GREAT DESIGNS IN STEEL

ARCELORMITTAL MULTI PART INTEGRATION™: PIONEERING NEW BEV ADVANCED BATTERY ENCLOSURE DESIGN

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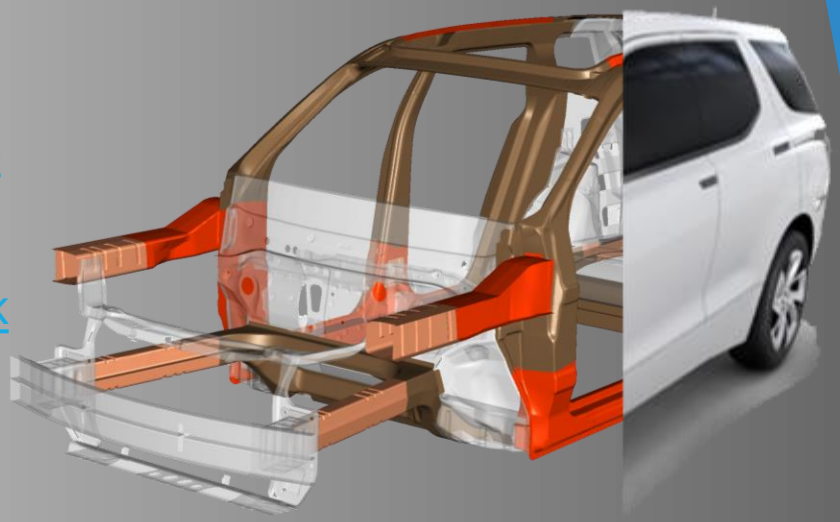
Agenda



Changes in the Automotive industry

GDIS

Electrification Challenges

Cost increase

+40-50%

Fleet CO_2 targets

<100 gms per km

Assembly line upgrades

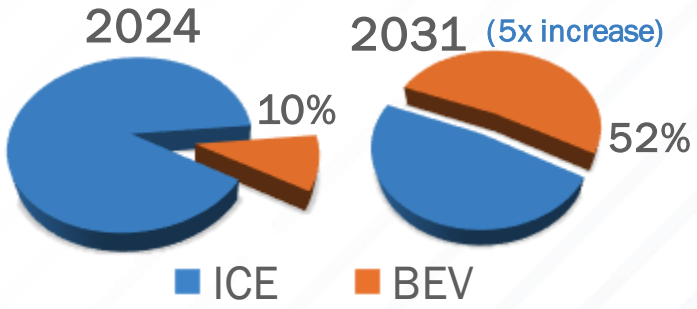
Heavy vehicles

+20-30%

Battery & Occupant protection

Battery Pack Logistics

BEV Production Volume



Source: S&P Forecast – March 2024

Ongoing Development & Implementation

Part Consolidation

Tailored Steel Blanks

Additive Manufacturing

Die Castings

Modular Platforms

Flexible Cell Manufacturing

Supply Chain Sustainability

Mix Material Light-weighting

Evolution of BEV design concepts

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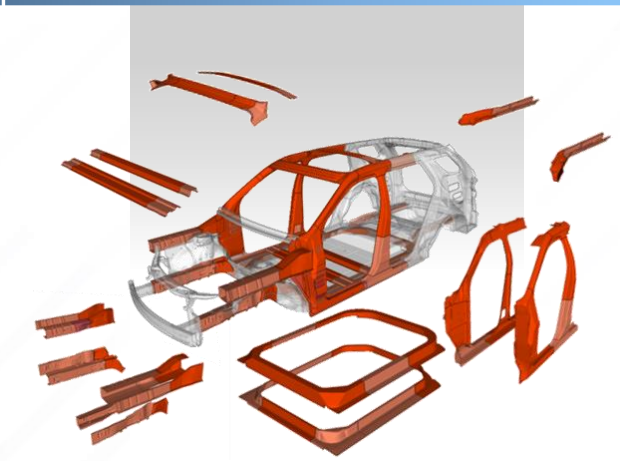
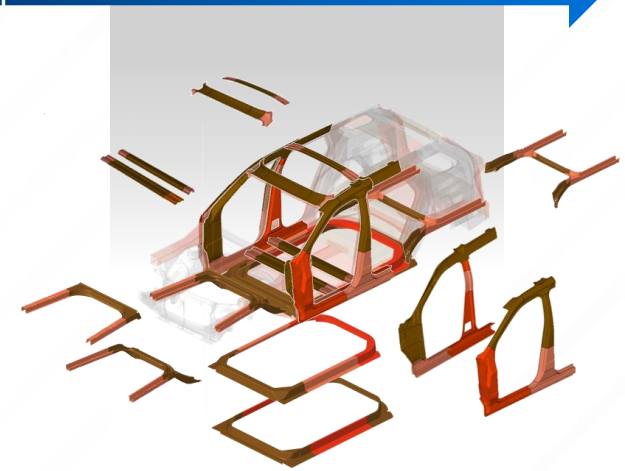
AMTB BEV (2020)



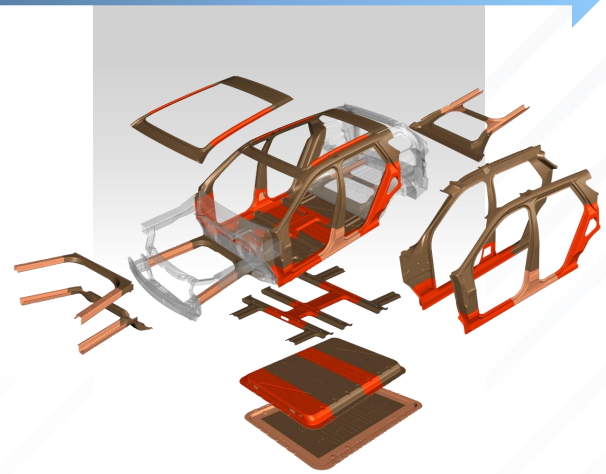
Design Highlights
- Door rings – the first MPI
- Battery rings
- PHS LWB Front & Rear Rails
- PHS LWB Floor & Roof Crossmembers
- Ductibor 1000 Introduced
- **Assembly simplification** – 28 fewer stampings
- ~250 kg CO_2 emissions reduced
- ~50 kg gross mass reduced

AMTB BEV2.0 (2022)



Design Highlights
- Rear rail H-frame
- Front rail U-frame
- Door Rings (w/ PHS 2000)
- Battery Rings (w/ PHS 2000)
- **Assembly simplification** – 39 fewer stampings
- ~340 kg CO_2 emissions reduced
- ~60 kg gross mass reduced

AMTB NBEV (2023+)



Design Highlights
- Double Door Ring Inner & Outer
- Floor Cross Member MPI
- Double Door Ring Inner & Outer
- Structural Battery Cover & Battery Tub
- Front U-frame
- Rear O-frame
- **Assembly simplification** – 59 fewer stampings
- ~380 kg CO_2 emissions reduced
- ~90 kg gross mass reduced

AMTB BEV concepts evolving with architecture changes offering assembly simplification and sustainability benefits

ArcelorMittal Multi Part Integration™ (MPI) Concepts

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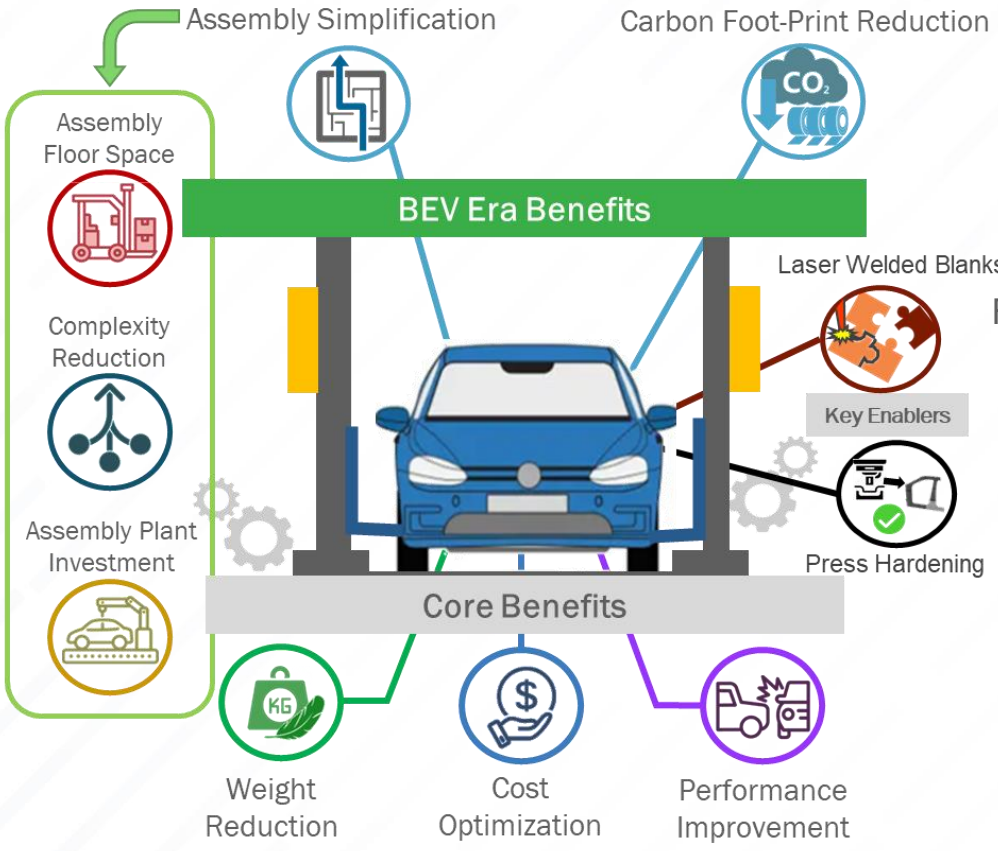

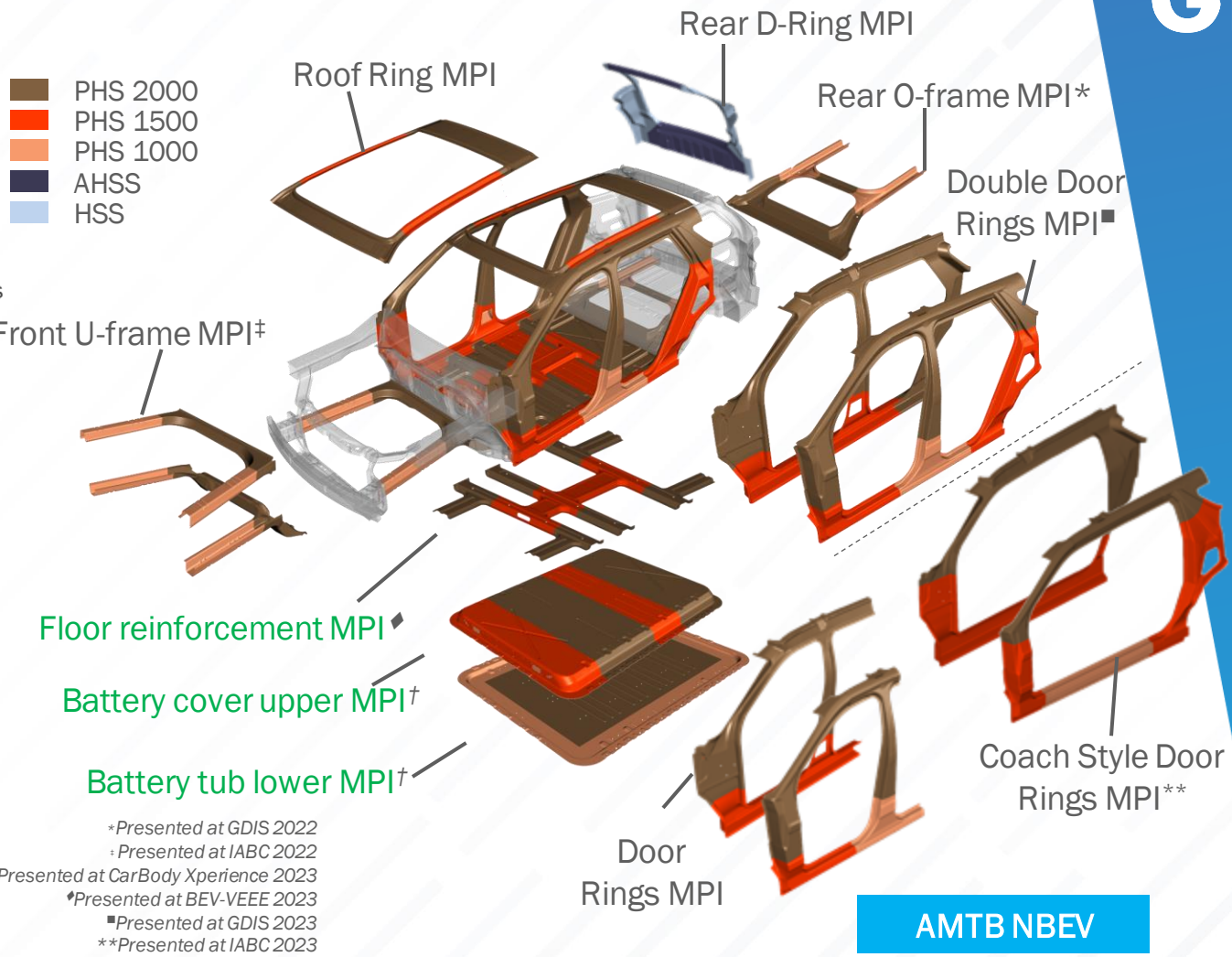

*Presented at GDIS 2022
‡Presented at IABC 2022
†Presented at CarBody Xperience 2023
♦Presented at BEV-VEEE 2023
■Presented at GDIS 2023
**Presented at IABC 2023

