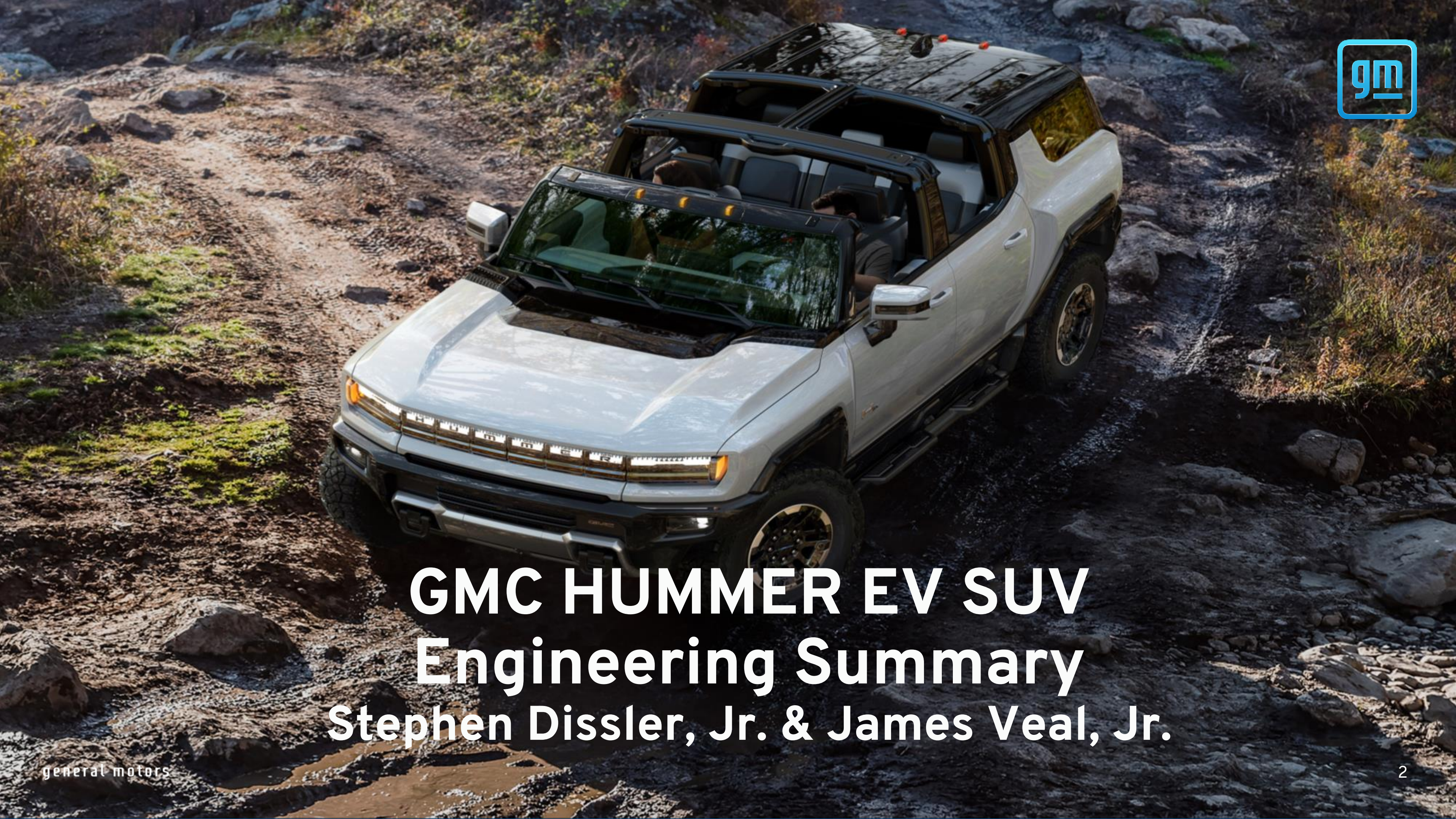
GMC HUMMER EV

everybody in.

24 May 2023
Great Designs in Steel Conference

General Motors



GMC HUMMER EV SUV Engineering Summary

Stephen Dissler, Jr. & James Veal, Jr.

HOW IT'S GOING…

GM Vision: Zero Crashes, Zero Emissions, Zero Congestion

Simulated or preproduction products shown and subject to change. Certain products not currently available or subject to limited availability. See vehicle websites for details.

GMC HUMMER EV SUV
REVOLUTIONARY 5

OFF-ROAD BEAST
Advanced, tactical off-road chops that enable you to forge any path.

IMMERSIVE
An experience that puts you in the middle of every moment, moving in near-silence with nothing between you and the world

SUPERFAST
Revolutionary street performance from a truck, enabled by extraordinary next-gen EV power.

TECH-STRONG
Loaded with smart, purposeful tech designed to enhance every excursion.

NEXT-GEN ELECTRIC
Ultium-powered range and quick-charging capabilities let you take the adventure further.

INFINITY ROOF

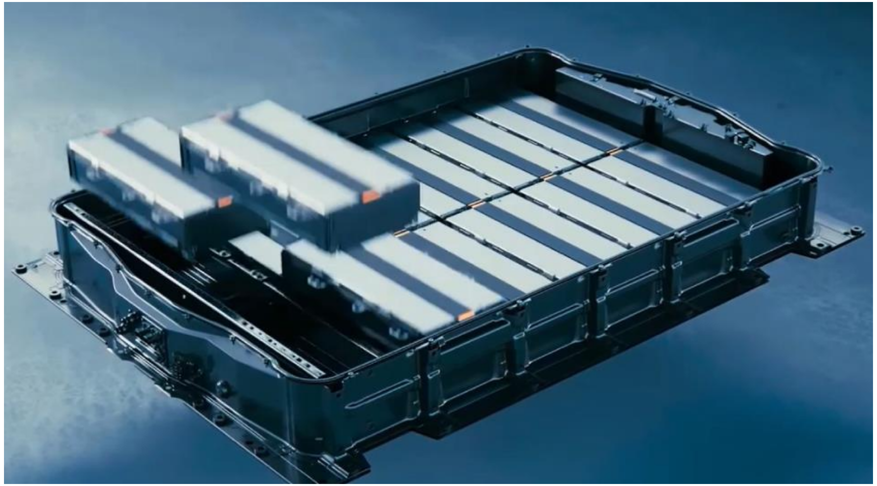
Let the world in with an open-air experience

GMC

HUMMER EV – Features Enabled by Body Structures

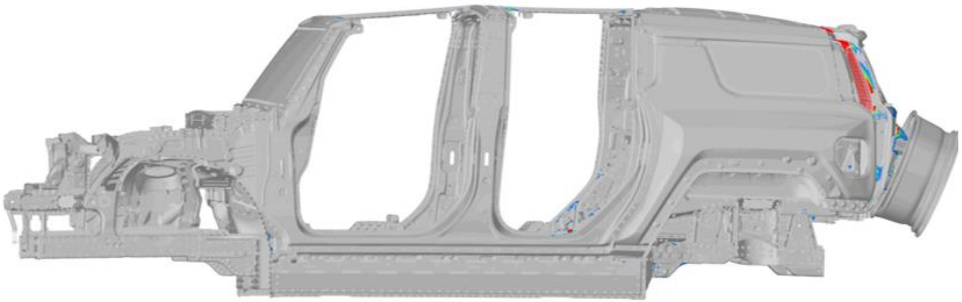
- Off road performance: large tires and suspension travel
- Infinity roof: open top structure
- EV range for adventure: GM's RESS
  - RESS = Rechargeable Energy Storage System
- RESS structural integration

Double-Stack RESS

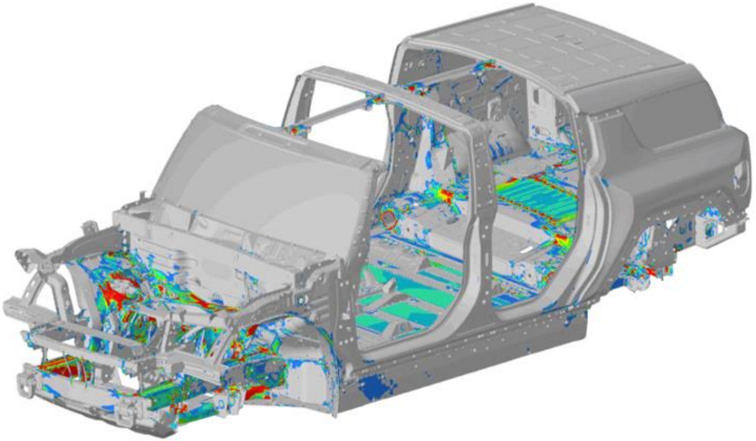


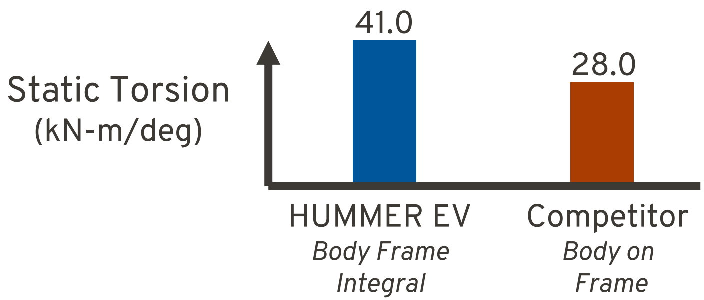
BIW Stiffness

- High vehicle stiffness required for...
  - Extreme off-road capability
  - Open air experience



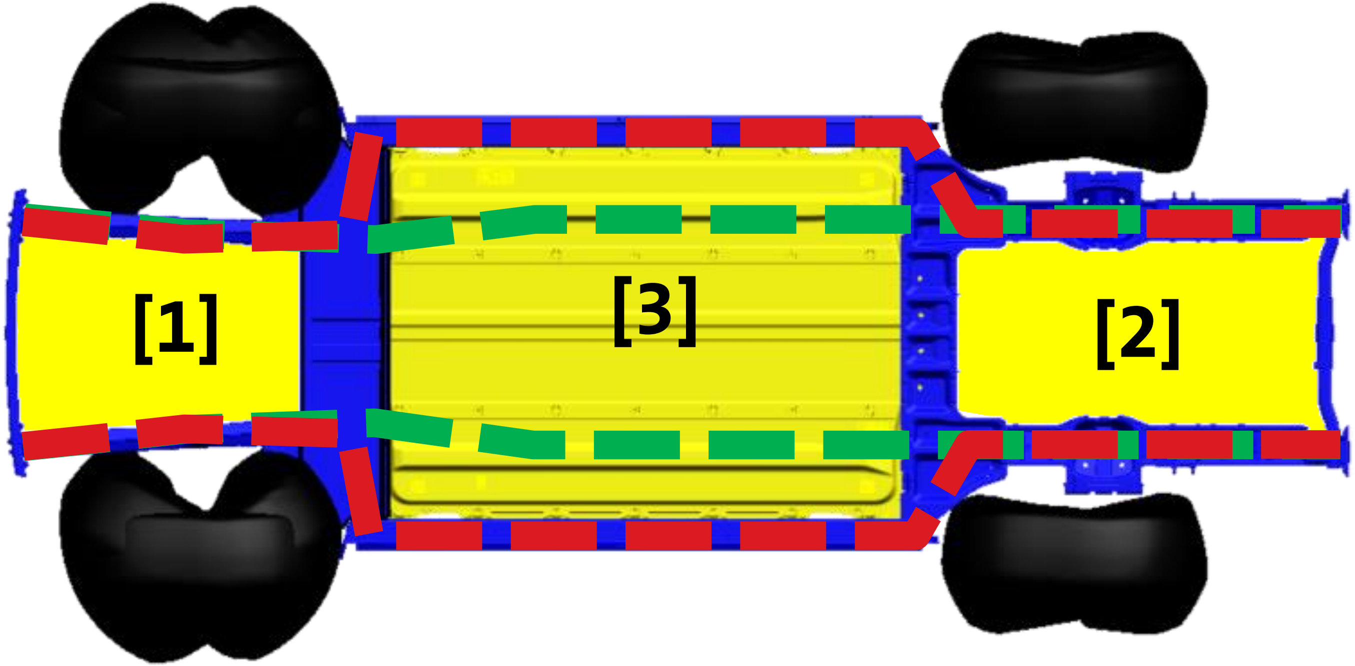
Trimmed Body Modes
Bending 16.5 Hz
Torsion 22.2 Hz





