference surface to include the twist unit's transfer function directly into the model reducing cumulative twist error and improving surface consistency.

Wide Open Views : Mach-E Structural Adapter Ring

Base Roof



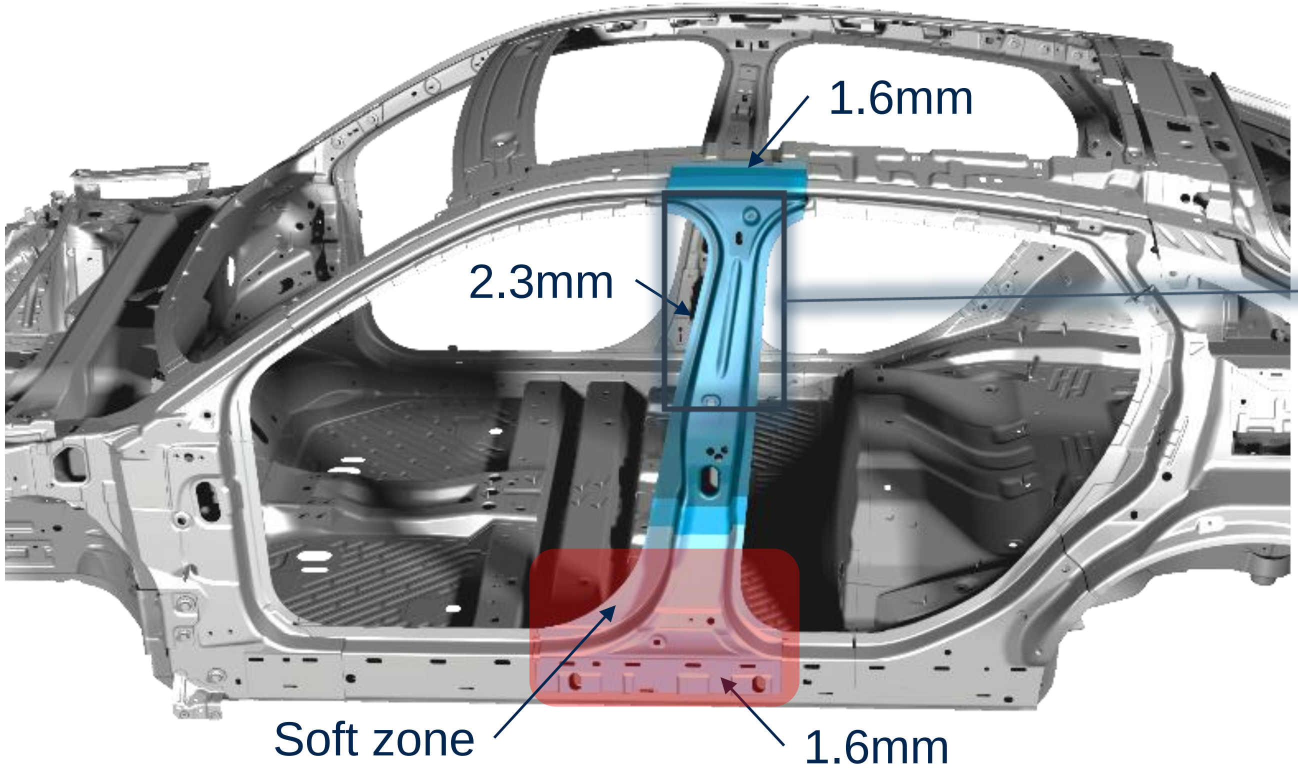
Glass Roof

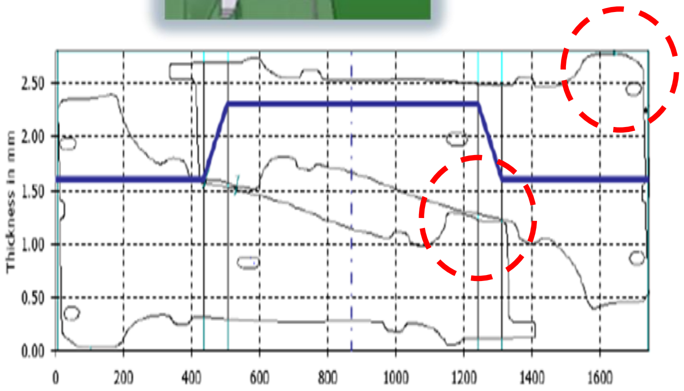


- DP780 Structural Halo on Glass Roof allowed elimination of traditional cross roof bows - providing Wide Open Viewing Experience for Occupants
- Full Structural Roof Halo provided added strength for Glass roof vehicle loads
  - allowed for common bodyside assemblies for all roof variants
  - prevented 4.5kg scar mass that would have needed to be added to common bodyside structure