OEMs have realized MPIs concepts as one of the key drivers for innovation in BEV Era

Evolving Battery Pack challenges from the industry

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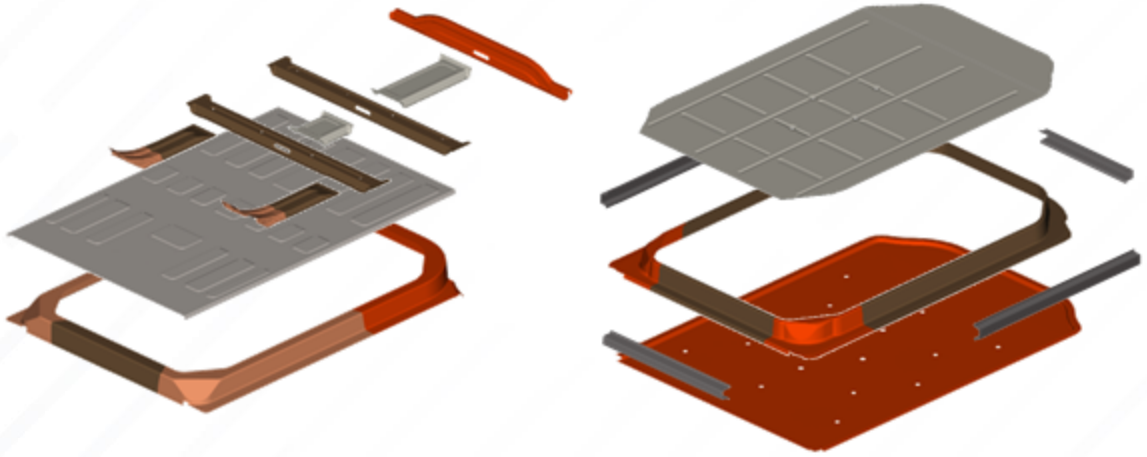
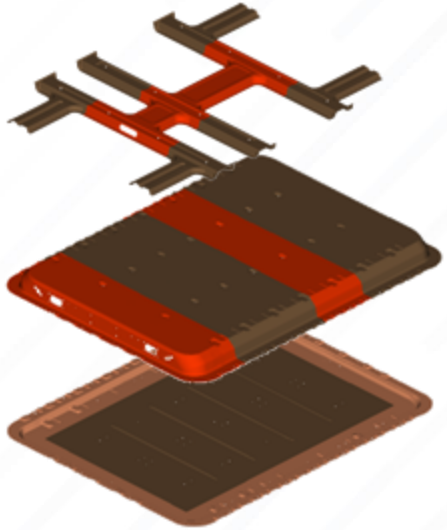
AMTB BEV – Battery Rings

- Architecture commonality with ICE vehicles
- Lightweight, cost-effective solution
- Scalability across vehicle segments
- Maximizing Battery capacity
- Recyclability – Steel Intensive design



AMTB NBEV – Structural Battery Pack

- Part consolidation – 3 stampings
- Minimizes assembly operation
- Excellent sealability



Limitations

16 stampings in assembly – Multiple sub-assemblies

Spotwelded Lower shield – additional sealing needed

AMTB's MPI solutions are implemented with evolving market needs

AMTB NBEV MPI Concepts – Structural Battery Pack

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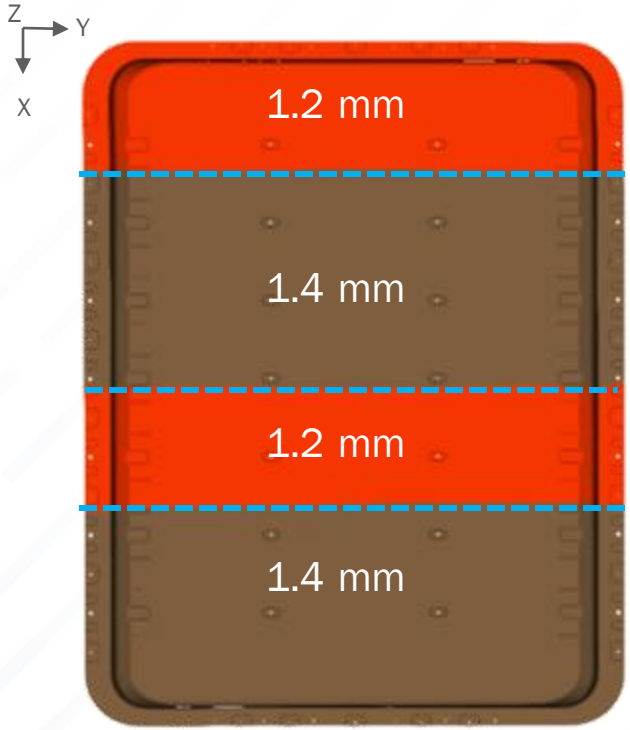
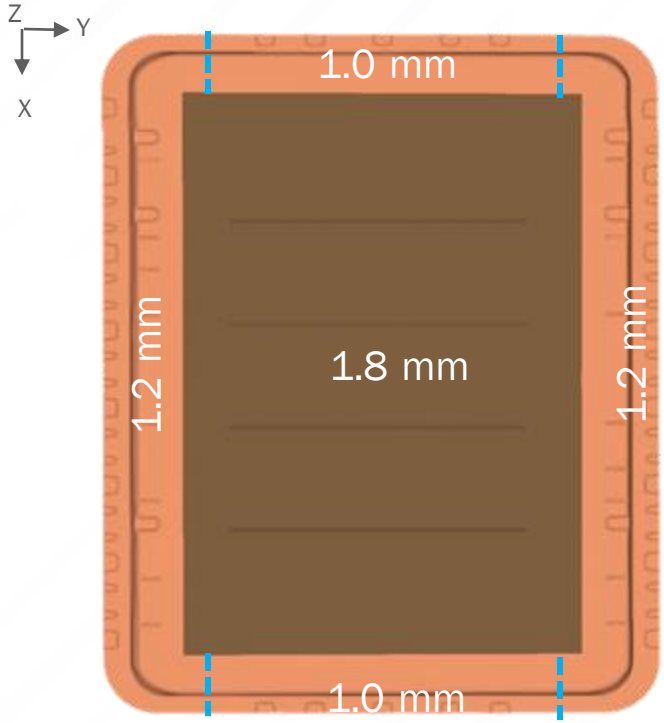
Battery cover upper MPI

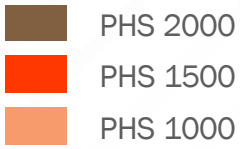


The weldlines are aligned with the floor reinforcement layout

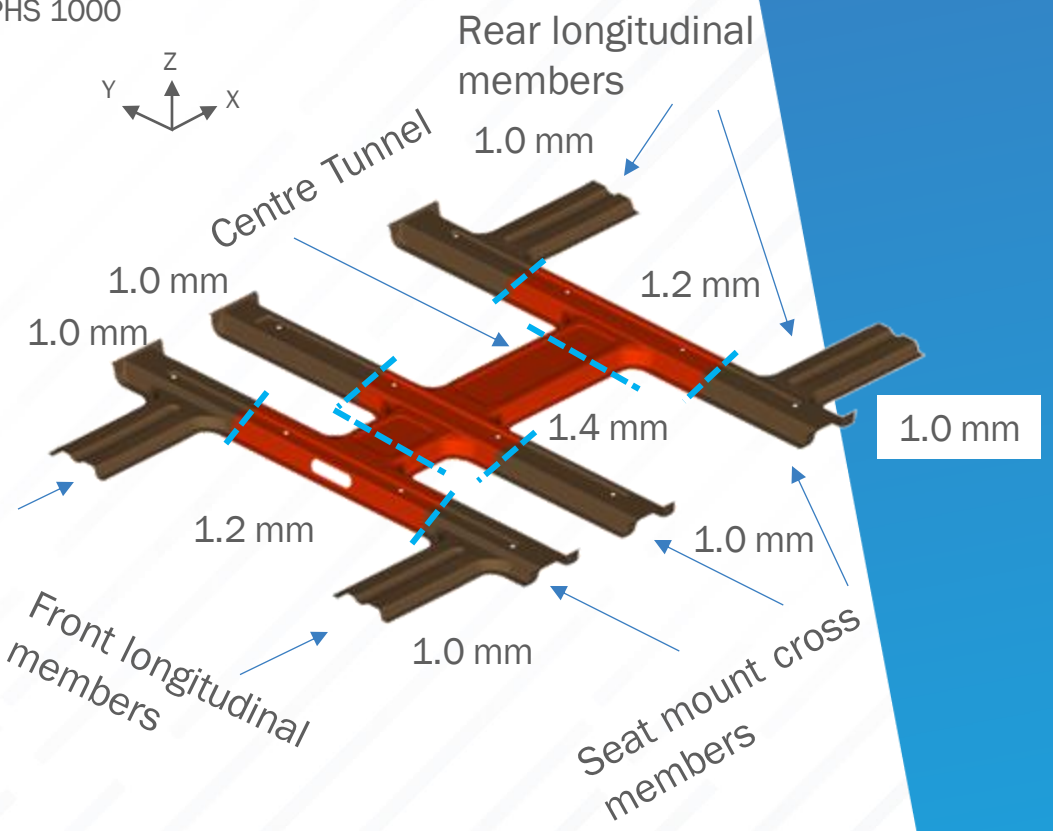
Battery tub lower MPI



The central blank helps in anti-intrusion during crash events



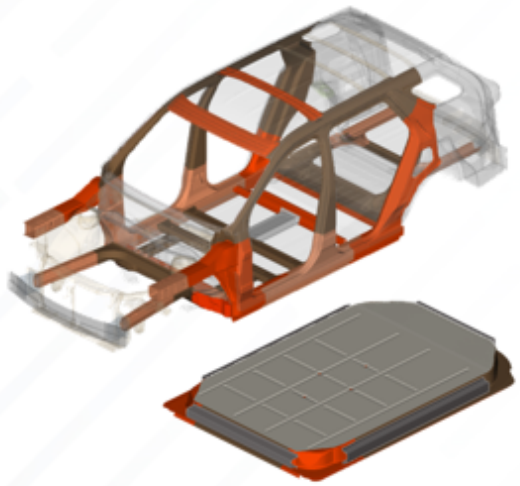
Floor reinforcement MPI



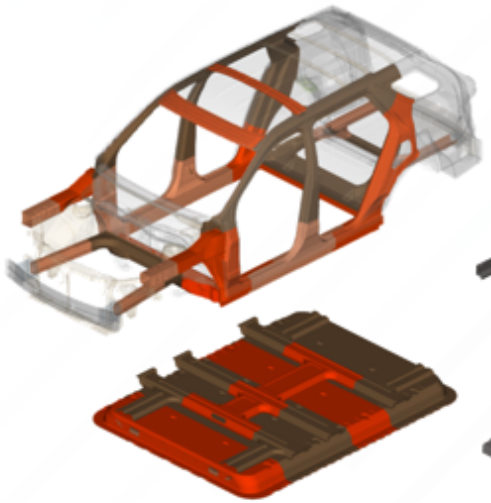
The MPI designs optimize performance while reducing the total part count