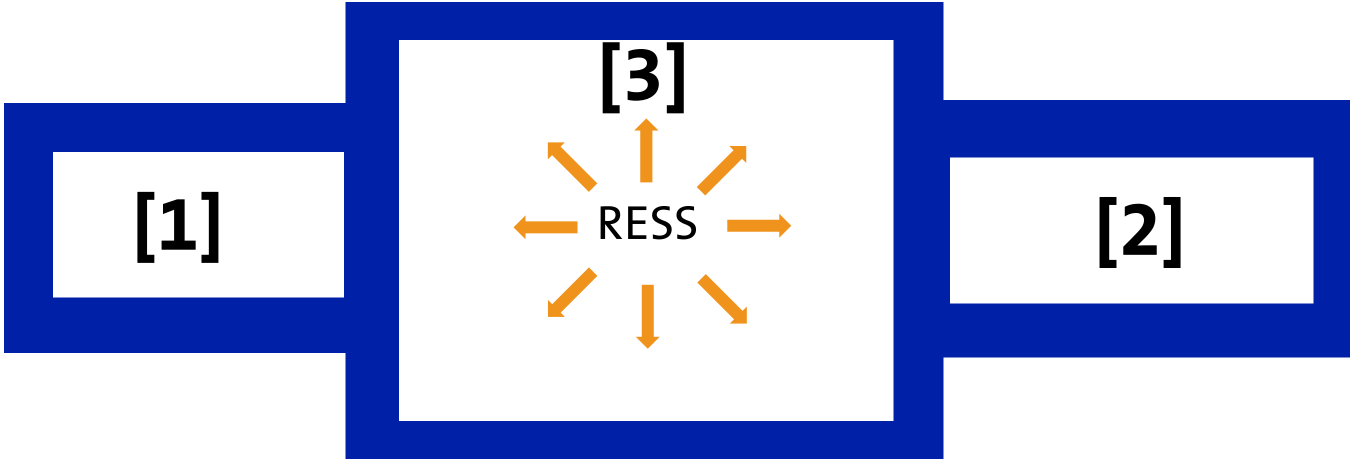
Body Structures Topology

- Large tires require narrow rail spans
- Large RESS fills space between rockers to maximize available energy



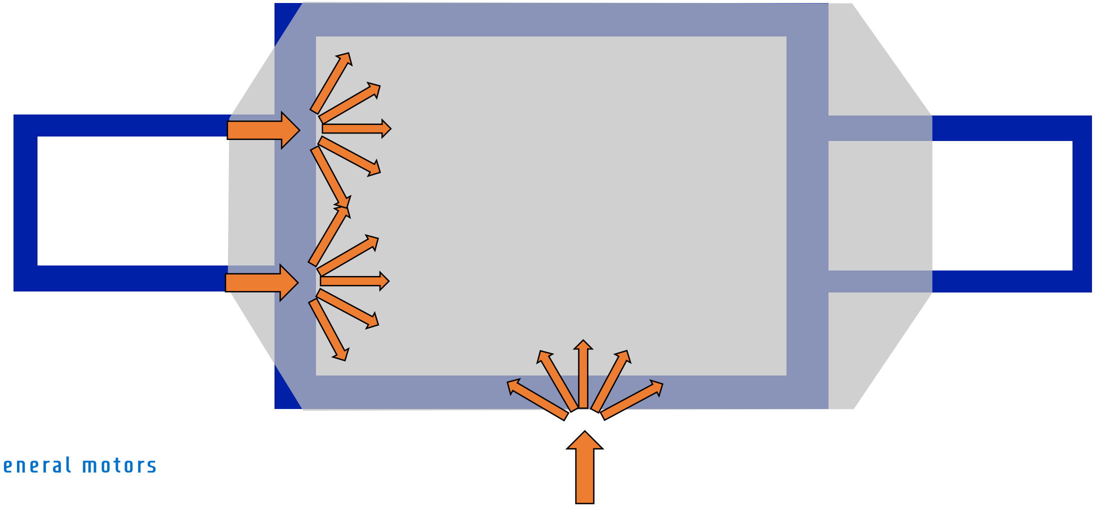
Body Structures Topology

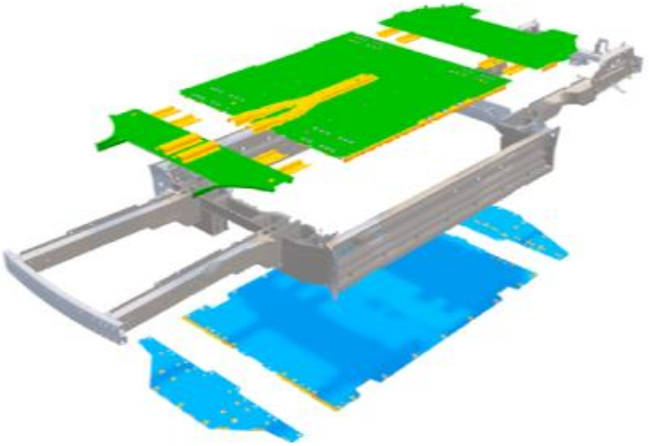
- Large tires require narrow rail spans
- Large RESS fills space between rockers to maximize available energy
- Resulting unique “3 box” layout



Shear Structure Construction

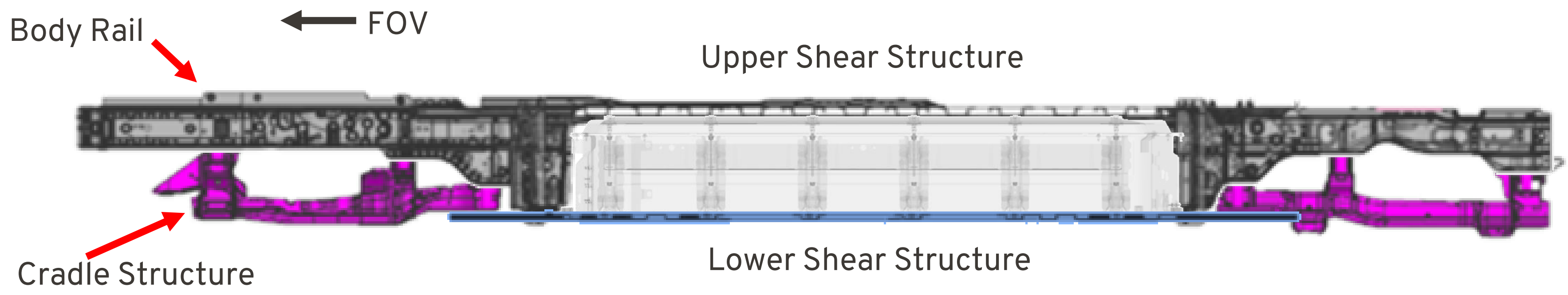
- Load is distributed through shear structures
  - Main load paths to protect RESS internals
  - Varying construction depending on packaging space/welding requirements.
  - Enables uniform load capacity





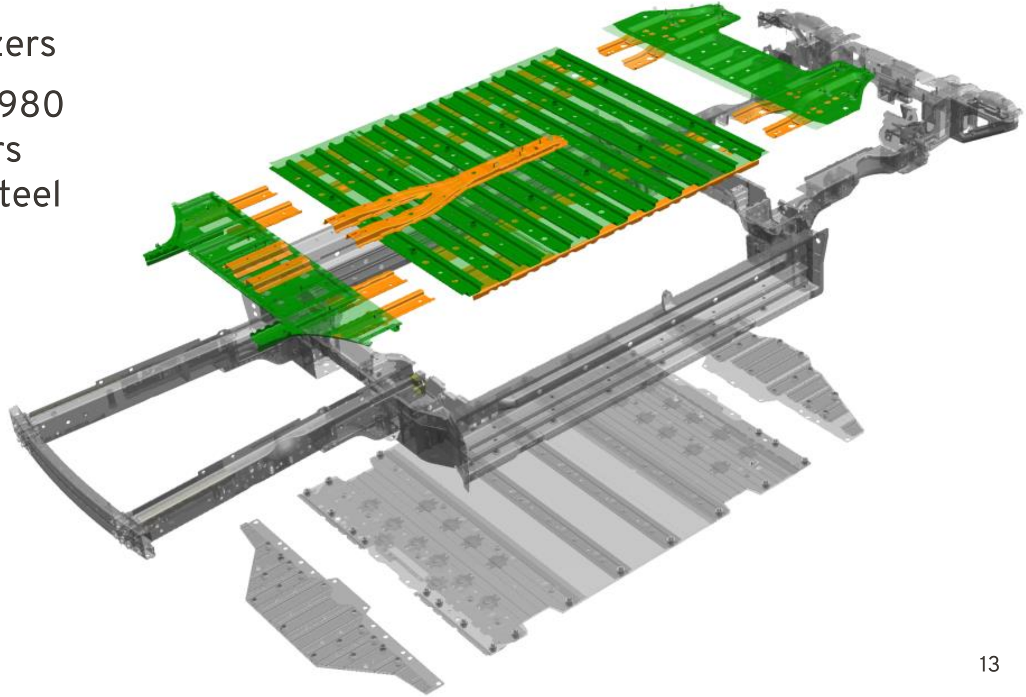
Body Structure Load Management

- Upper shear structure through body structure
  - Welded lattice assembly
- Lower shear structure tying hard mounted chassis and RESS structure together
  - Welded shear assembly as bottom of RESS
  - Bolt on assemblies in GA to continue that load-path



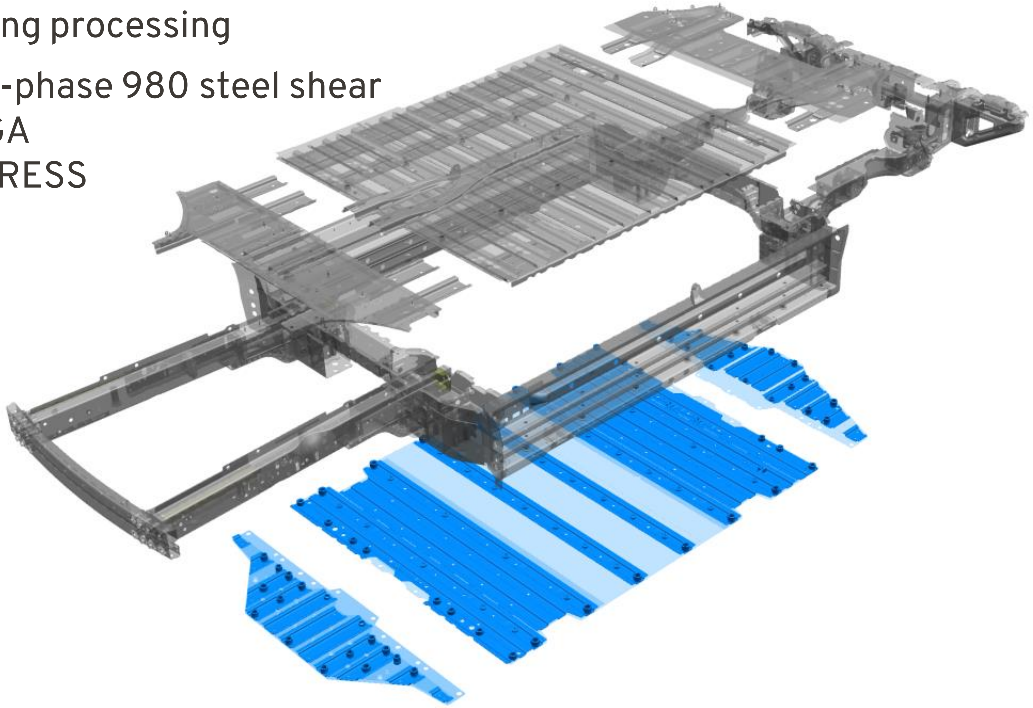
Shear Structure Development

- Upper shear structure designed as system level lattice structure
  - Construction with shear panels for load disbursement and section stabilizers
  - Made from high strength multi-phase 980 shear panels and continuous stabilizers from martensitic 1500 high strength steel
  - Creates high main load-path for energy management

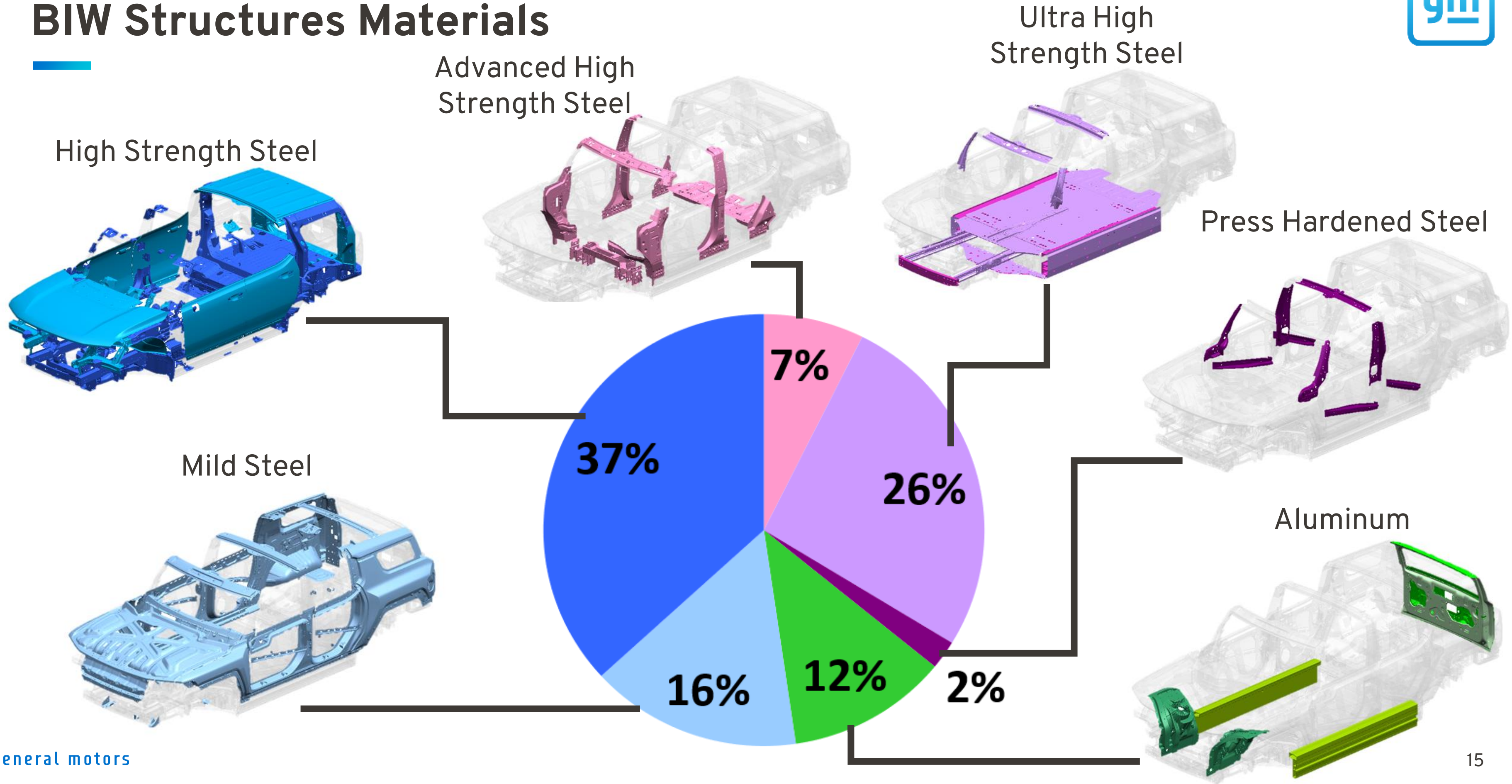


Shear Structure Development

- Lower shear structure system connects cradles and RESS
  - GA installed to enable manufacturing processing
  - Constructed of high strength multi-phase 980 steel shear panels with fore/aft stabilizers in GA panels and cross-car stabilizers in RESS
  - Helps generate continuity of load-paths and improve global vehicle stiffness