- Structural Ring Adapter to manage height difference between Stamped vs Glass Roofs for consistent urethane applied across a variable roof rail section.
- Decreased part variation by creating a Halo for both Glass Roof and Steel Roof to commonize Bodyshop tooling.
- Glass Roof Halo gage & grade leveraged to eliminate the need for a structural B-pillar bow.

B-Pillar Design for BEV in CUV package: TRB, Soft zone & Insert Technologies





Customized B-pillar Structure

- TRB + Insert delivered 1.8kg weight reduction vs. PWB.
- Boron soft zone in lower pillar enabled a balanced B pillar response during high loads and strain interface to a stiff rocker section.

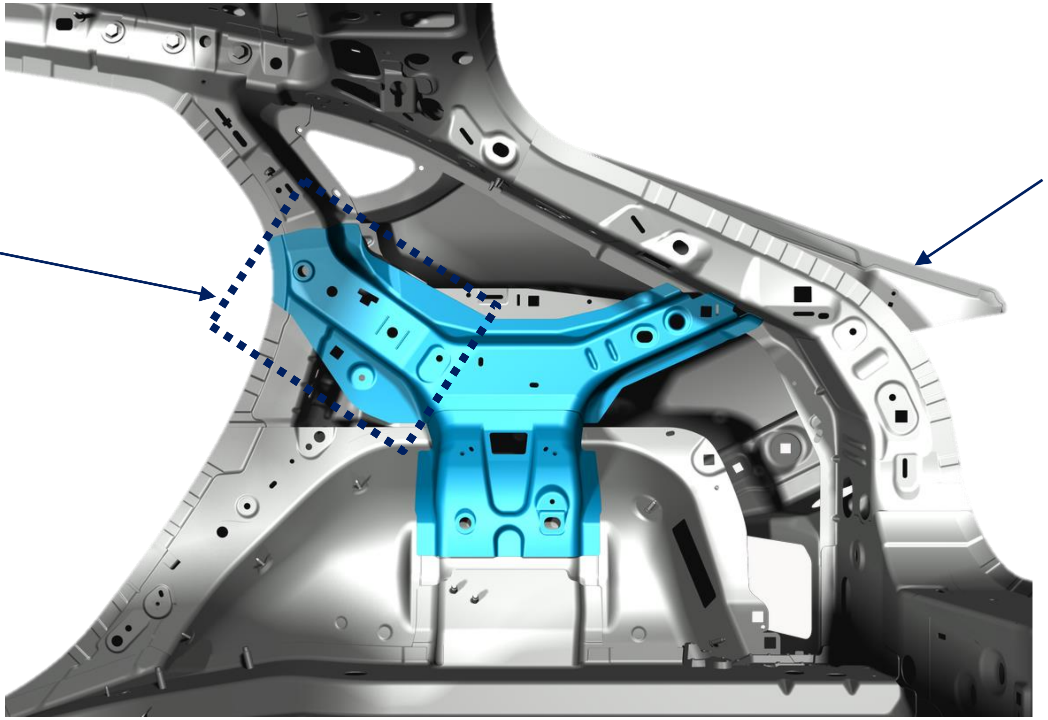
2-out blank and efficient cost

Key Control Points and trim lines optimized to maintain

Weight Efficient Y-Brace Quarter Structure for Fastback Design

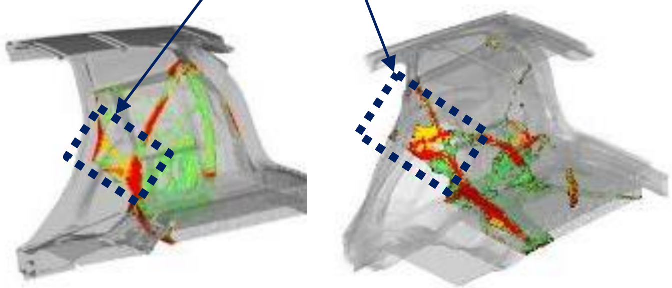
Front Leg

- Transfers shock and subframe loads up C-Pillar for improved shock stiffness
- Stabilizes C-Pillar during roof crush crash mode
- Provides robust structure for rear seat striker mounting