AMTB BEV Architectural changes – New BEV (NBEV) design

- AMTB developed a Body-In-White design in 2019 to develop BEV specific LWB solutions
- The mid underbody and battery pack consists of a total of 16 components including 2 MPI applications – Battery ring upper and lower
- The AMTB NBEV architecture consolidates all these components into 3 MPI designs

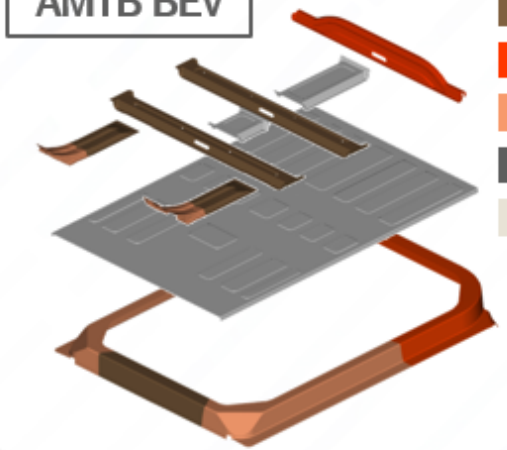


AMTB BEV BIW & Battery pack



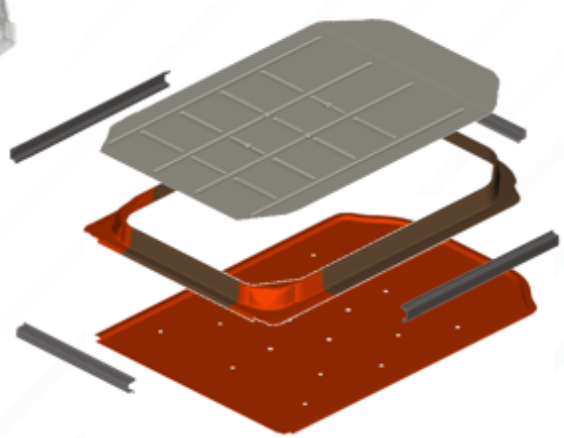
NBEV BIW & MPI Battery pack

AMTB BEV



BIW mid-underbody

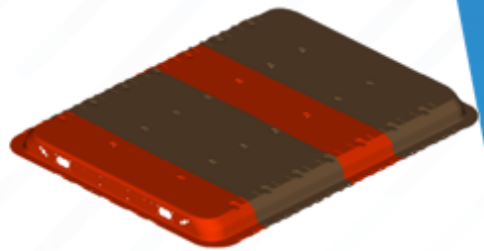
PHS 2000
PHS 1500
PHS 1000
AHSS 1500
Mild Steel



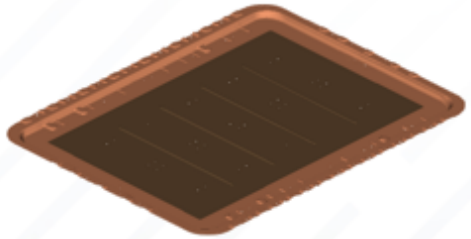
Battery pack enclosure

AMTB NBEV

Floor reinforcement MPI



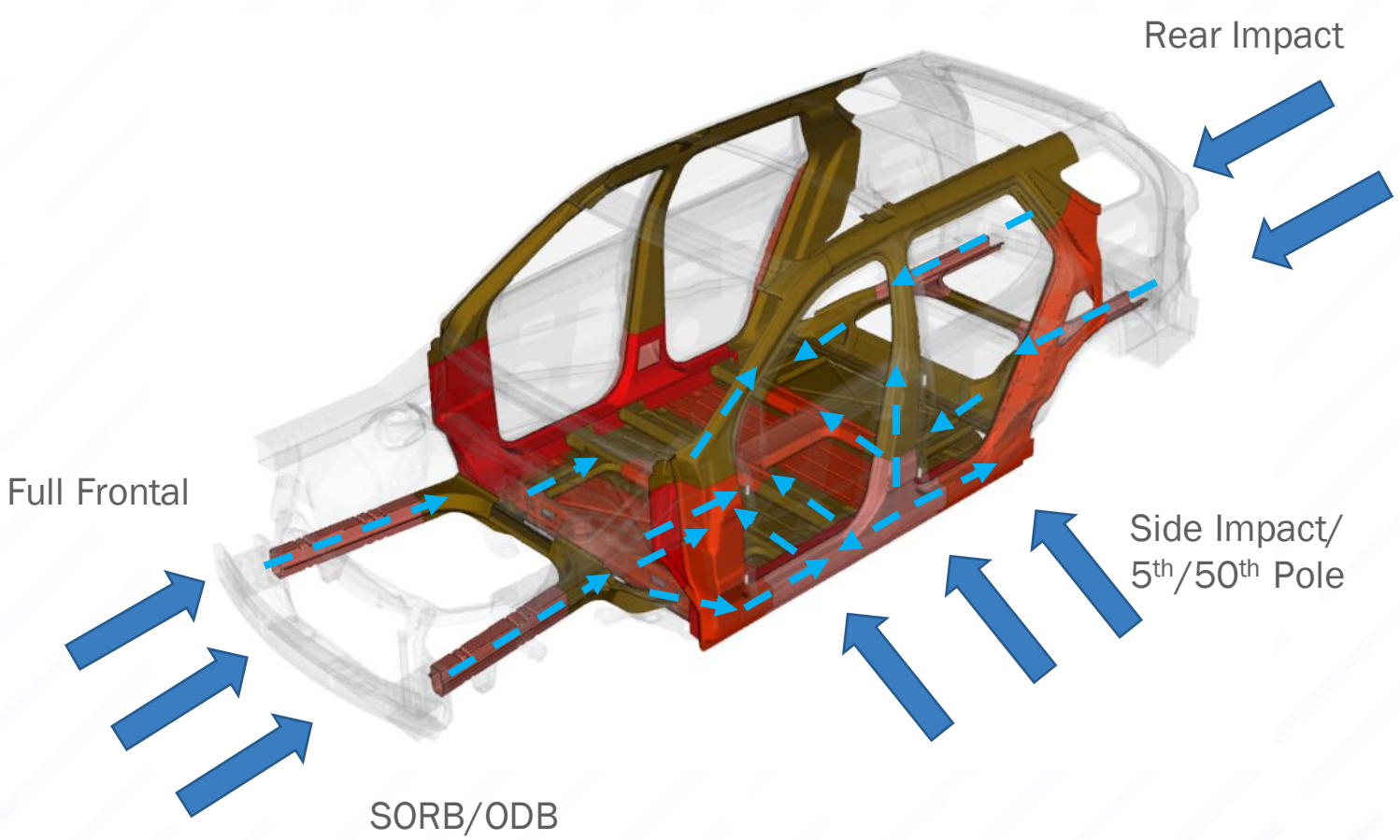
Battery cover upper MPI

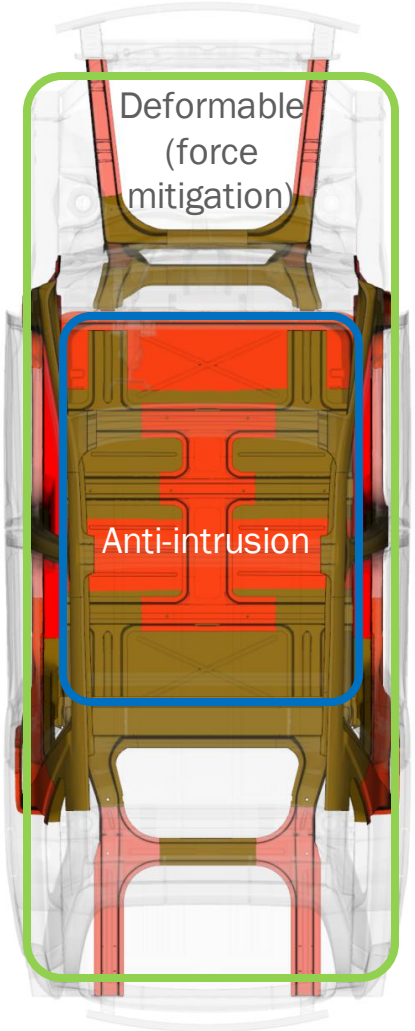


Battery tub lower MPI

16 BIW and Battery enclosure parts are consolidated into 3 MPI parts

AMTB NBEV MPI Structural Battery Pack – crash load paths



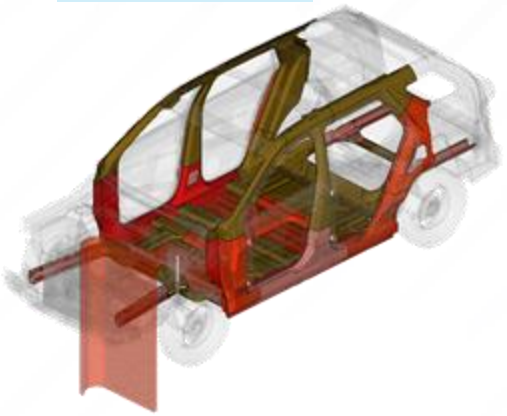


The Floor reinforcement create a safety structure with other MPIs for occupant and battery protection

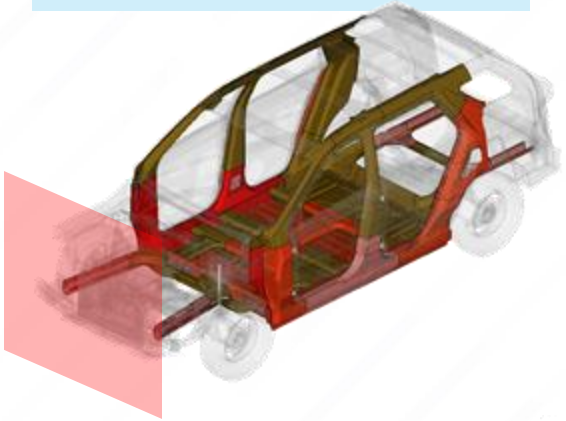
AMTB NBEV MPI Structural Battery Pack – Crash Performance

GDIS

IIHS SORB



FMVSS 208 Full Frontal



IIHS Side Impact

FMVSS 214 50th Pole

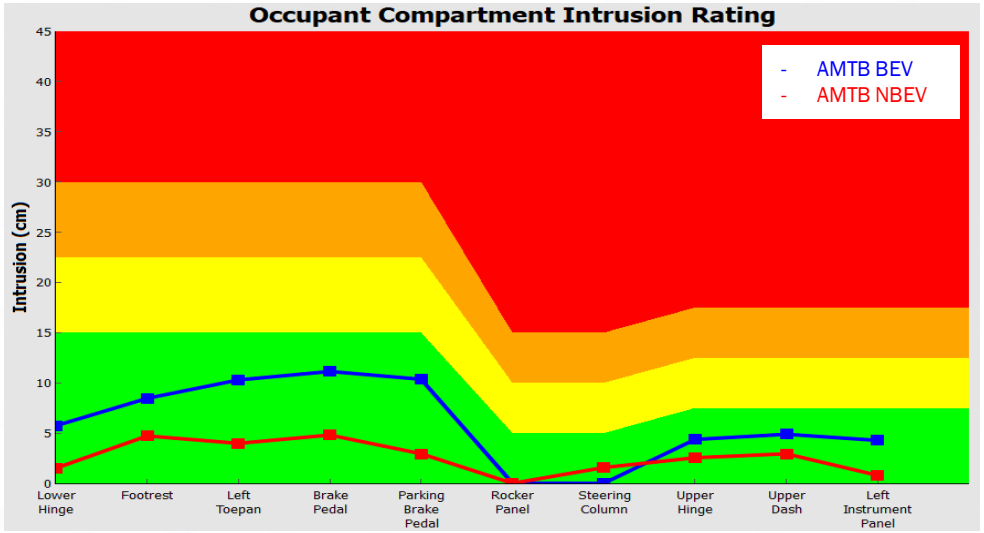
FMVSS 214 5th Pole

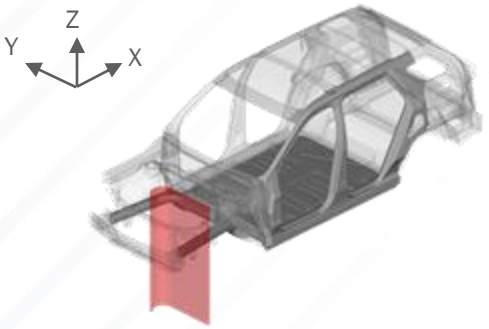
FMVSS 301 Rear Impact

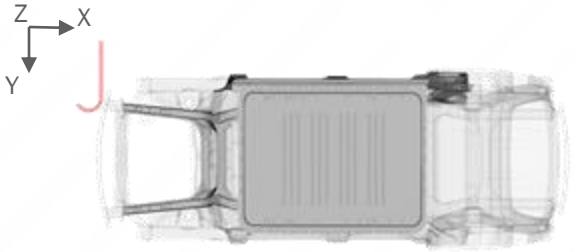
MPIs (Battery pack enclosures) help manage all crash load cases for occupant and battery protection