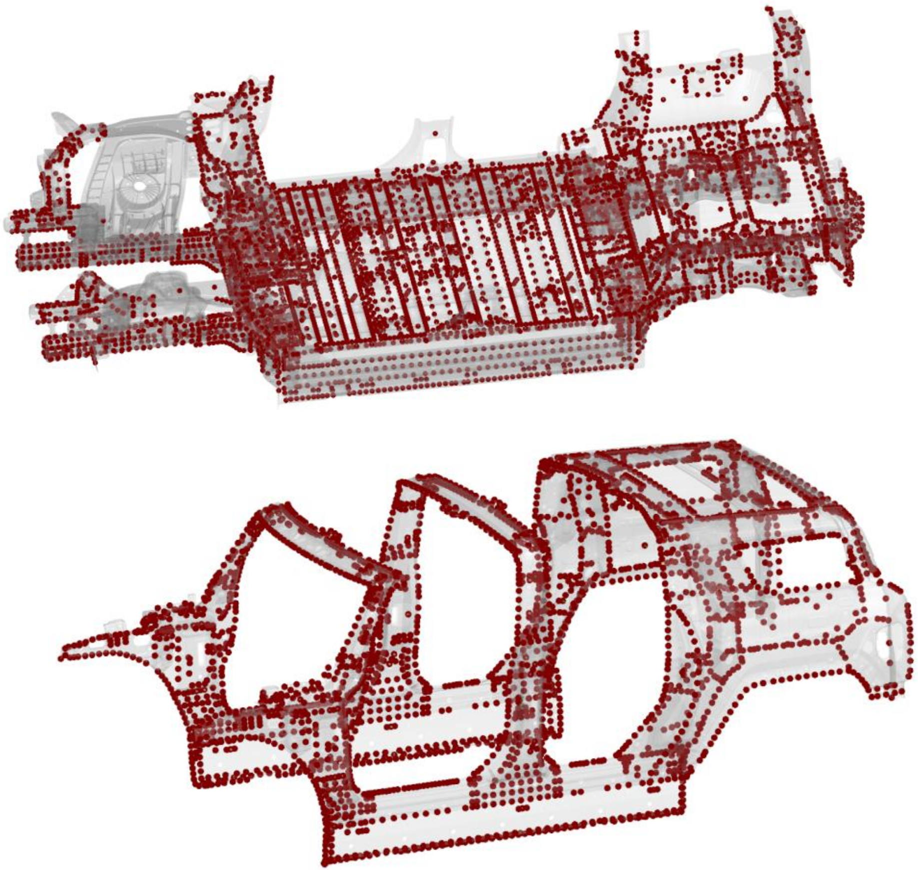
BIW Structures Materials



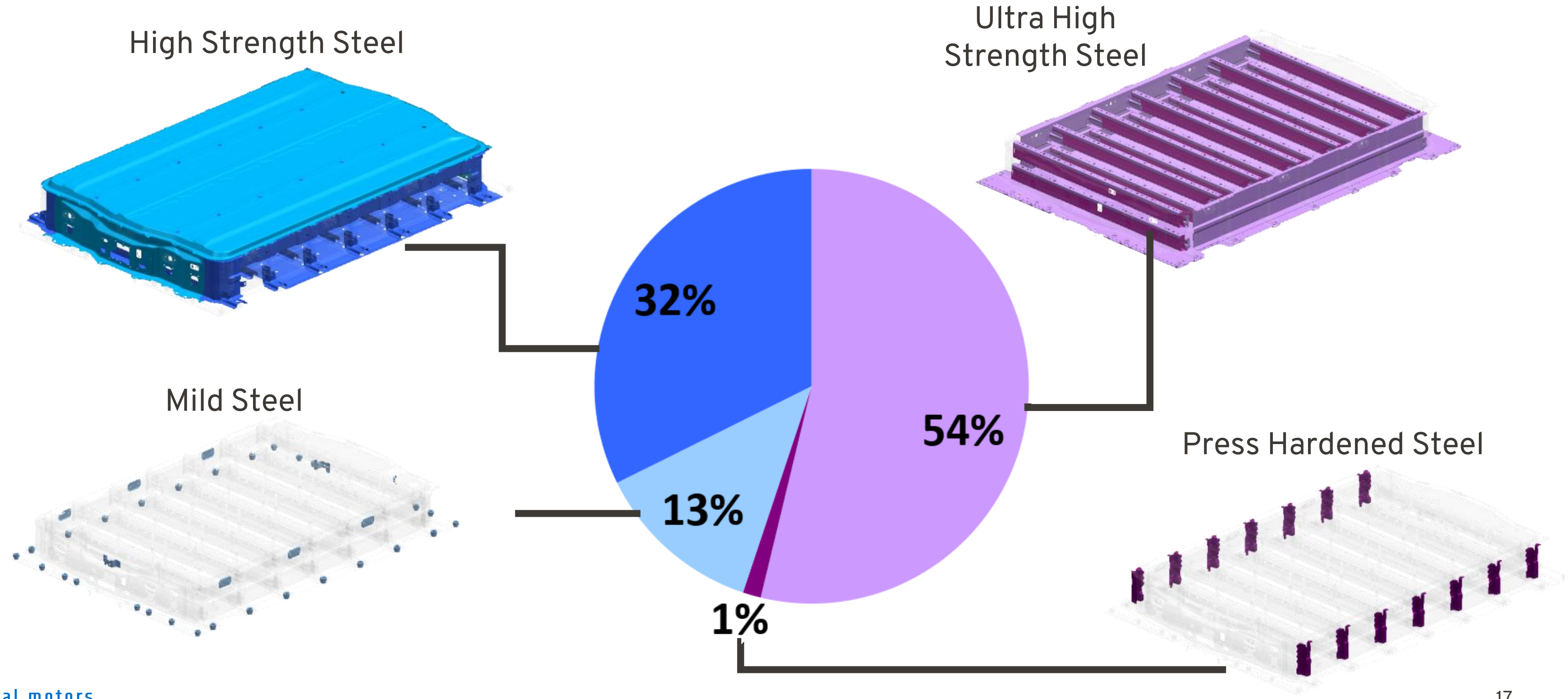
Body Structures Joining*

	HUMMER EV
Parts	611
Weld Spots	10,008
Weld Studs/Nuts	542
MIG Welds (m)	13
Laser Welds (m)	34
Laser Weld (#)	**949**
Adhesive (m)	144

*Body in White only. Does not include RESS Enclosure



RESS Structure Materials



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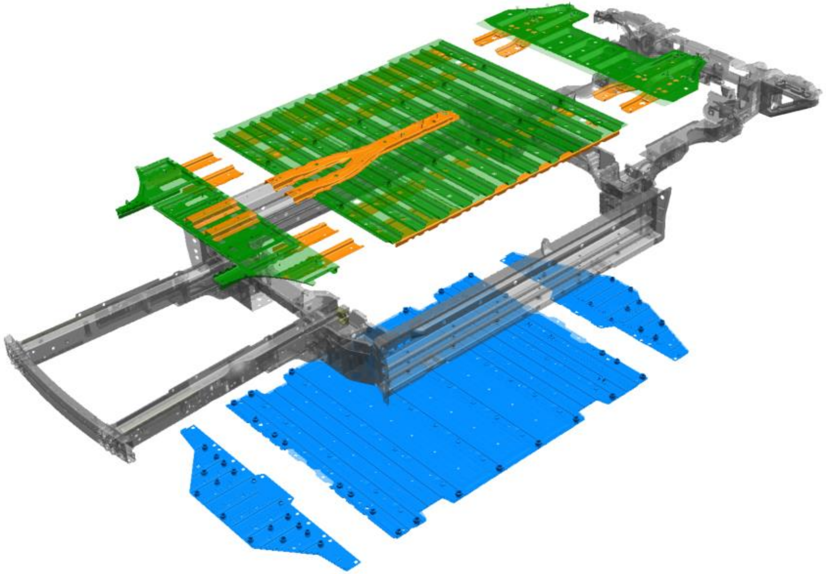
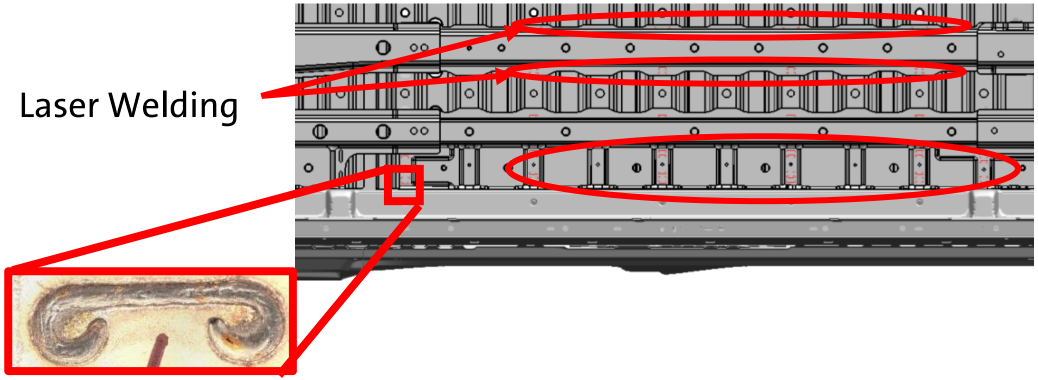
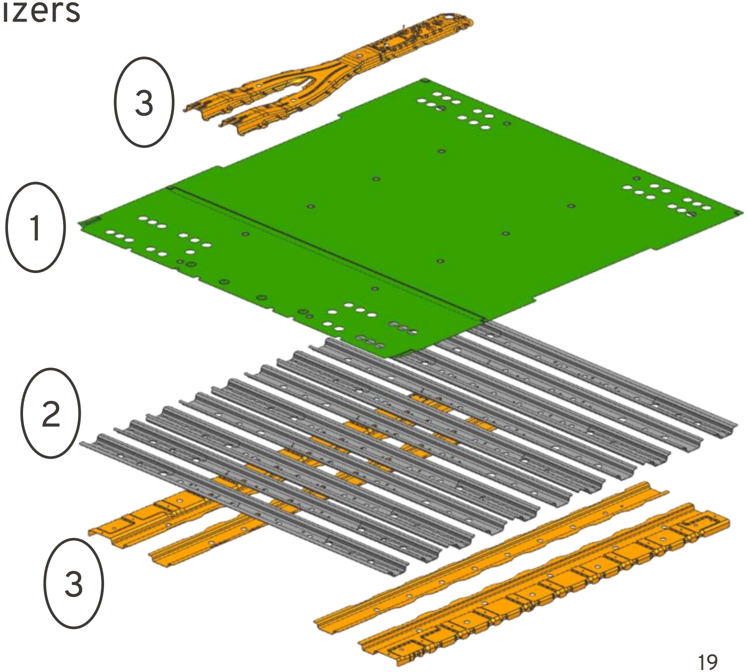


Floor Shear Structure Lattice

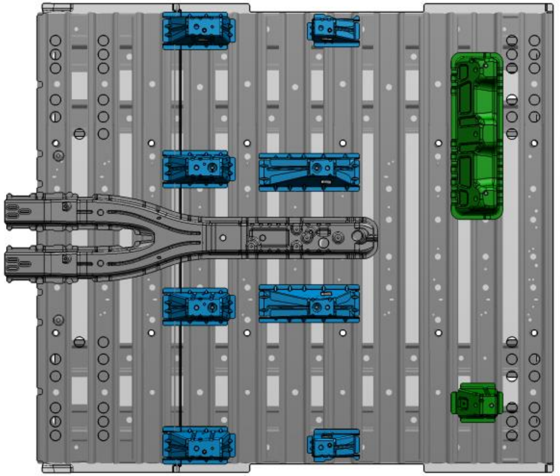
- Shear structure created with lattice build
  1. Top flat shear panel made of high strength material Multi-Phase 980
  2. Spot weld cross-car primary load-path and panel stabilizers
  3. Laser weld fore-aft stabilizers
- Laser welding enables closed sections
  – Minimal disruption to shear panel