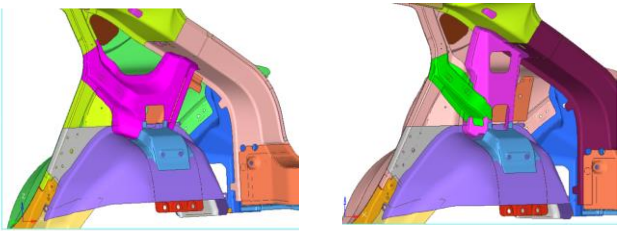


Rear Leg

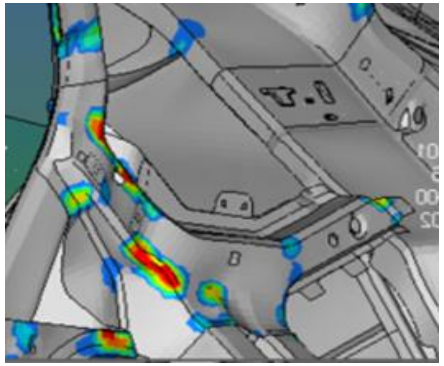
- Resists D-Pillar intrusion during rear impact crash mode
- Provides sufficient rigidity for lifting rear half of BIW through e-coat bath



Early Development Work



Roof Crush C-Pillar Stabilization

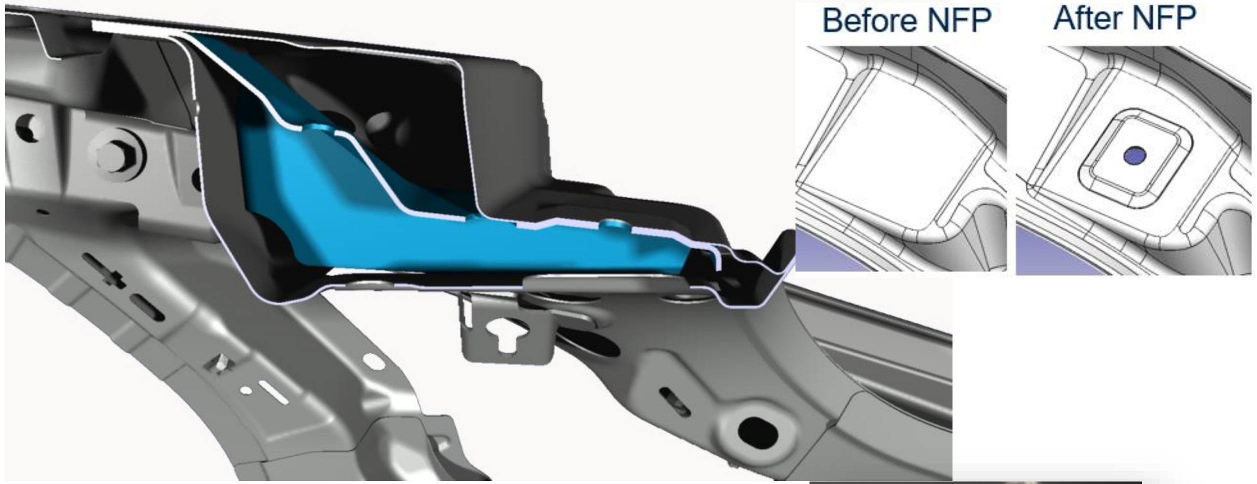


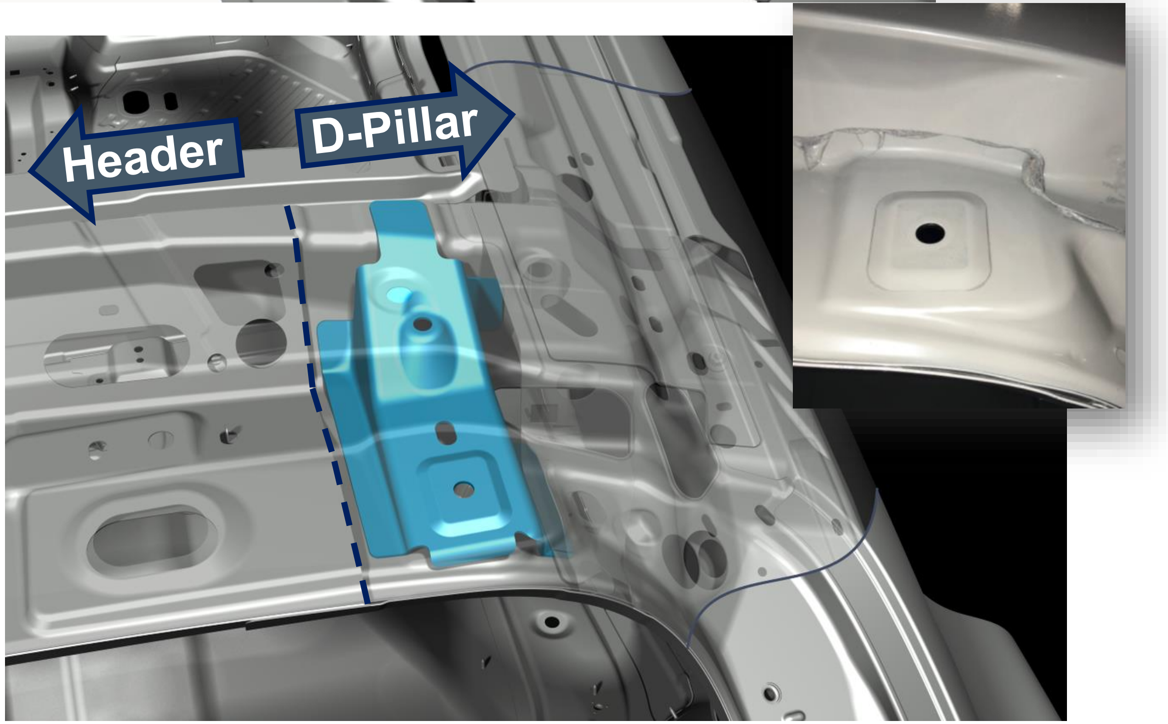
Y-Brace Structure

HSLA 350 Y-Brace provides adequate stiffness and energy management without need for heavier traditional full quarter panel

- Increased torsional stiffness by 31 kN-m/rad*
- Increased global torsional mode by 0.4 Hz*