AMTB NBEV MPI Structural Battery Pack – Crash Performance (IIHS loadcases)

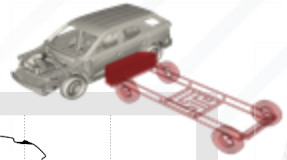
IIHS SORB

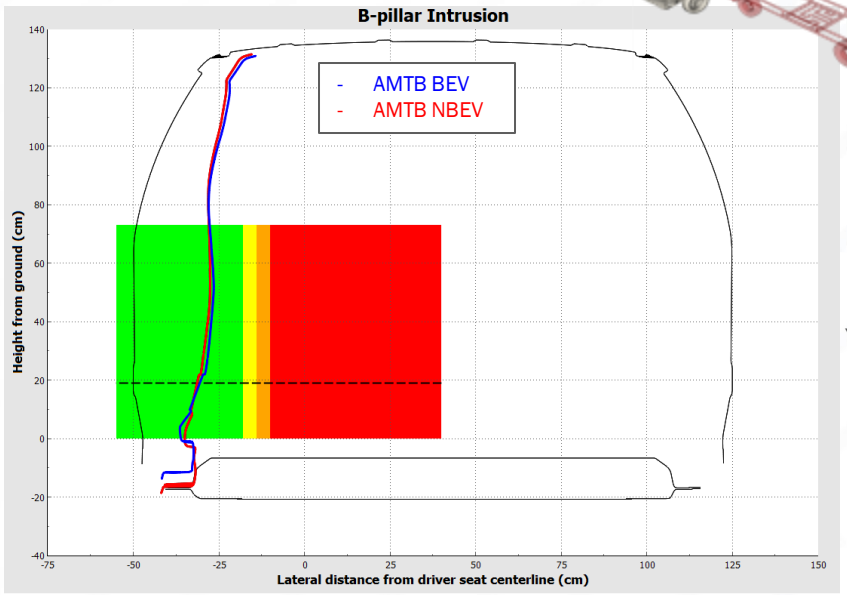


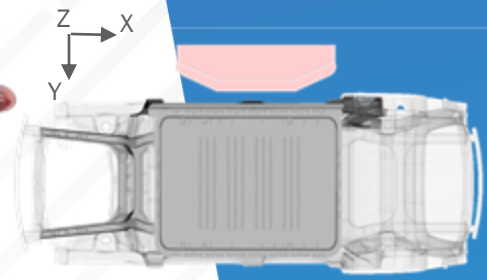


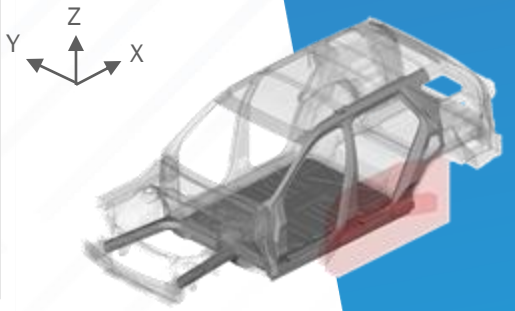


IIHS Side Impact









10 ms Sill starts crushing

75 ms max. deformation

150 ms barrier separated

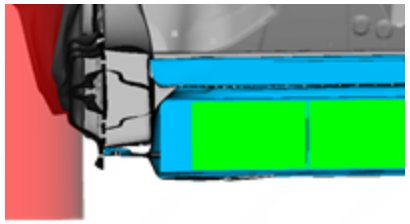
The Battery pack MPIs provide enhanced protection to battery and occupant space

AMTB NBEV MPI Structural Battery Pack – Crash performance (Pole Impact)

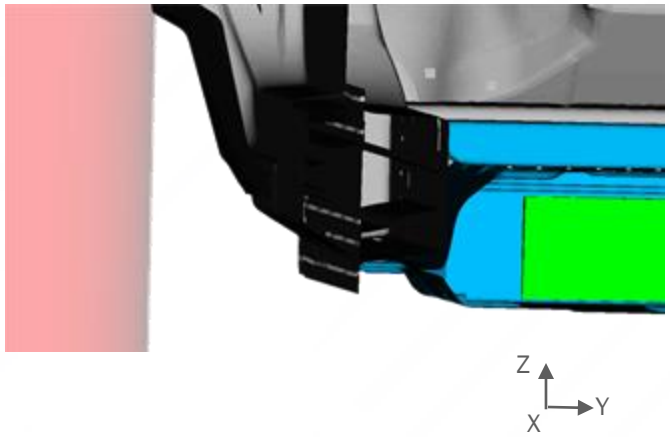
FMVSS 214 5th Pole

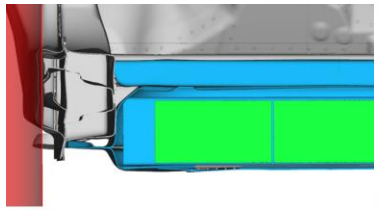
Barrier Pole
BIW structure
Battery structure
Battery modules

FMVSS 214 50th Pole

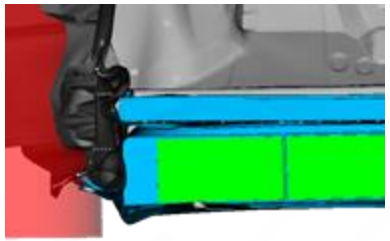


20 ms: Sill start crushing

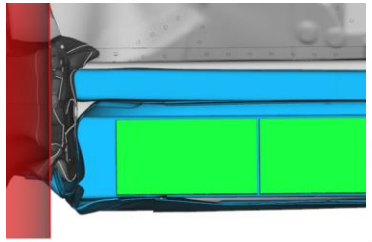




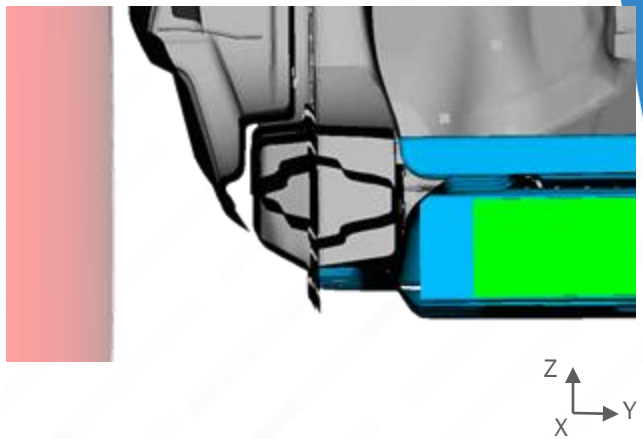
20 ms: Sill start crushing

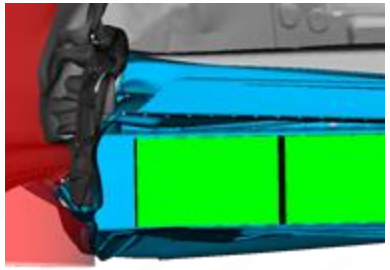


35 ms: Midway through crush

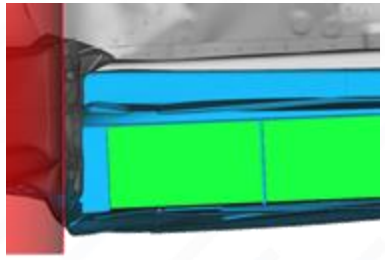


35 ms: Midway through crush





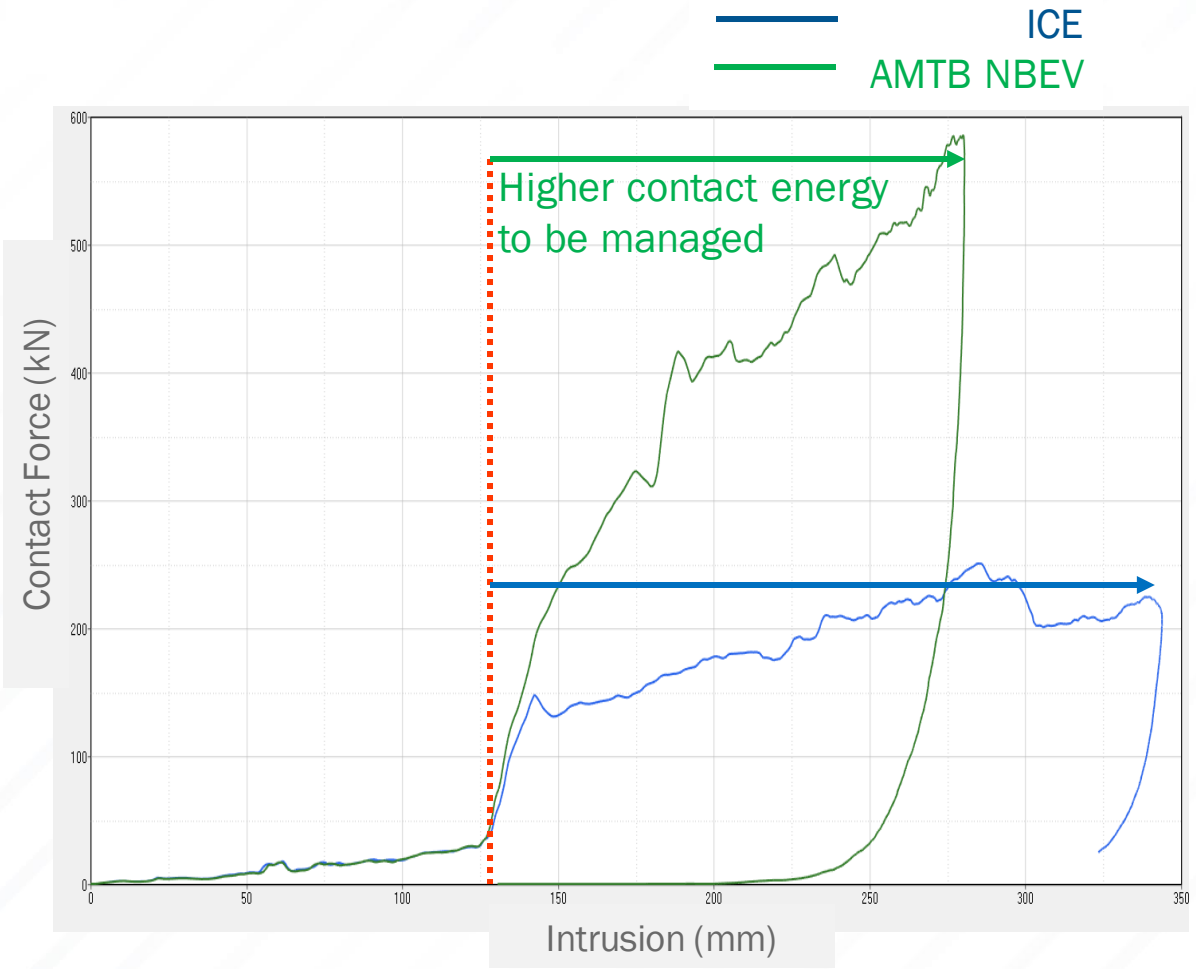
65 ms: Max. deformation, no contact with battery modules