Seat Pod Flexibility

- Primary floor structure created by attaching to under floor stabilizers
- No cross-car structure above floor skin
  - Provides room for wire harness routings and under-carpet air ducts
  - Pods located in common tool for dimensional control
- Discrete pods welded to cross car stabilizers
  - Improves pod stiffness and occupant performance
  - Flexible location for different occupant positions and future variants



Seat pods weld to underfloor stabilizers
(HUMMER Pickup: Blue only,
HUMMER SUV: Blue and Green)

Floor Lattice Corrosion Protection

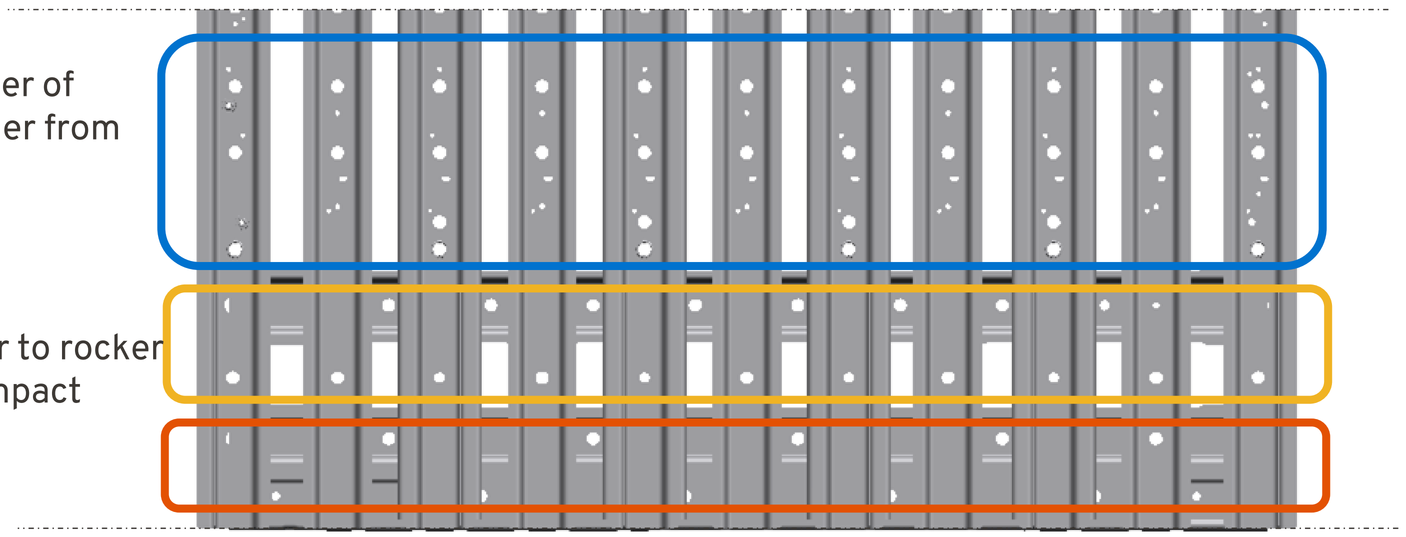
Many Holes added in lattice structure for ELPO coverage and drainage

– ELPO simulation used to adjust location

C/L

More holes in center of lattice where farther from charge source

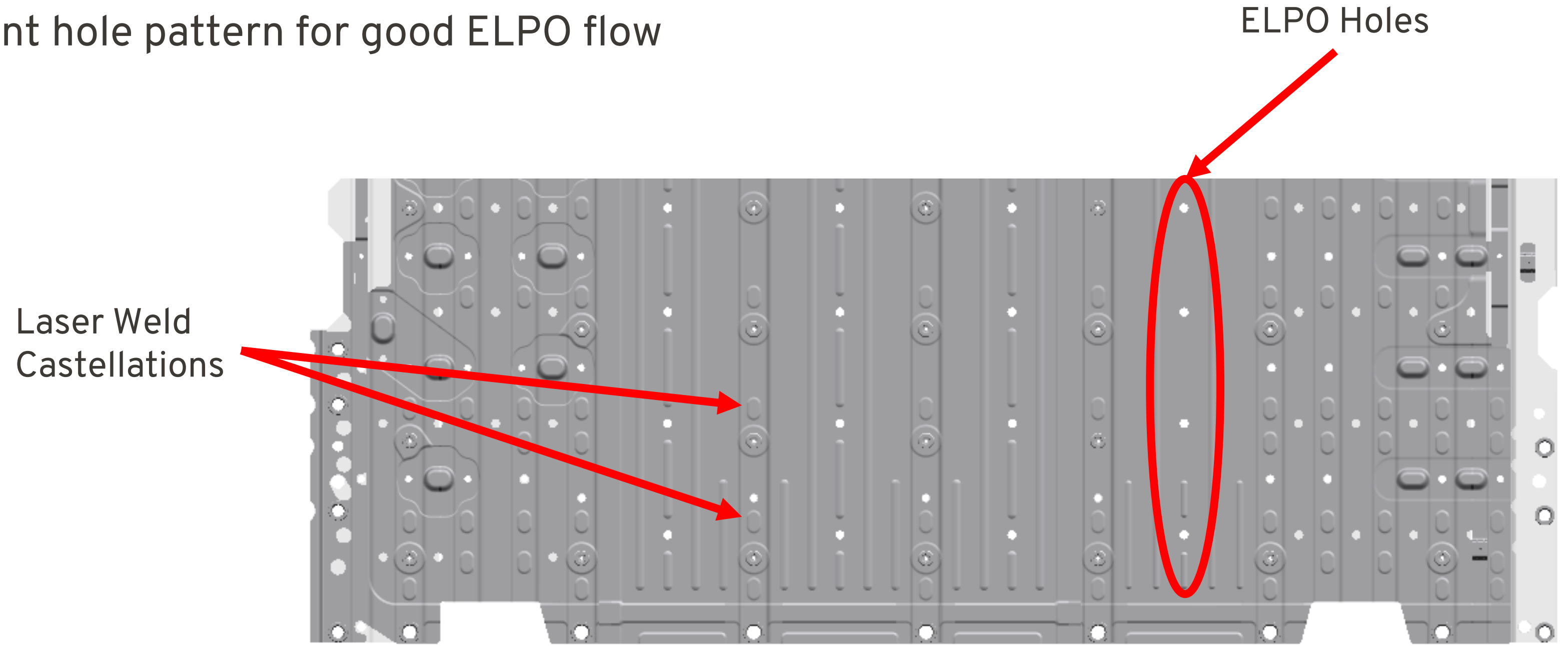
Fewer holes closer to rocker to enhance side impact protection



Rocker

RESS Shear Structure Corrosion Protection

- Lower panel castellated around laser welds to limit line to line contact
- Very thin section challenges ELPO coverage and drainage
- RESS structure dipped in tank sideways to facilitate drainage
- Consistent hole pattern for good ELPO flow



GM Great Designs in Steel Conference

William Perry - Department Manager - Engineering

Wednesday, May 24, 2023

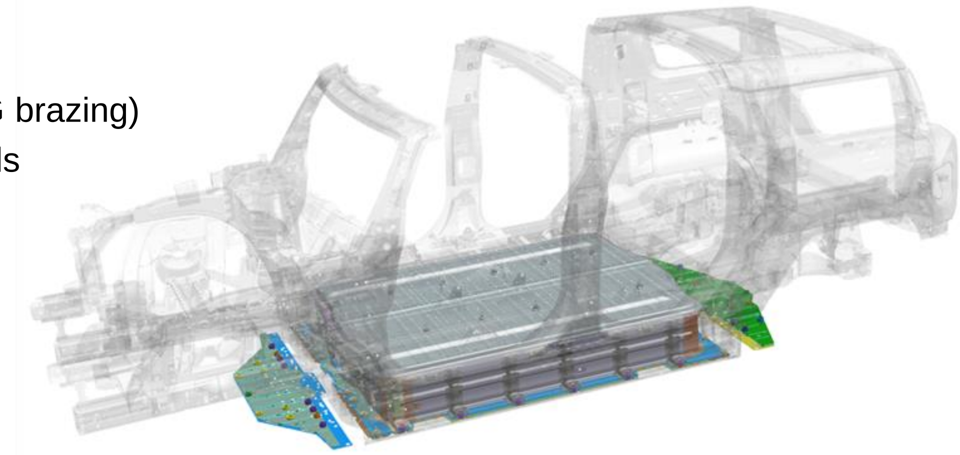
Cosma Assemblies Key Stats
2024 GMC HUMMER SUV Shear Plates

Materials

- Cold and hot stampings
- Rollform components

Joining Technologies

- Gas Metal Arc Welding & Gas Metal Arc Brazing (MIG brazing)
- Resistance Spot Welds & Resistance Projection Welds
- **Tactile Laser Welding**
- **Remote Laser Welding**



Laser Welding

- 1,900+ laser welds
- 76.1 meters of Remote Laser Welds
- 28.5 meters of Tactile Laser Welding

Types of Laser Welding

- Laser staple shape
  - Curl of staple isolates stress risers that form at start and end of weld
  - Length optimized for space and strength characteristics
- Alternate shapes used in unique packaging situations
  - Laser spot in small areas
  - Straight line used with limited section height
  - Longer staple for added strength when required

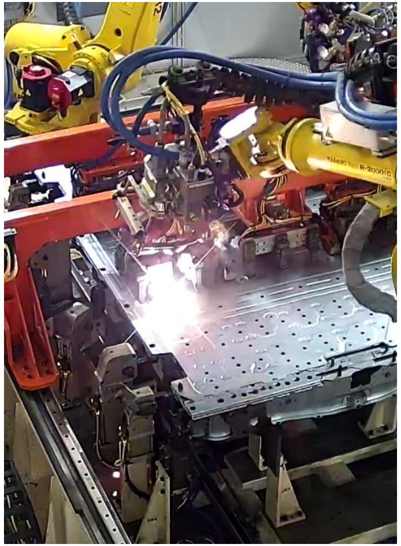
Laser Staple

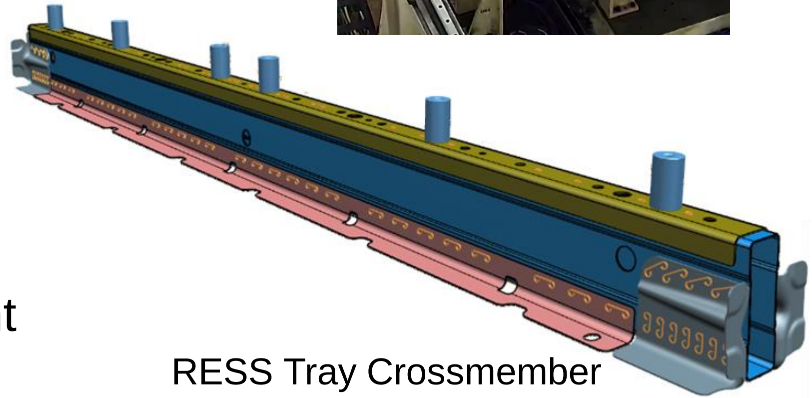
Laser Spot

Laser Stitch

Benefits of Laser Welding

- Strength
  - 1 Laser Remote Weld ≥ 1 Resistance Spot Weld
- Speed
  - 2 to 3 Staple Welds per second
  - High productivity
- Single sided process
  - No back-side access required, unlike resistance spot welding
  - Welding onto closed tubes, long channels
    - Maintain strength of structures
- Low heat input
  - Low part distortion
  - Weld near sealant without degrading sealant