- Increased rear shock stiffness by 6%*

Tailored Liftgate Fits with Net Form and Pierce





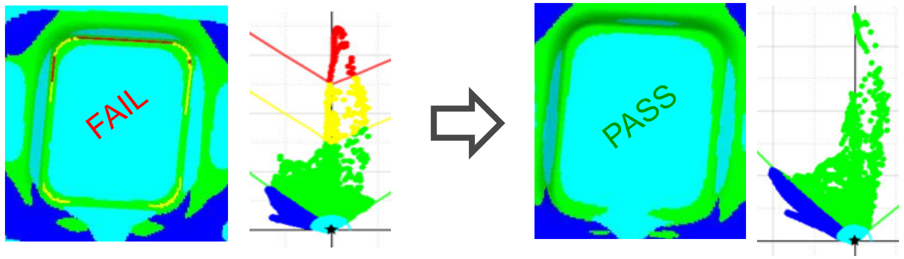
Precision Plastic Liftgate Fitting

- Net Form and Pierce technology allows the liftgate hinge pad positions to be custom tailored for each individual body using laser measurements
- Balanced parameters:
  - Panel grades & gages
  - Hinge pad shape
  - Liftgate structural loading CAE

Integrated into D-Pillar Structure

Hinge reinforcement is integrated into the D-Pillar structure in order to utilize the pillar stiffness to maximize hinge span resulting in reduced plastic liftgate twist