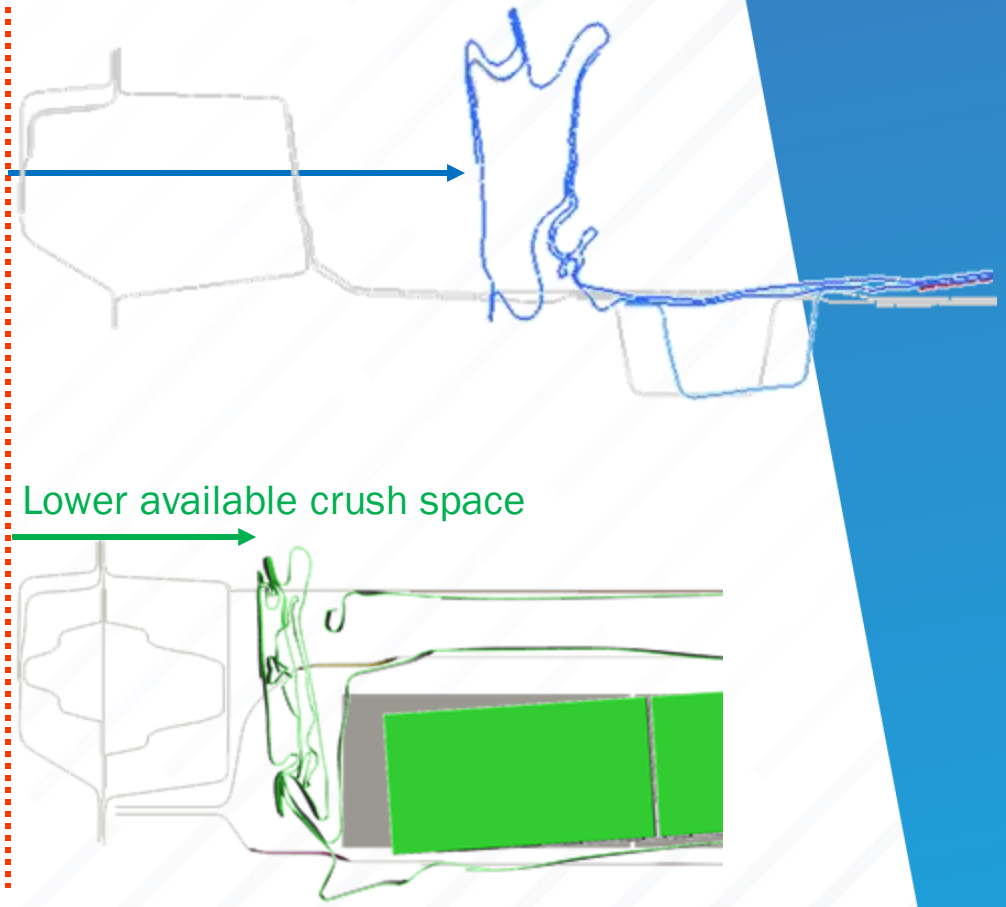


65 ms: Max. deformation, no contact with battery modules

MPIs help manage critical pole impact load cases with no contact to battery modules

Pole Crash comparison – ICE vs BEV challenges

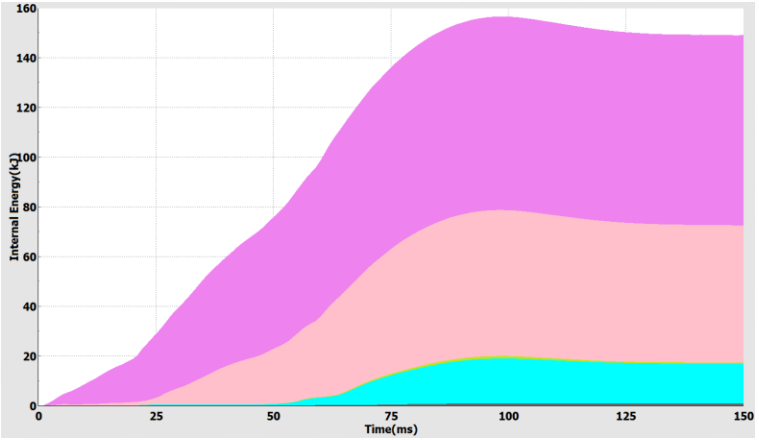




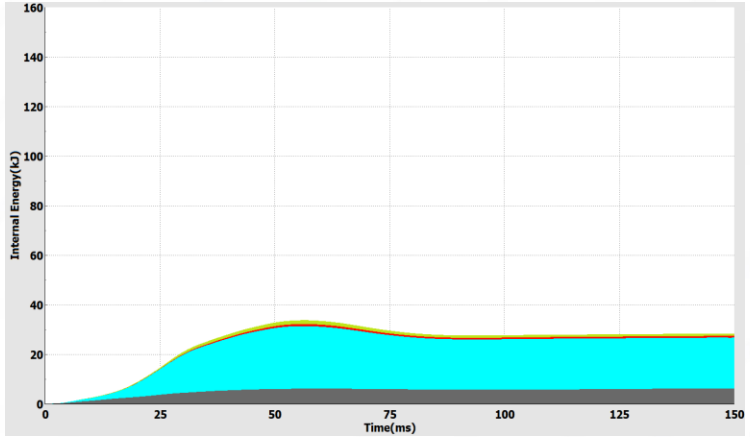
NBEV: 40% higher kinetic energy, 20% lower cabin intrusions → 230% resultant contact force

AMTB NBEV MPI Structural Battery Pack – Internal Energy Distribution

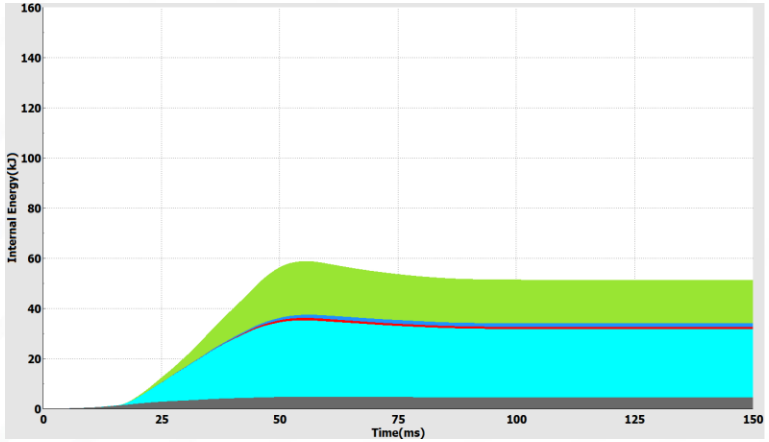
IIHS Small Overlap



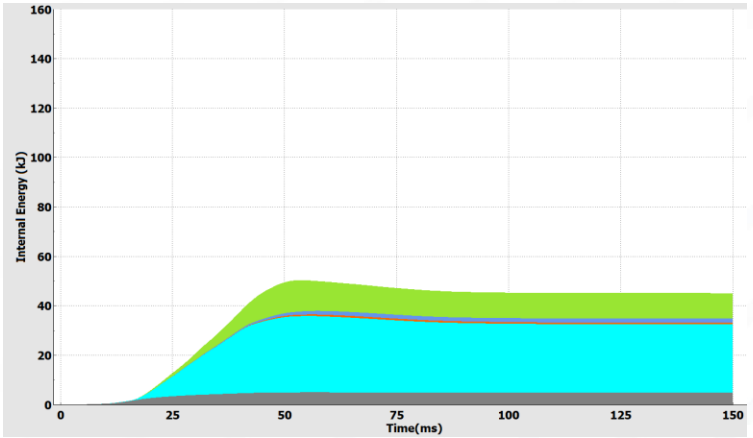
IIHS Side Impact



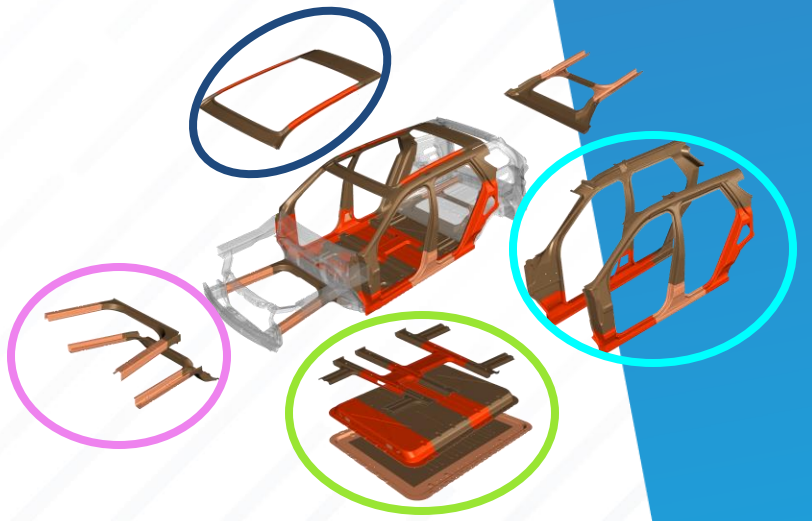
FMVSS 214 5th Pole



FMVSS 214 50th Pole



- Doors
- Double Door ring MPI
- Roof MPI
- Battery Assembly MPI
- Wheels and Subframe
- Front MPI



MPIs form an integral safety structure and distribute the crash forces efficiently in all crash loadcases

AMTB NBEV MPI Structural Battery Pack – Leak test

- In 2023, AMTB collaborated with ArcelorMittal R&D to assess the feasibility of a prototype MPI Battery tub using PHS LWBs
- Objective of this study was to assess the formability & sealing of a deep drawn MPI battery tub

Prototype MPI design

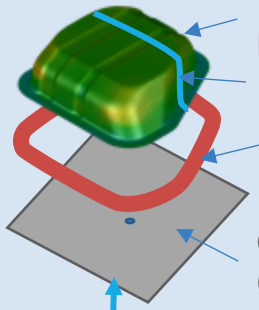
Sample 1
1.2 mm-1.4 mm PHS1500

Sample 2
0.8 mm PHS1000 -
1.0 mm PHS1500

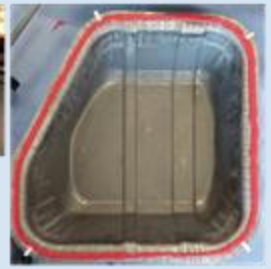
The samples replicate a corner of a battery tub design

Test setup

Exploded view:



Leak measurement points



Physical setup

AMTB tested and validated the sealing of the MPI battery tub design with scaled prototypes

AMTB NBEV MPI Structural Battery Pack – Leak test

Test 1: Global leakage by pressure variation

- Helium at 100 mbar placed inside the battery tub setup
- Global leak rate is calculated in ml/min
- Visible inspection with leakage spray, 5 measurements per sample

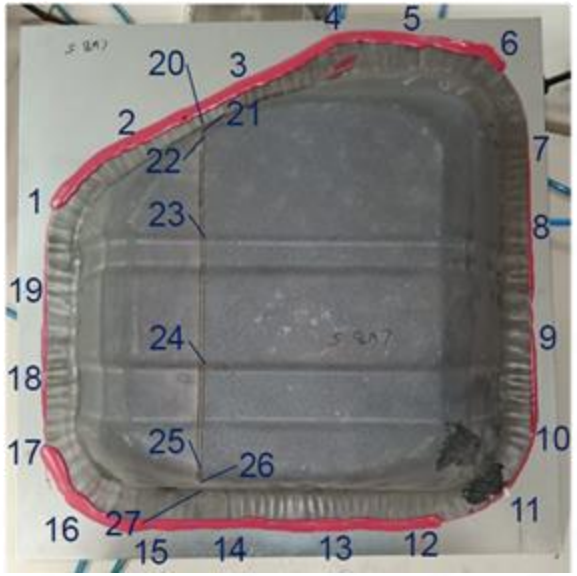
$$Q = \frac{\Delta p * V_i}{\Delta t}$$

$Q = Leak\ rate$
$\Delta p = Pressure\ variation$
$V_i = \text{Initial volume}$
$\Delta t = Time\ period$