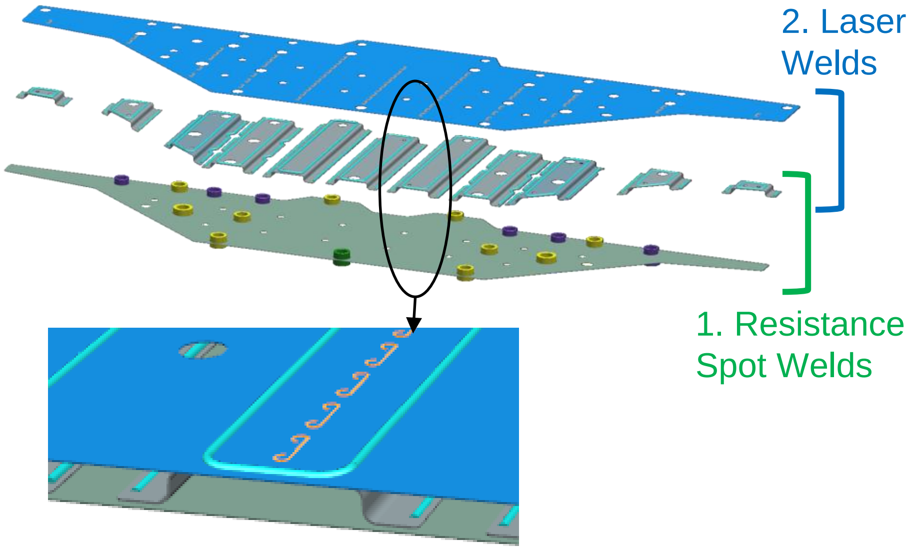
RESS Tray Crossmember

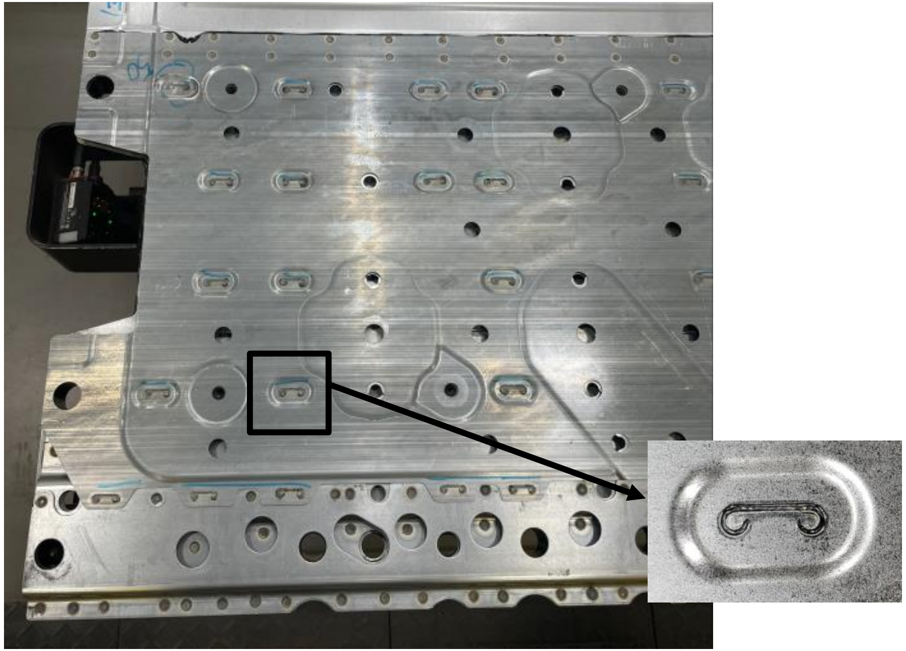
Laser Weld Locations

- Front and Rear Shear Plates
  - Laser Staples are utilized

- RESS tray
  - RESS Lower Shear Structure
    - Laser staples are utilized

Front Shear Plate (Exploded View)

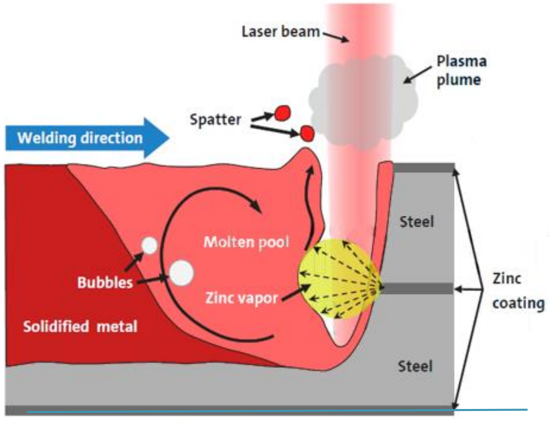




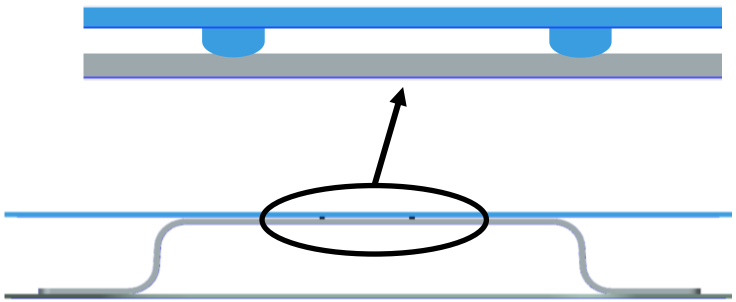
Underside of RESS Tray

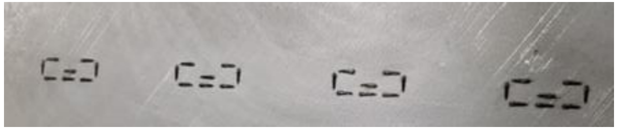
Variables of Laser Welding
Cosma's Lessons Learned

- Plasma plume absorption of laser beam – inconsistent weld penetration
- Spatter ejected back toward laser head – Cover-slide high replacement frequency
- Optimize process to minimize spatter and add air jets to control plume and spatter
- Trapped zinc vapor can blow out into weld pool
    - To combat this, a Laser dimple was added to the mating surface to create ~100 um gap



Mechanism of Zn outgassing



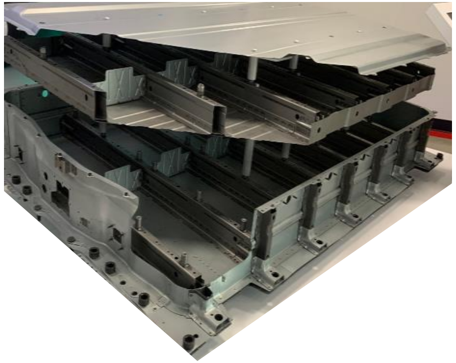


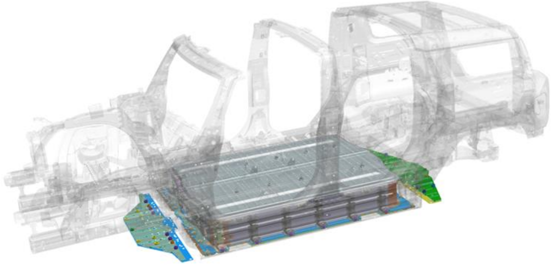
Actual Laser Dimples

Laser Welding Collaboration Efforts

MAGNA

- Collaboration team consisted of GM / MEVS / Massiv Automation / Cosma Engineering
- Program collaboration (development, design, and process):
  - Early up-front planning – cell and tool design, equipment selection, physical weld trials and evaluations
  - Dimensional control / tolerance allocation / slip planes (part to part fit-up) / assembly sequence development
  - Optimization of Tooling / clamping placements to obtain repeatable weld gaps
- Take-aways for future programs
  - Very early upfront design development with supplier which allows for early validation and testing of intended processes and equipment
  - Using production intent components, build early assemblies to understand the variables for dimensional stability
  - Early feasibility & physical weld trials to understand the variables and how to optimize for each weld

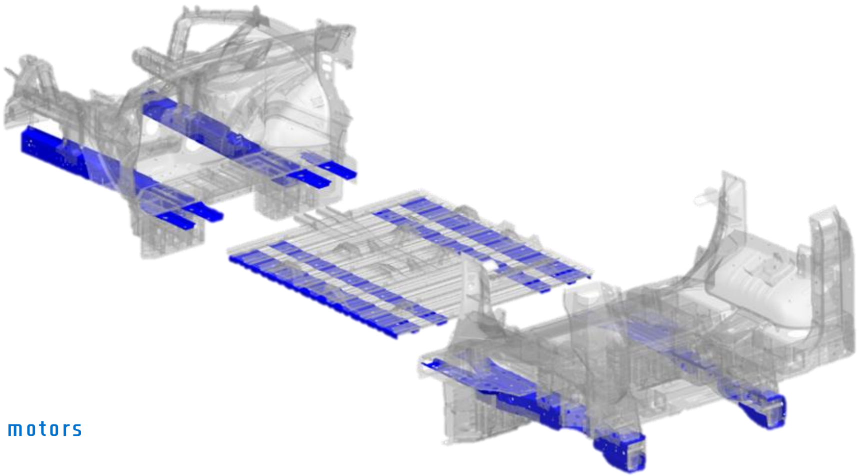


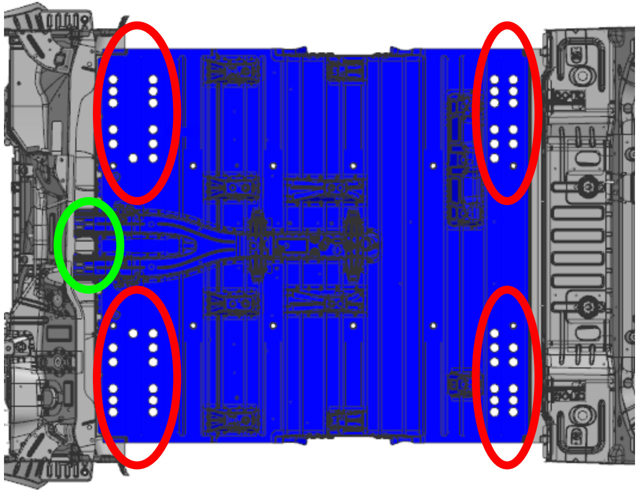


Forward. For all.

Underbody Marriage

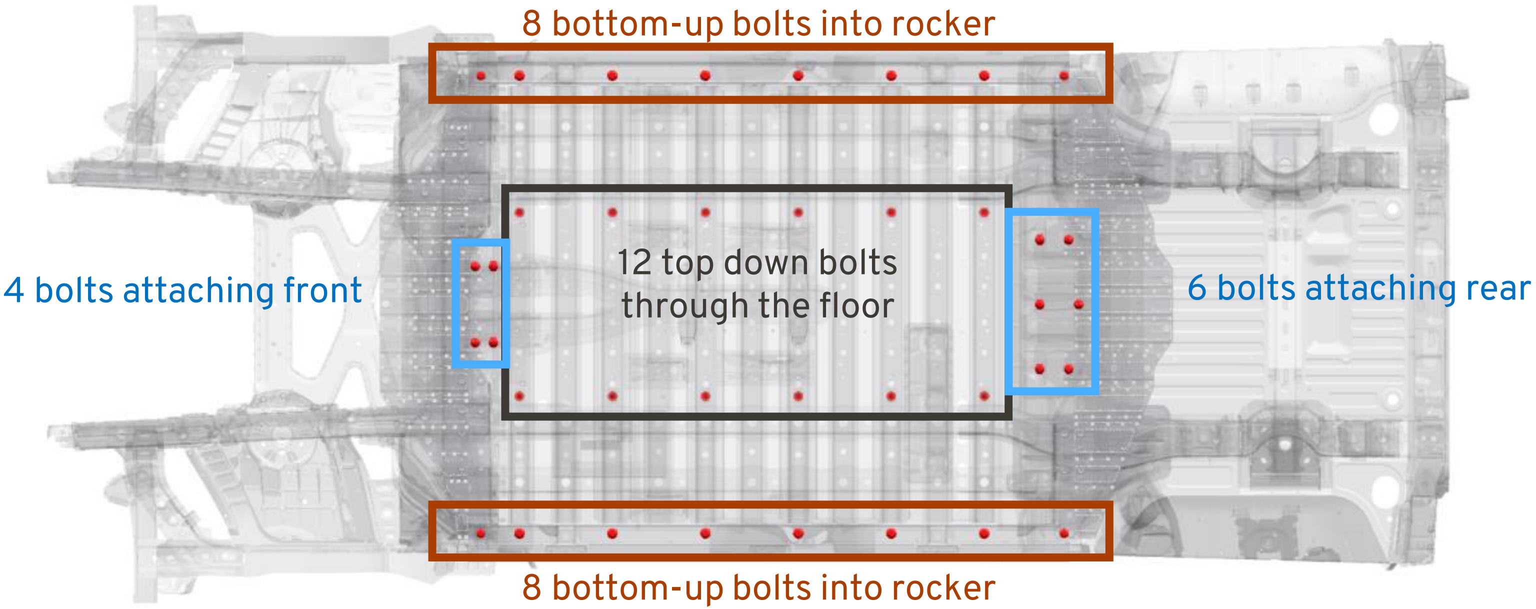
- Marriage loads front and rear compartment first and center compartment last
  - Center floor shingled on top
  - Helps improve dimensional capability for RESS attach (12 bolts in center area)
- Continues load-path from front and rear rails (blue parts)
- Weld access holes to connect rails across compartments
- MIG welds to front stabilizer across front compartment joint