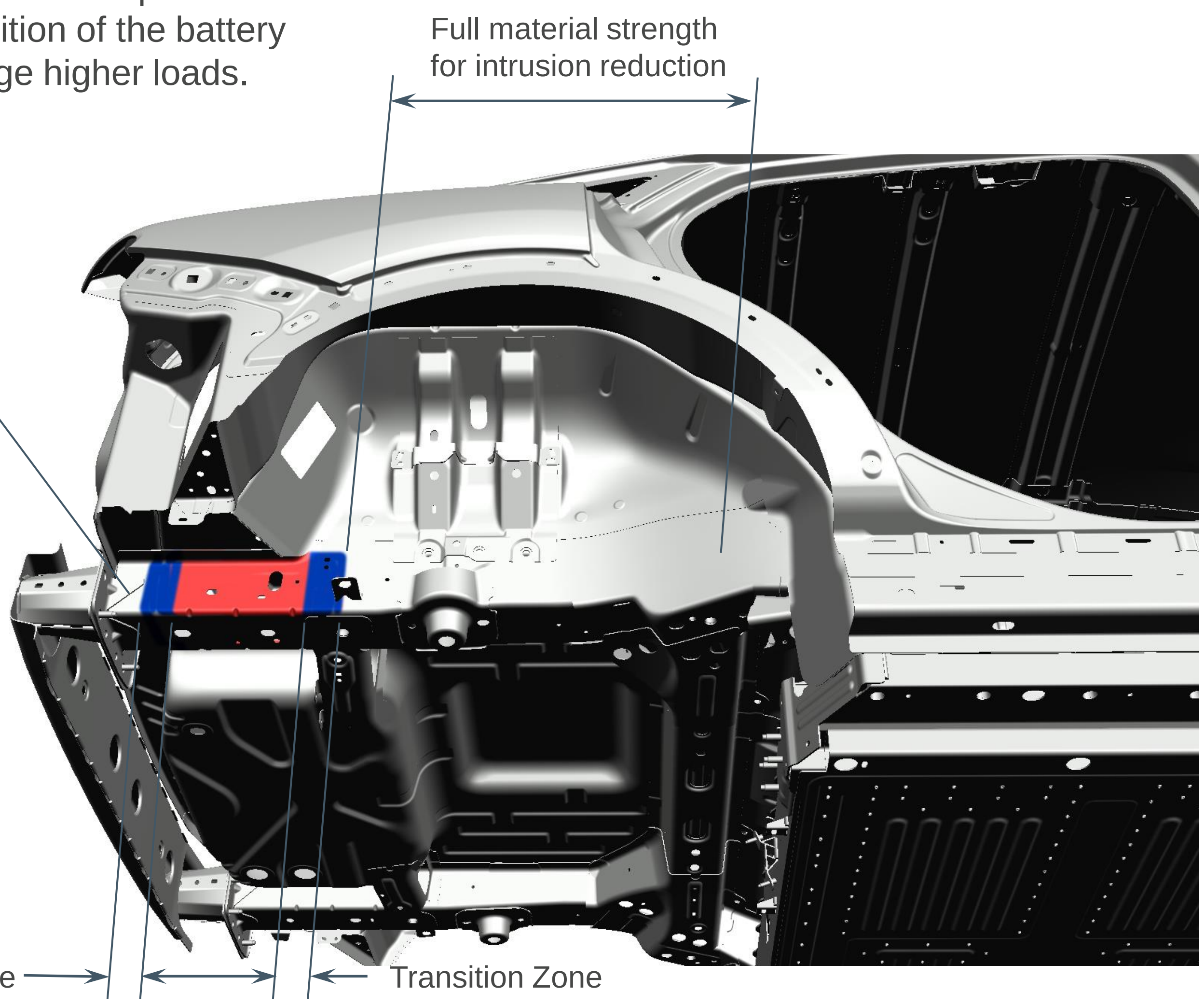
Balancing Max Allowable Tool Force, CAE Feedback, Pad Size, and Gage and Grade Selection



Energy Management of BEV – Rear Structure

Rear overhang reduction of 23% when compared to an equivalent ICE vehicle and the position of the battery pack requires the rear rail to manage higher loads.

Press hardened steel rear rail incorporates soft zones to allow for energy absorption and reductions in intrusion



Thank You