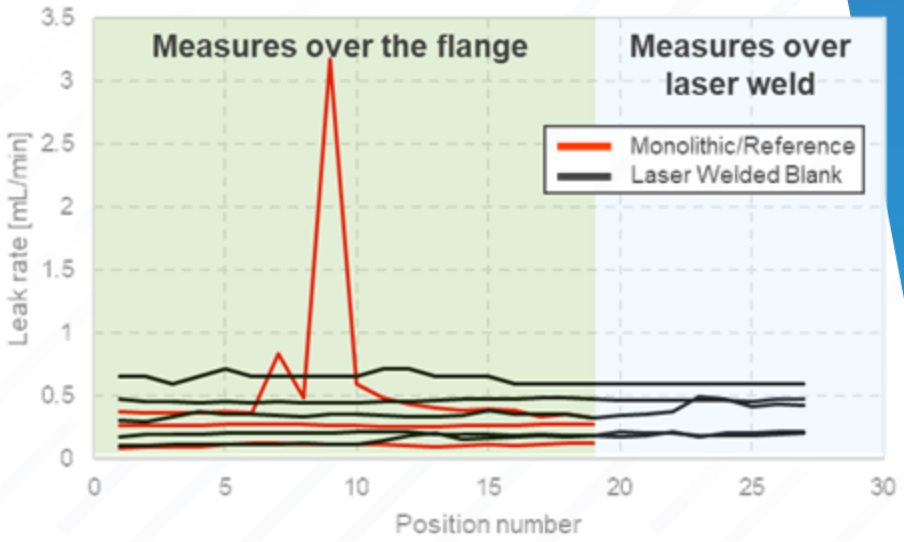
The use of leak spray for visual inspection confirmed no leaks

Test 2: Helium sniffing for local leaking

- Helium at 100 mbar placed inside the battery tub setup
- 27 sniffing points along the perimeter and weld seam



Leak measurement points

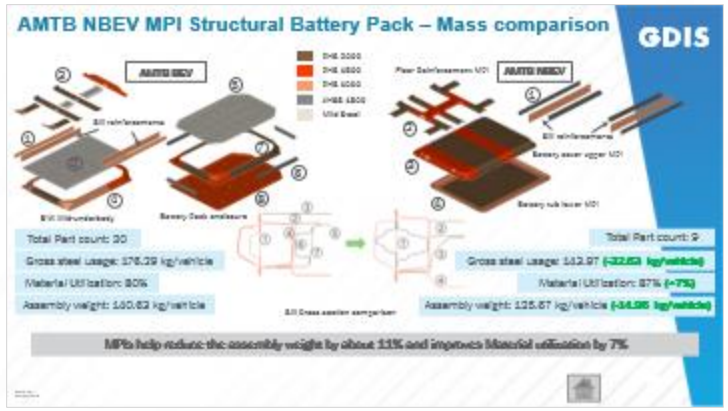


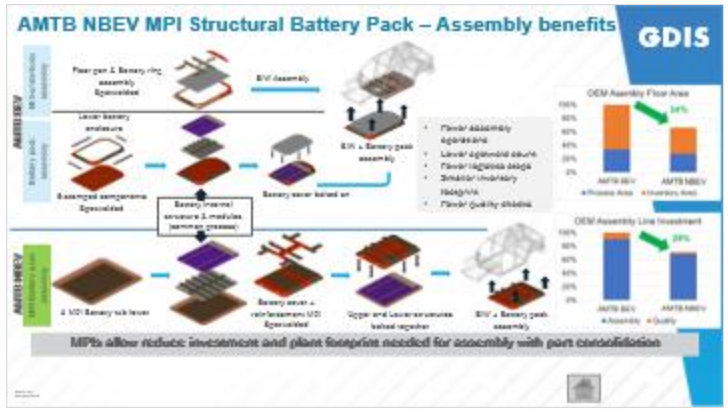
** There is always a small leak rate detected due to the presence of Helium in the room.*

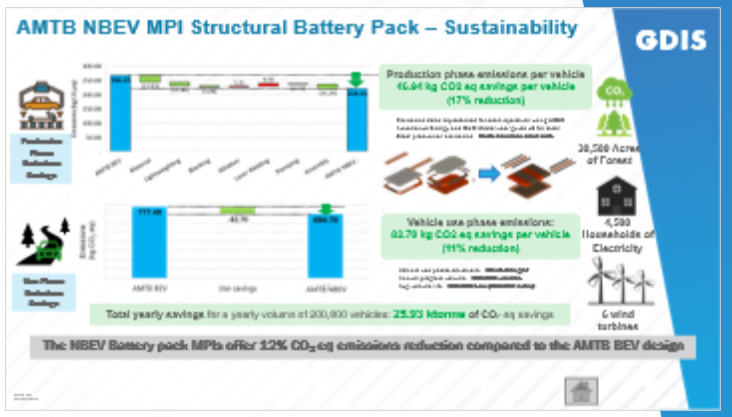
Results: Similar leak rate for both Monolithic and Laser Welded blanks

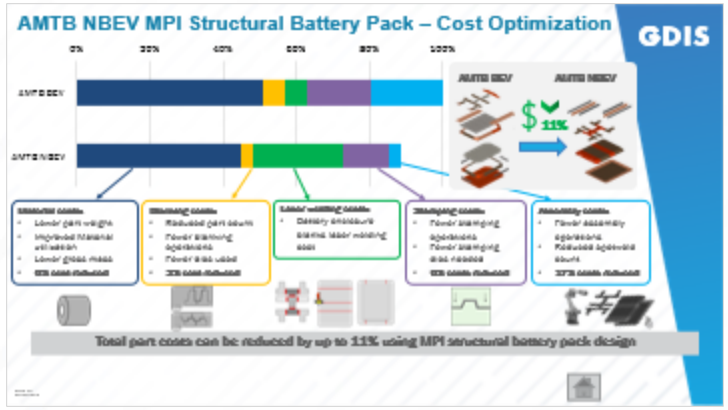
AMTB tested and validated the sealing of the MPI battery tub design with scaled prototypes

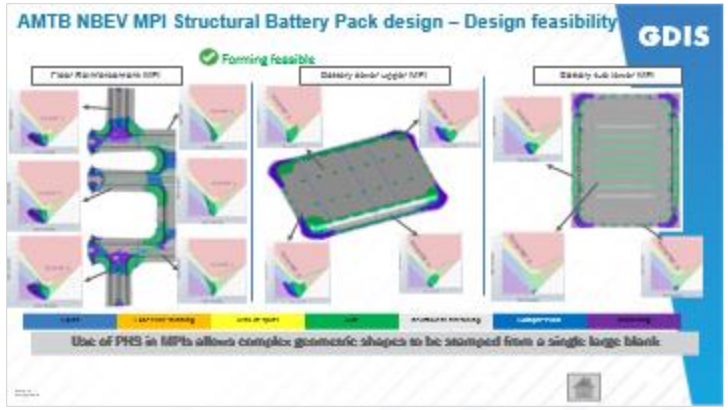
Benefits Case study – AMTB NBEV MPI structural battery pack

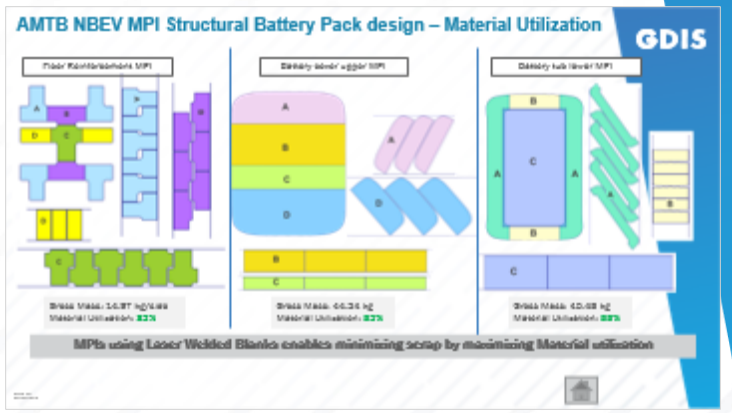










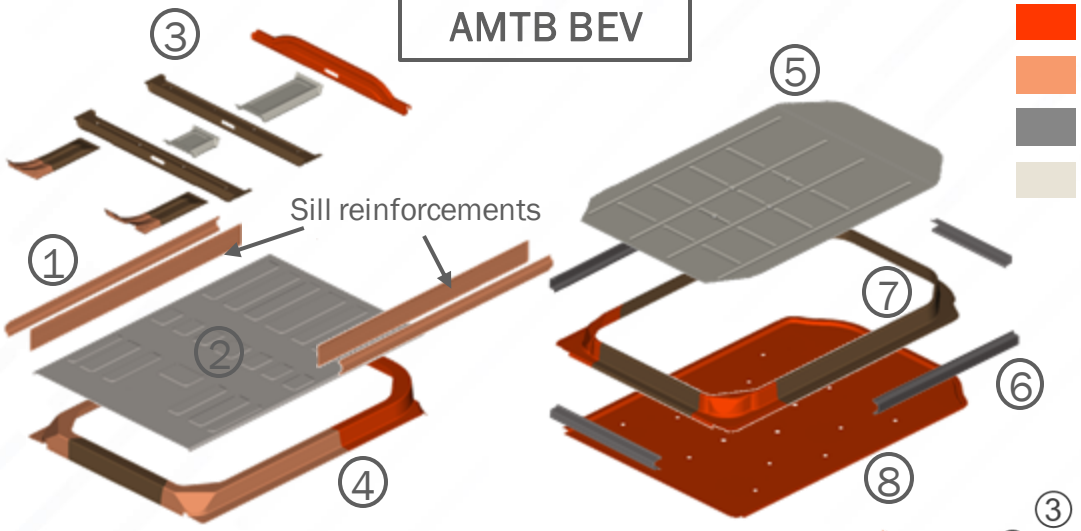


AMTB NBEV MPI Structural Battery Pack – Mass comparison

GDIS

PHS 2000
PHS 1500
PHS 1000
AHSS 1500
Mild Steel

AMTB BEV



BIW Mid-underbody

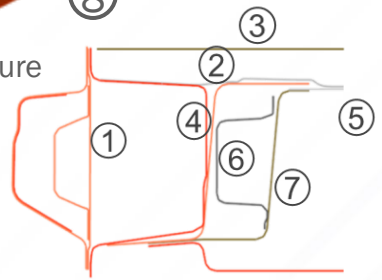
Battery Pack enclosure

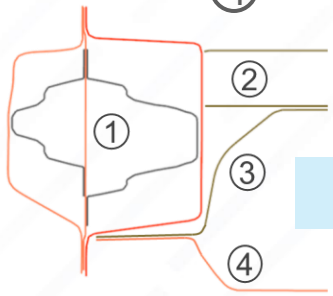
Total Part count: 20

Gross steel usage: 176.29 kg/vehicle

Material Utilization: 80%

Assembly weight: 140.63 kg/vehicle

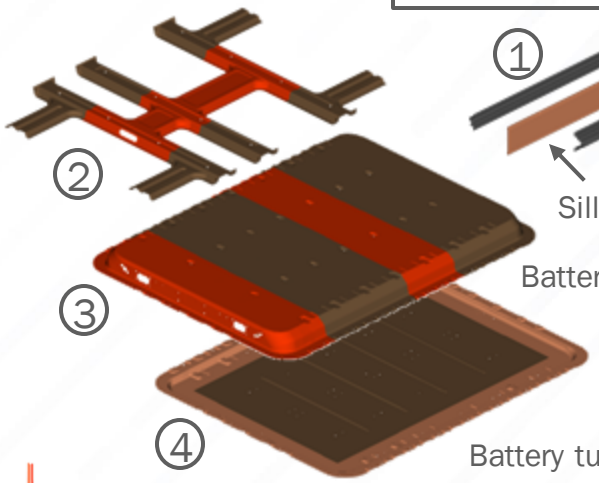




Sill Cross section comparison

AMTB NBEV

Floor Reinforcement MPI



Battery tub lower MPI

Total Part count: 9

Gross steel usage: 143.97 (-32.63 kg/vehicle)

Material Utilization: 87% (+7%)

Assembly weight: 125.67 kg/vehicle (-14.96 kg/vehicle)

MPIs help reduce the assembly weight by about 11% and improves Material utilization by 7%

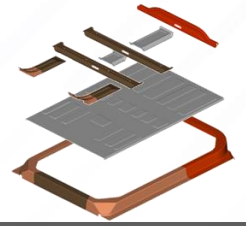
AMTB NBEV MPI Structural Battery Pack – Assembly benefits