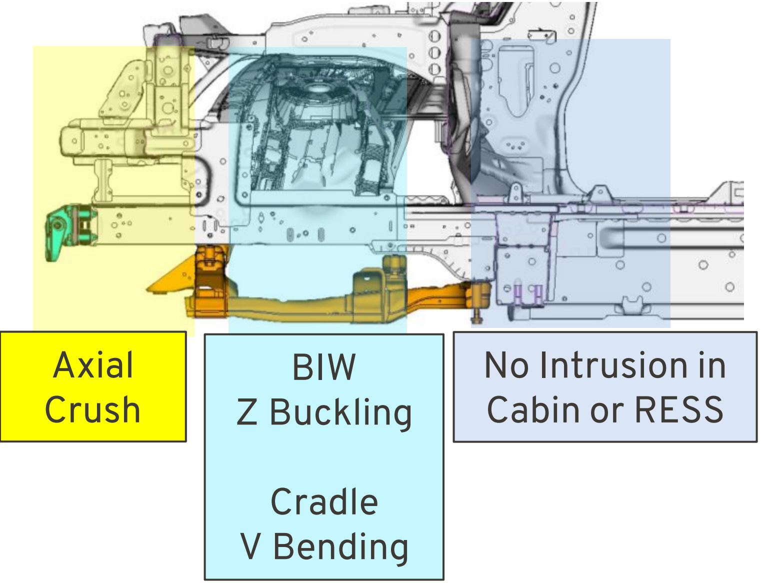
RESS Fastener Install

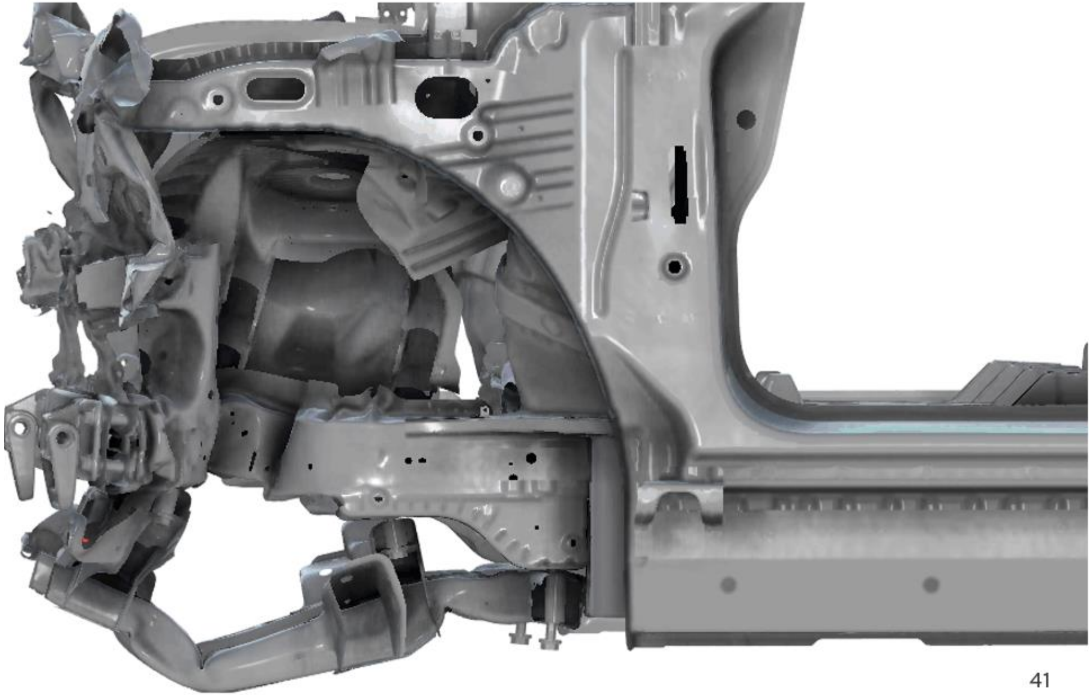
- 38 bolts attaching RESS structure to body structure
  - Spans across 8 different critical sub-assemblies
  - Complex dimensional control plan and challenging execution



Front Impact Rail Crush

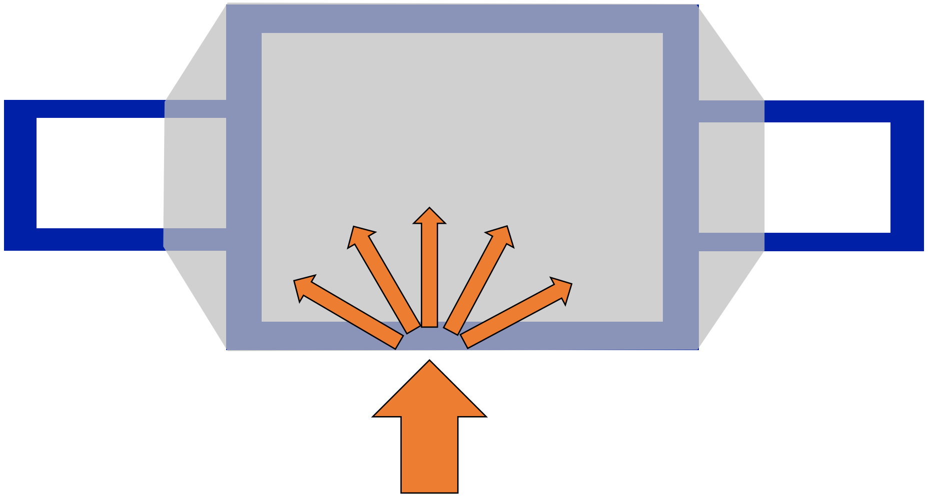
Shear structure provides stable back-up structure to support desired rail crush mode

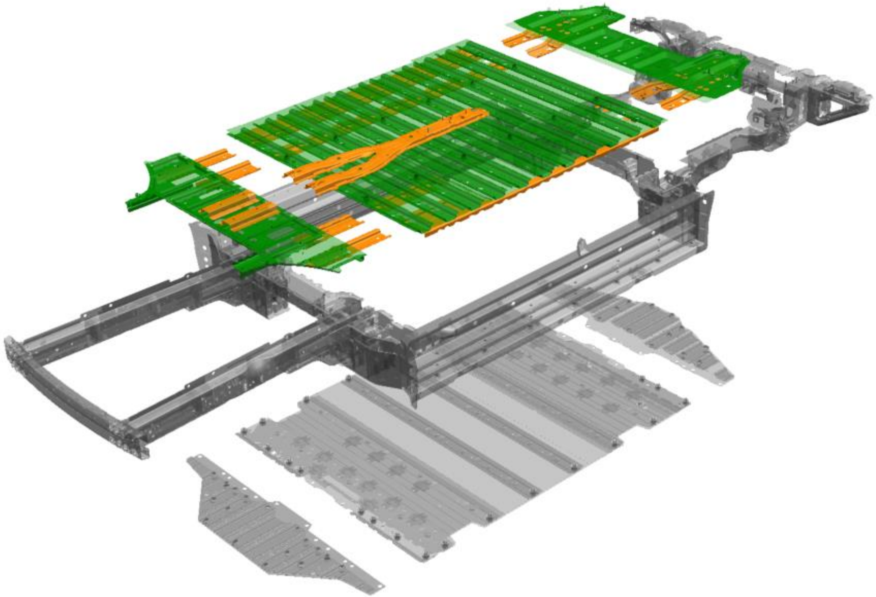




3-Box/Shear Structure In Side Impact

Load transfers through rocker section into shear structures and RESS crossbeams



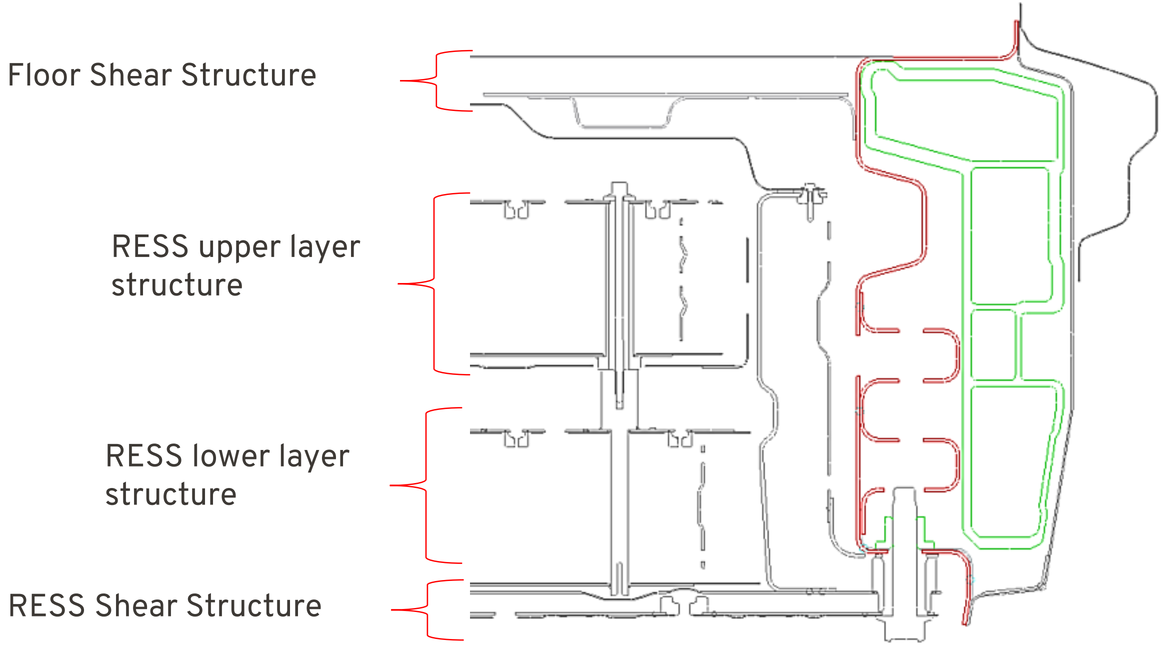


Side Pole Results

Slowing ~5 Ton vehicle from 32 kph in less than 120mm → generates 1.6MN!

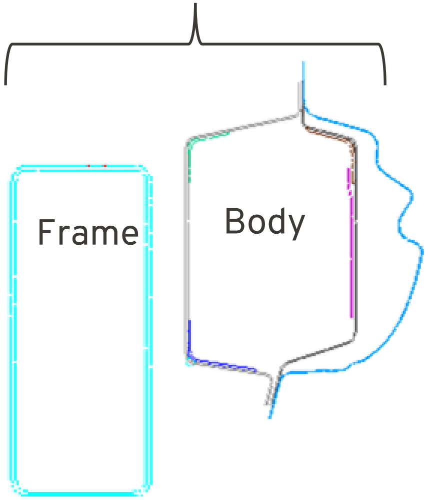
Rocker System Size*

Tall section due to **double-stacked** RESS

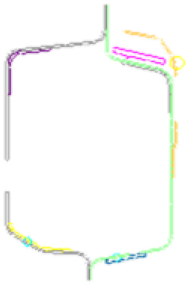


Compare to……

Full Size Truck
Chevy Silverado (BOF)



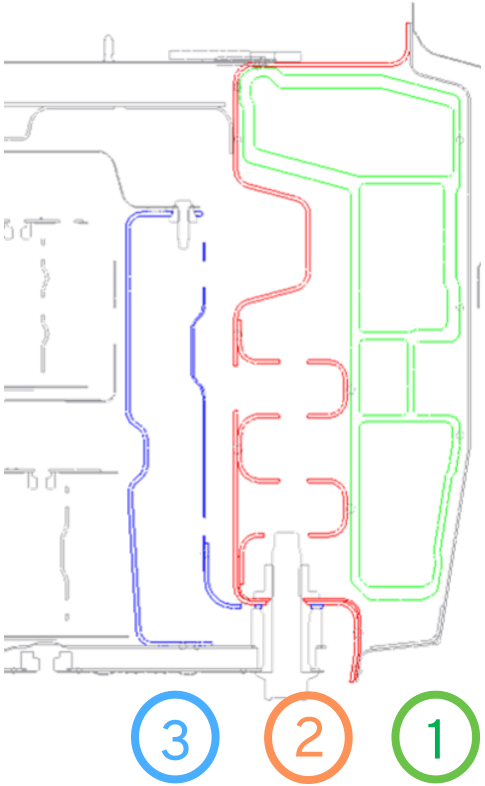
Chevy Equinox
SUV (BFI)

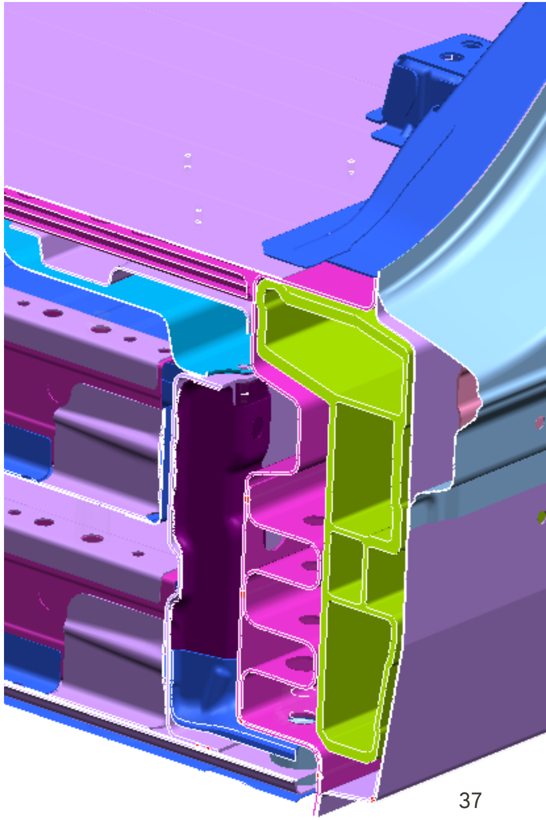


*Images to scale

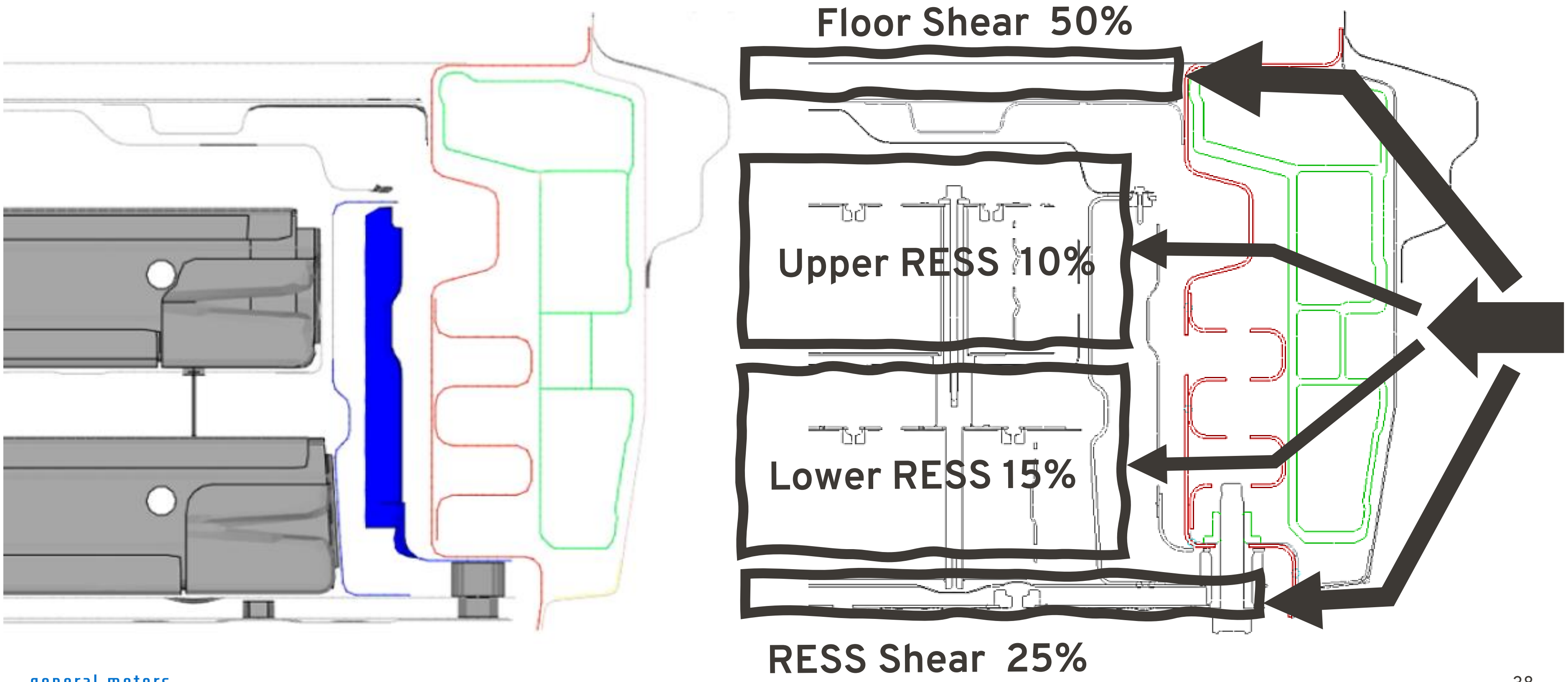
3-Zone Energy Absorption & Back-stop

1. Extrusion for Energy Absorption
   - 6000 Series Aluminum
   - Absorb incoming loads in a controlled manner
   - Full rocker length to protect RESS in all impact locations
2. UHSS back-stop in rocker
   - Martensite 1500 Roll-form for full length protection of RESS
   - Strong to induce EA crush
   - Direct load-paths to supporting RESS back-up structure
3. UHSS structure in RESS
   - Full Length Multi-Phase 980 Side Wall
   - Local PHS Risers





Side Pole Crush Behavior



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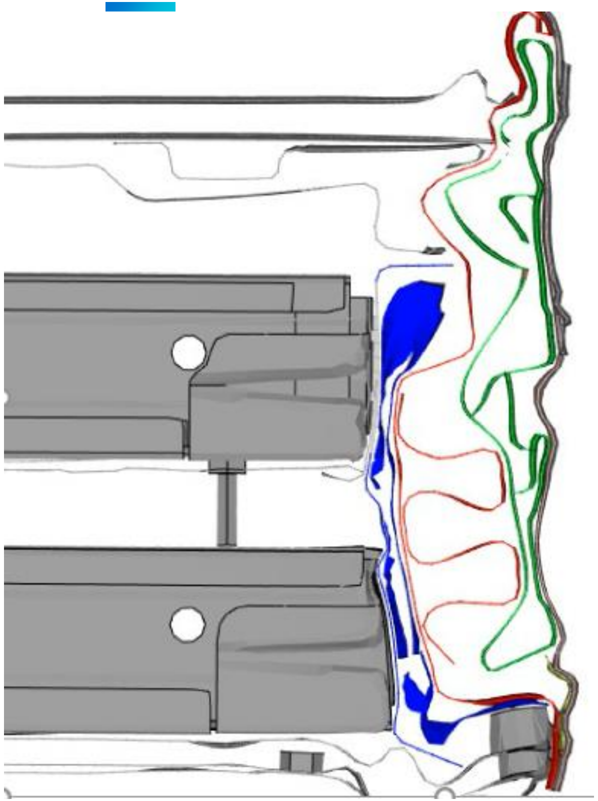
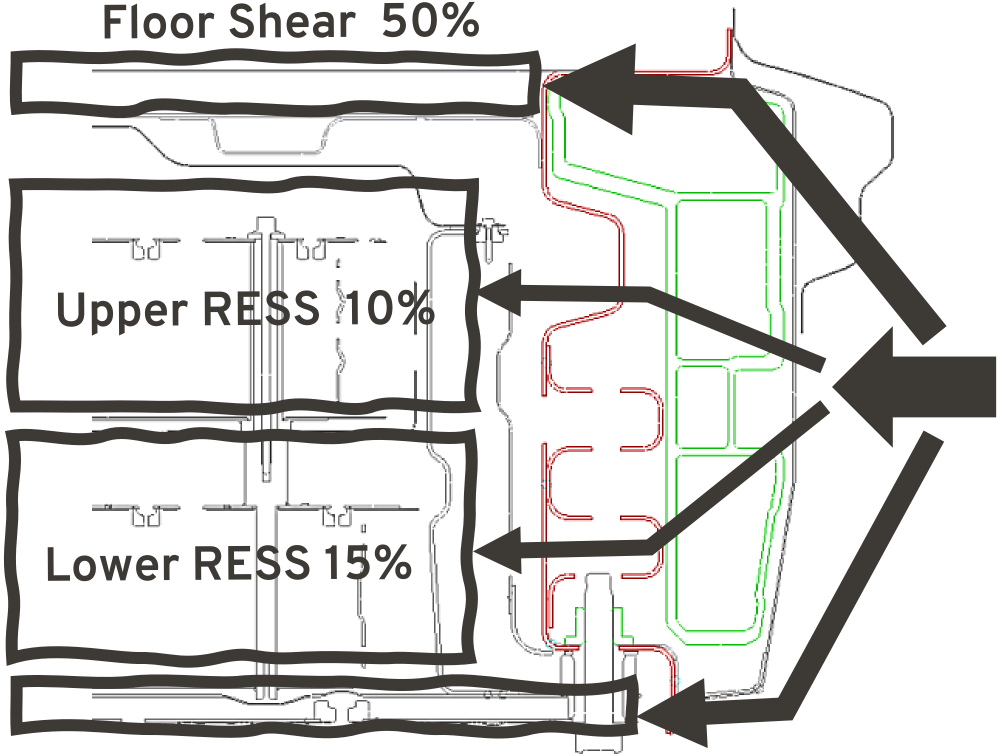
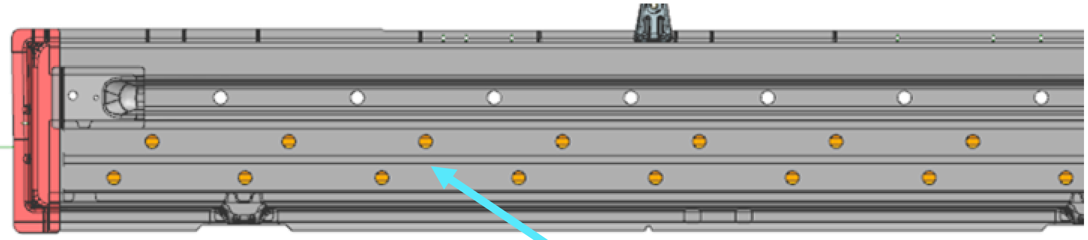
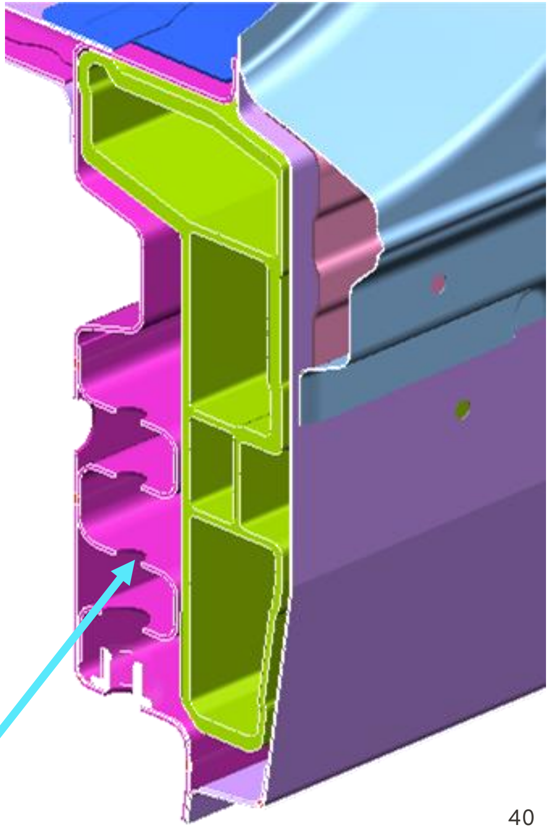




Rocker Corrosion Protection

- Expandable adhesive for galvanic isolation
- Aluminum extrusion became heat sink in ovens
  - Thermal analysis/iterations required to ensure ELPO coverage/cure
  - Many ELPO holes required in steel backstop parts
  - Additional holes required to improve heat transfer
  - Early mock-up baked to correlate analytical tools



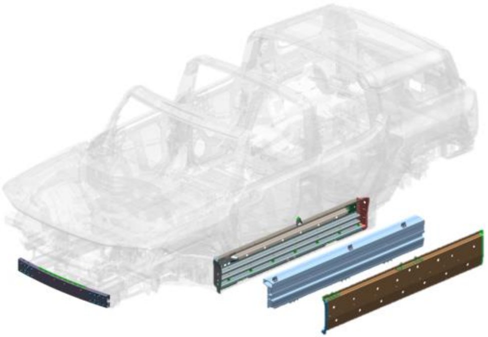


Many holes for ELPO coating/ curing

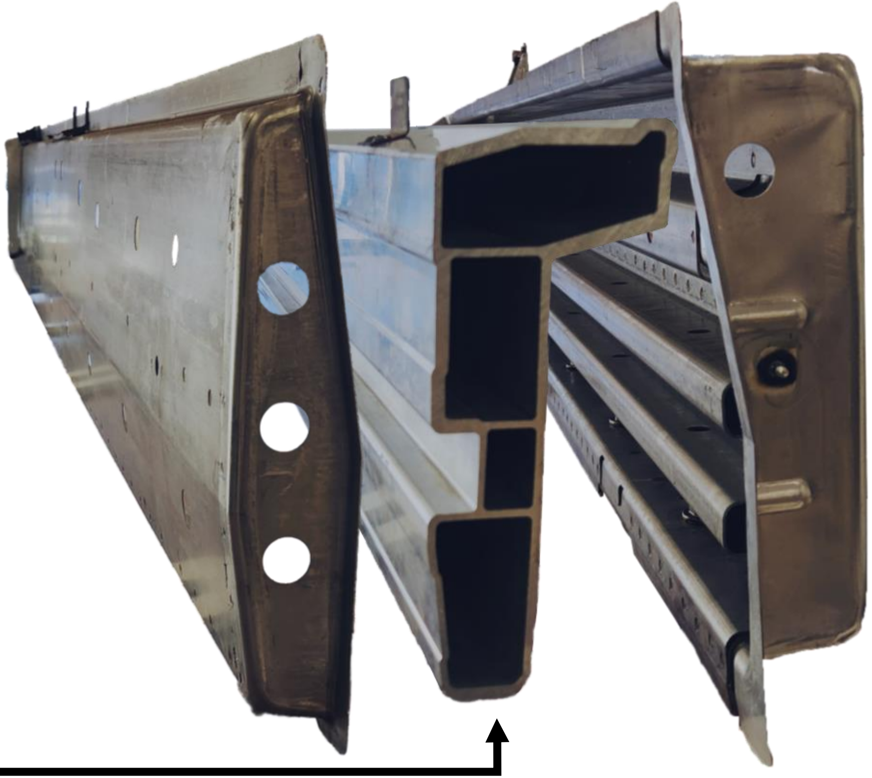
David Seiter

Global Engineering Leader

Exploded View of Rocker Sub-System



Rocker Outer Assembly
- 2 Roll Form Parts
- 3 Stampings
- Sealer
- 110 Spot Welds
- 6 Weld Nuts
- 10 Kg