GDIS

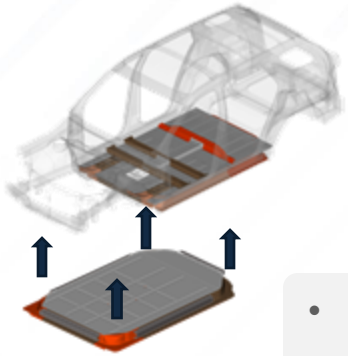
AMTB BEV

Mid-underbody assembly

Floor pan & Battery ring assembly Spotwelded



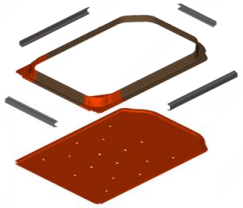
BIW Assembly



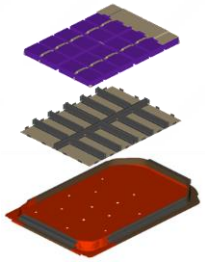
BIW + Battery pack assembly

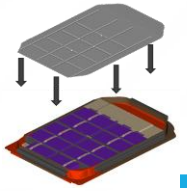
Battery pack assembly

Lower battery enclosure



6 stamped components Spotwelded

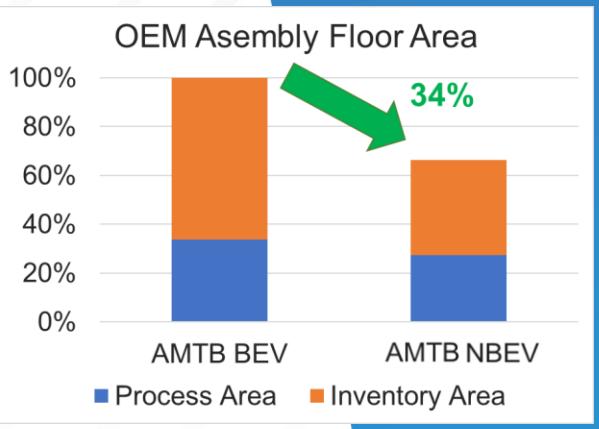




Battery cover bolted on

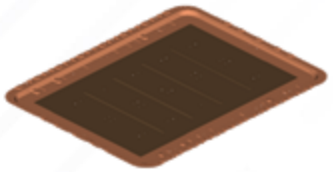
Battery internal structure & modules (common process)

- Fewer assembly operations
- Lower spotweld count
- Fewer logistics steps
- Smaller inventory footprint
- Fewer quality checks

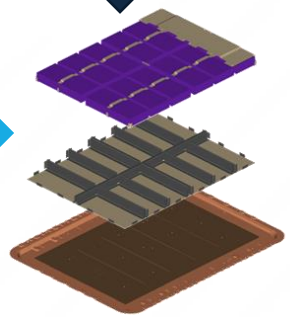


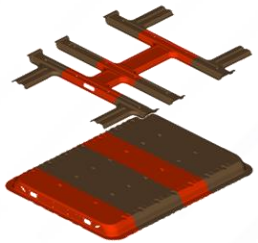
AMTB NBEV

MPI Battery pack assembly

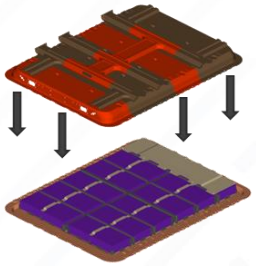


1 MPI Battery tub lower

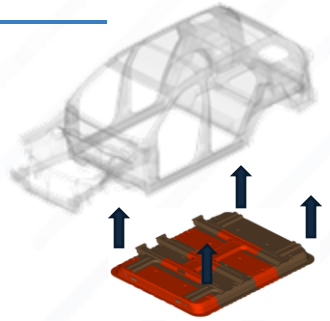




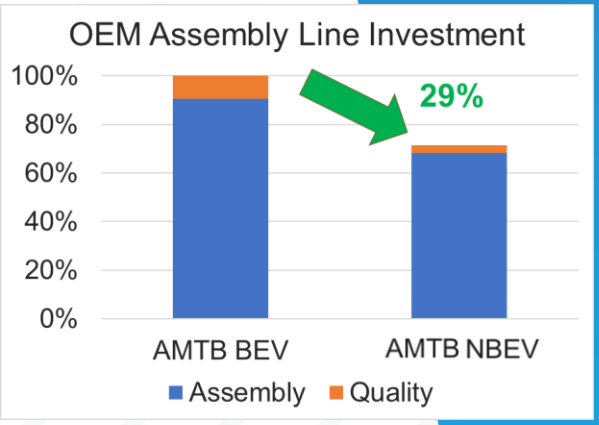
Battery cover + reinforcement MPI Spotwelded



Upper and Lower structures bolted together



BIW + Battery pack assembly

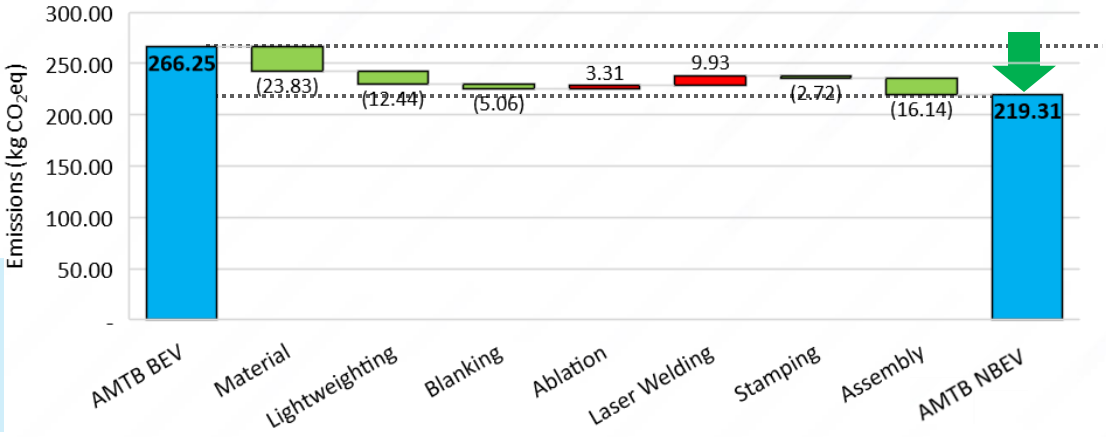


MPIs allow reduce investment and plant footprint needed for assembly with part consolidation

AMTB NBEV MPI Structural Battery Pack – Sustainability

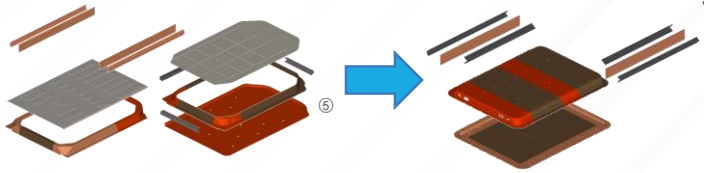
GDIS

Production Phase Emissions Savings



Production phase emissions per vehicle
46.94 kg CO2 eq savings per vehicle (17% reduction)

Emissions delta represented for each operation using UCSB Automotive Energy and GHG Model user guide v5 for steel
Steel production emissions : **North American steel mills**

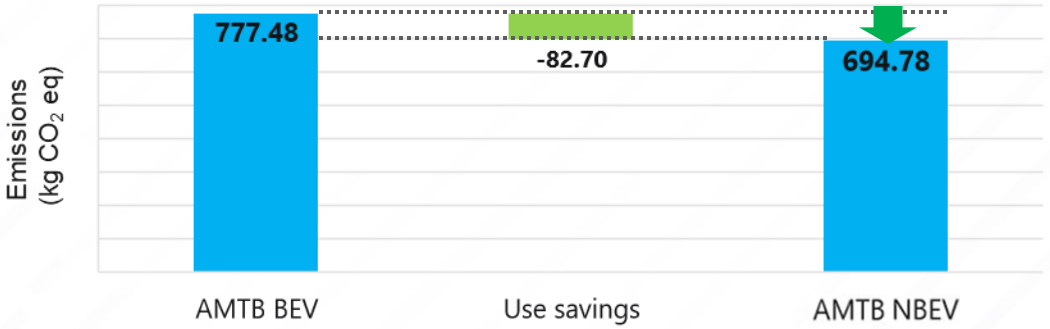


30,500 Acres of Forest

4,500 Households of Electricity

6 wind turbines

Use Phase Emissions Savings



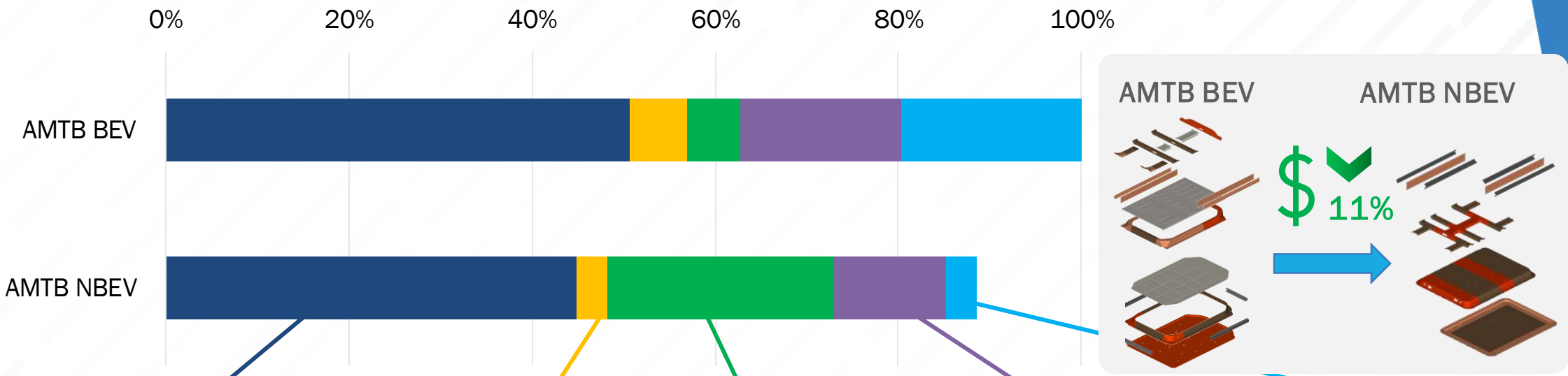
Vehicle use phase emissions:
82.70 kg CO2 eq savings per vehicle (11% reduction)

Vehicle use phase emissions : **US electric grid**
Annual program volume : **200,000 vehicles**
Avg. vehicle life : **200,000 kms (124,274 miles)**

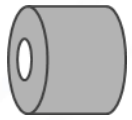
Total yearly savings for a yearly volume of 200,000 vehicles: **25.93 ktonne of CO_2** eq savings

The NBEV Battery pack MPIs offer 12% CO_2 eq emissions reduction compared to the AMTB BEV design

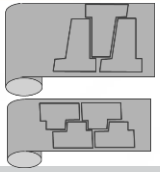
AMTB NBEV MPI Structural Battery Pack – Cost Optimization



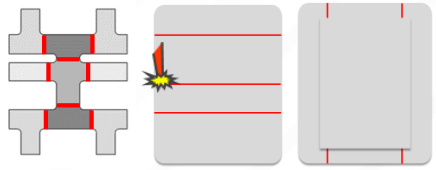
Material costs:
- Lower part weight
- Improved Material utilization
- Lower gross mass
- 6% cost reduced



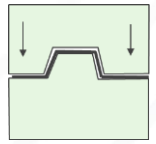
Blanking costs:
- Reduced part count
- Fewer blanking operations
- Fewer dies used
- 3% cost reduced



Laser welding costs:
- Battery enclosure blanks laser welding cost



Stamping costs:
- Fewer stamping operations
- Fewer stamping dies needed
- 6% costs reduced



Assembly costs:
- Fewer assembly operations
- Reduced spotweld count
- 17% costs reduced

Total part costs can be reduced by up to 11% using MPI structural battery pack design