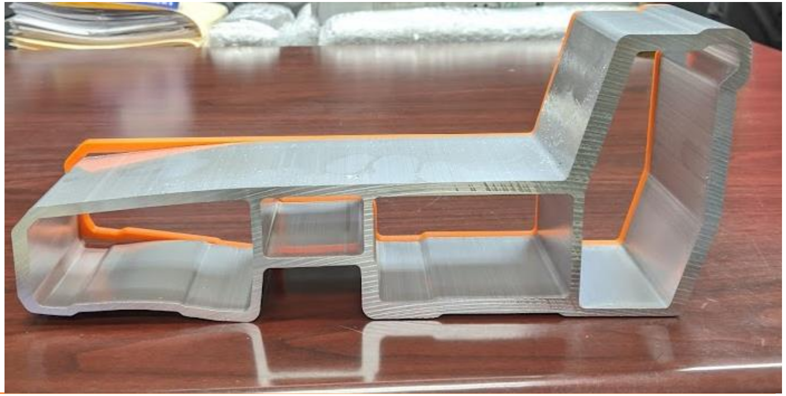


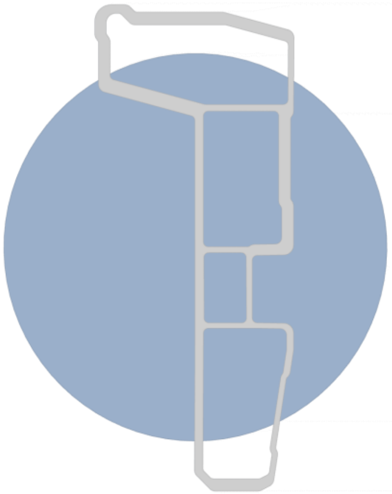
Rocker Insert
- 1 Extrusion
- 6 Stampings
- Adhesive
- 15 Rivets
- 30 Kg

Rocker Inner Assembly
- 3 Roll Form Parts
- 6 Stampings
- Sealer
- 250 Spot Welds
- 18 Weld Nuts & Studs
- 35 Kg

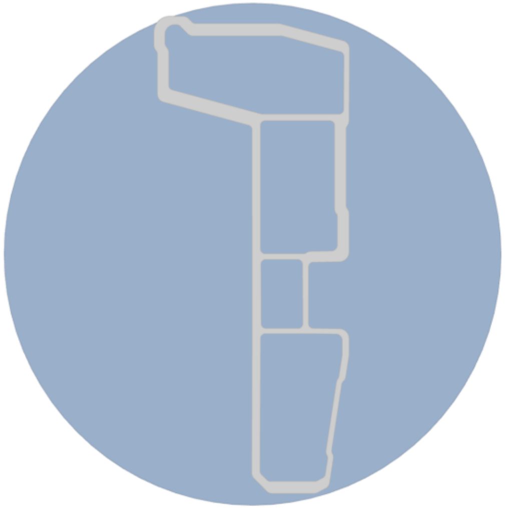
Rocker Insert – Aluminum 6082

- We started on a 9” press. On the 9” press the circle size of the part is greater than the press size by a significant amount
  - Due to the multi-void hollow and the height this was very abnormal
- We used 3D printed parts to ensure the entire Value Stream would have no issue with a part this size





Prototype



Production

Roll Forming Challenges

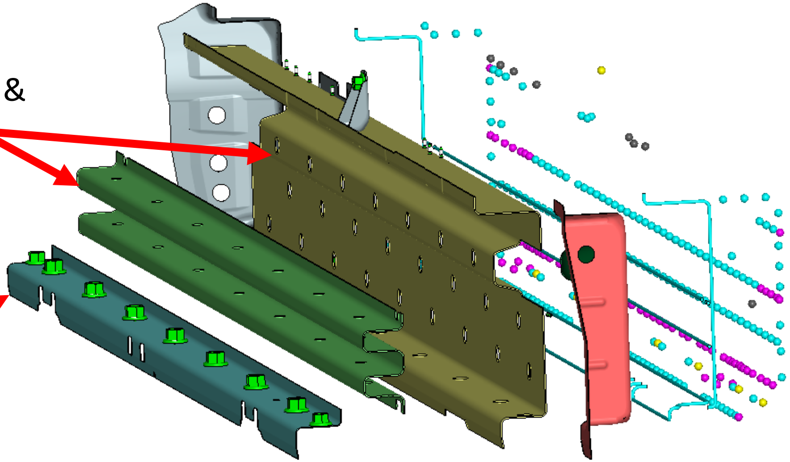
- The size, strength and thickness of the part were going to result in some unique issues that we had to plan for
- This led to some new methods of development for Shape
- Tolerances – Raw material tolerances, component tolerances and stacking into an assembly.

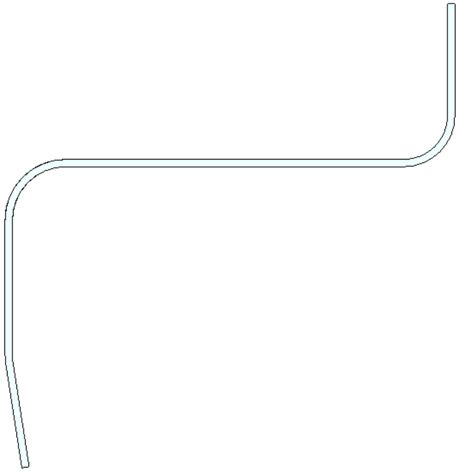
Rocker Inner Panel & W-Reinf

2 mm MS 1500

RESS Reinf

1.1 mm MS 1500



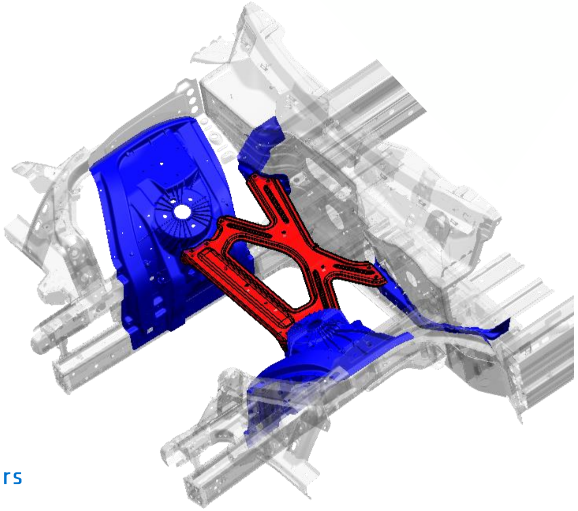


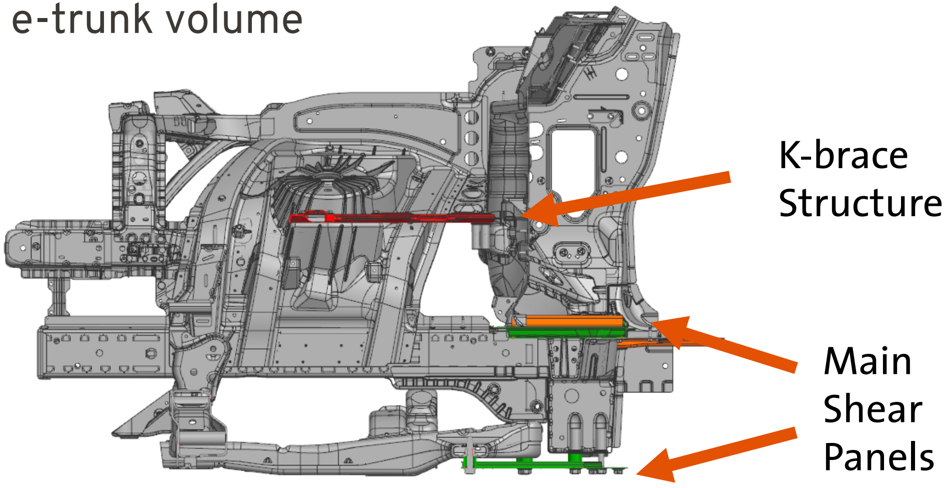
The Assembly Collaboration Story

- Equipment strategy that would scale with the launch curve.
  - Plan for initial low volume and ensuing high volume.
- The process flow & logistics complexity – multiple Shape locations & processes. Some of those processes were new!
- Material handling – larger than typical Shape Corp parts
- Assembly equipment availability & industry shortages

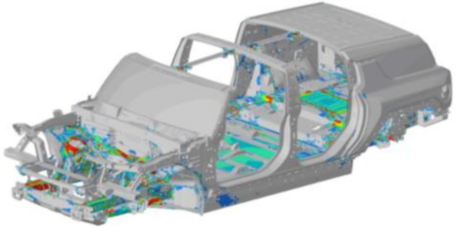
“K-brace” Added For Front End Stiffness

- Efficiently braces across shock towers and to dash panel
- Improves global stiffness of body structure
- Provides support for front storage bin (e-trunk)
- Optimized in a low position to improve e-trunk volume





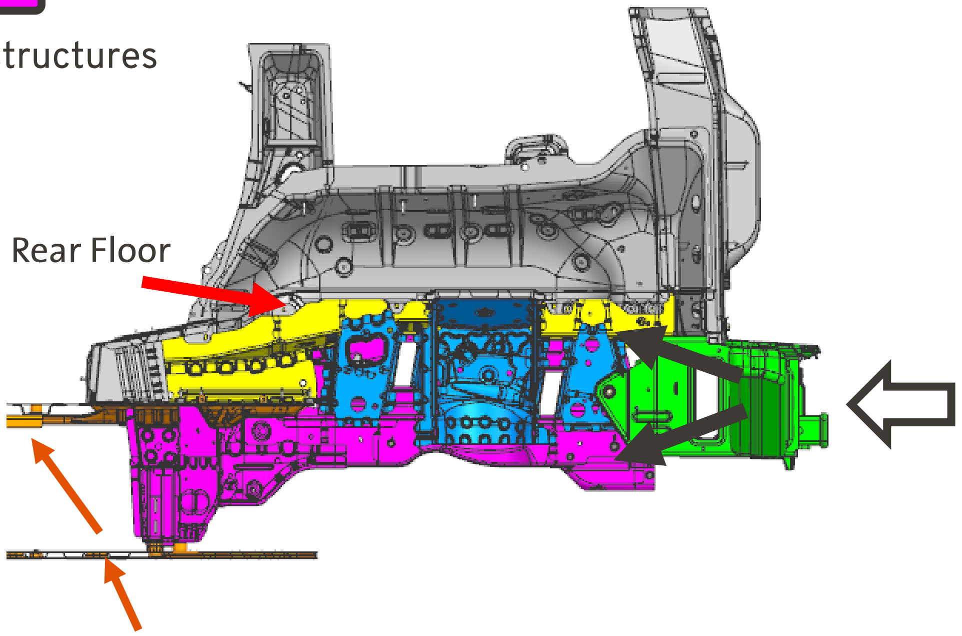
“K-brace” Improved Global Stiffness



- Increased rigidity during torsional inputs with K-brace structure
- Reduced stiffness discontinuity

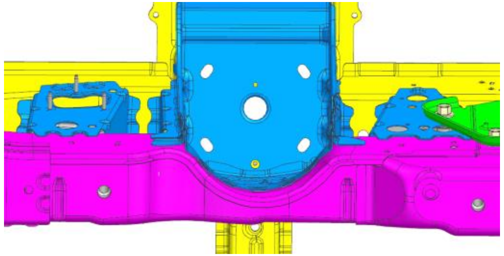
Rear Compartment - Double-Stack Rails

- Lower rail is primary impact load path
  - Creates rear of 3-boxes, aligned to shear structures
- Upper rail for added stiffness
  - Enables high travel suspension and supports rear floor
- Trailer hitch standard (bolt on)
  - Distributes crash and towing loads into both sets of rails
- Suspension Arched Support
  - Distributes loads in lower rail around suspension

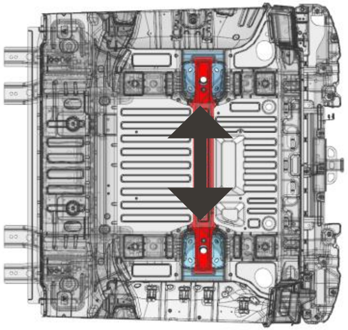


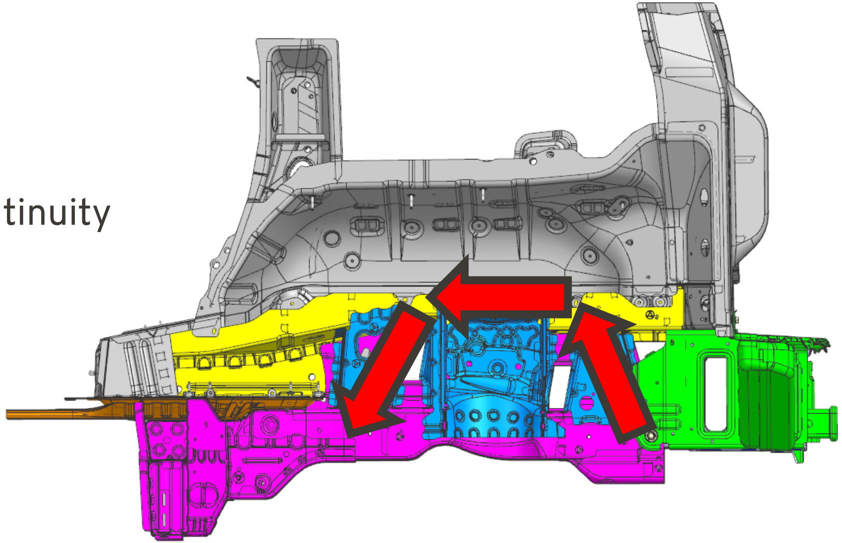
Rear Shock Interface

- Main rail section reduced for air suspension
  - Significant discontinuity in lower load path
- Arched load path at shock attachment
  - Directs load-path up and over the rail notch
  - Improves durability and stiffness
- Efficient connection tying shocks together
  - Helps continuity of load-path and stiffness continuity



Bottom View





FACTORY ZERO

A significant step in realizing GM's vision

of

Zero crashes, Zero emissions, Zero congestion

Thank You for Your Attention!

EVerybody is in on an all-electric future

everybody in.