AMTB NBEV MPI Structural Battery Pack design – Design feasibility

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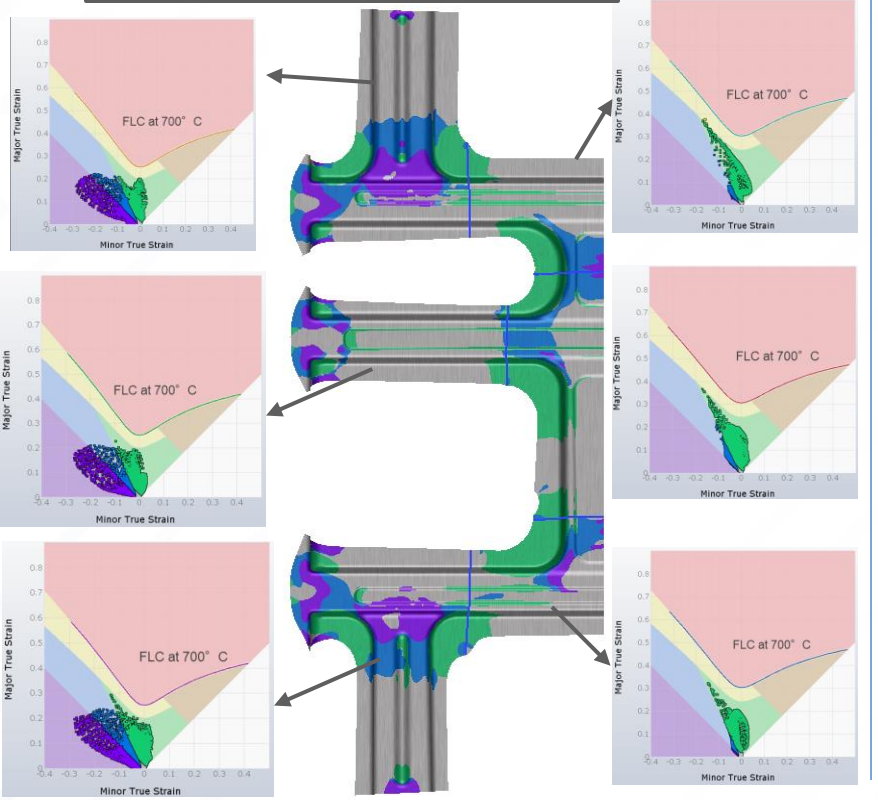
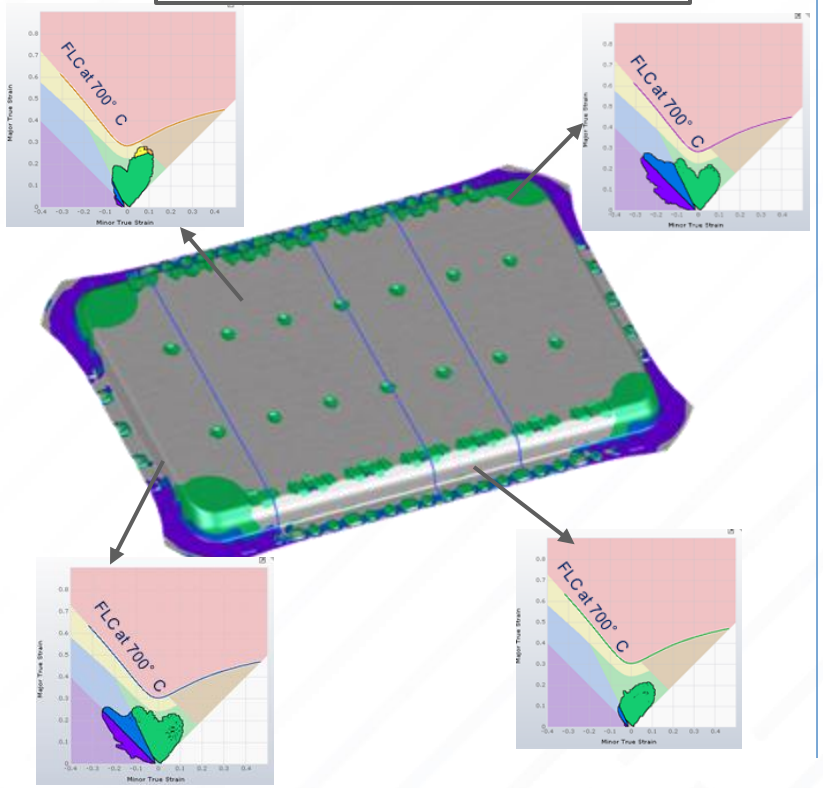
Forming feasible

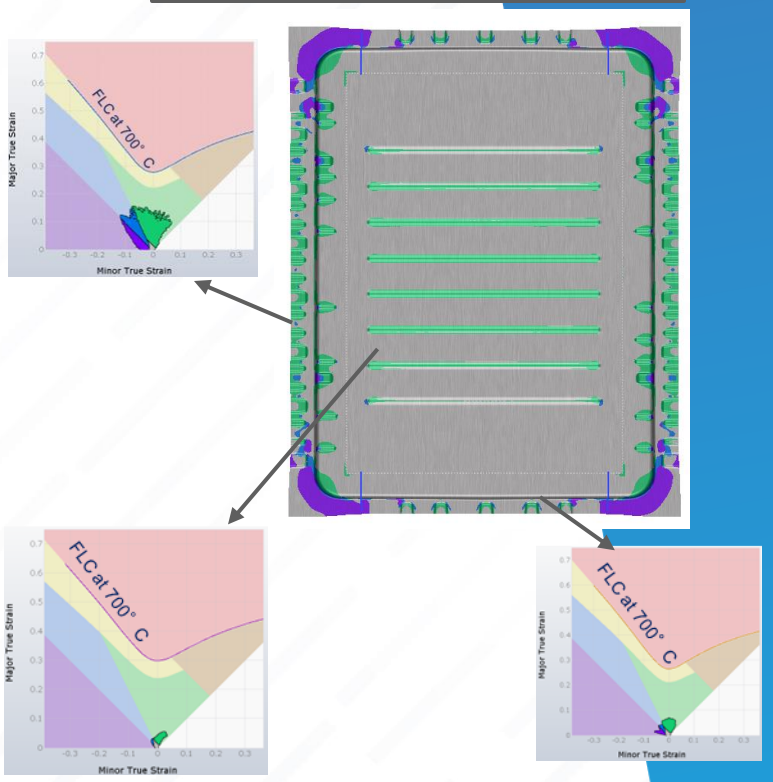
Floor Reinforcement MPI



Battery cover upper MPI



Battery tub lower MPI



Splits	Excessive thinning	Risk of splits	Safe	Insufficient stretching	Compression	Thickening

Use of PHS in MPIs allows complex geometric shapes to be stamped from a single large blank

AMTB NBEV MPI Structural Battery Pack design – Material Utilization

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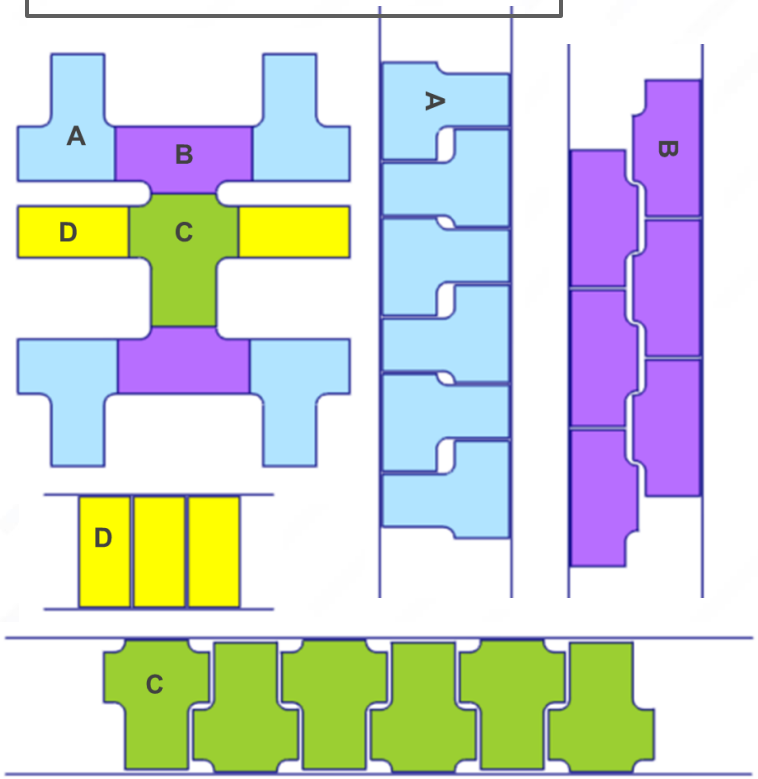
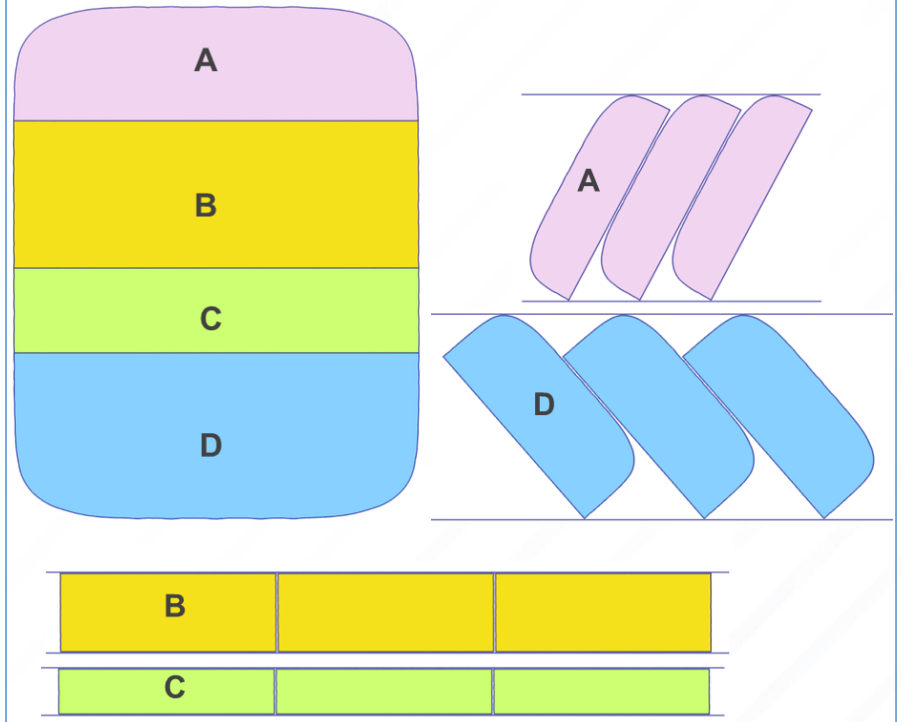
Floor Reinforcement MPI



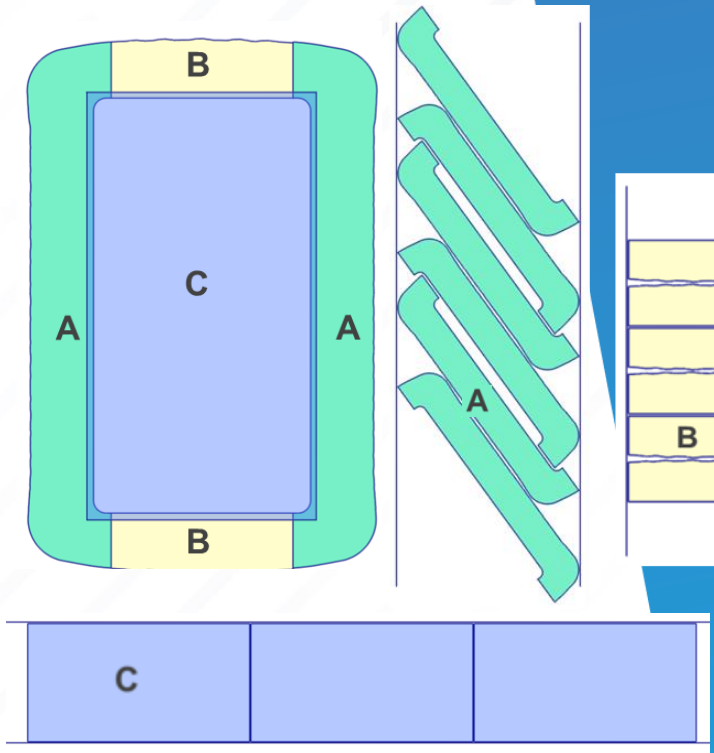
Gross Mass: 14.97 kg/side
Material Utilization: 83%

Battery cover upper MPI



Gross Mass: 44.34 kg
Material Utilization: 83%

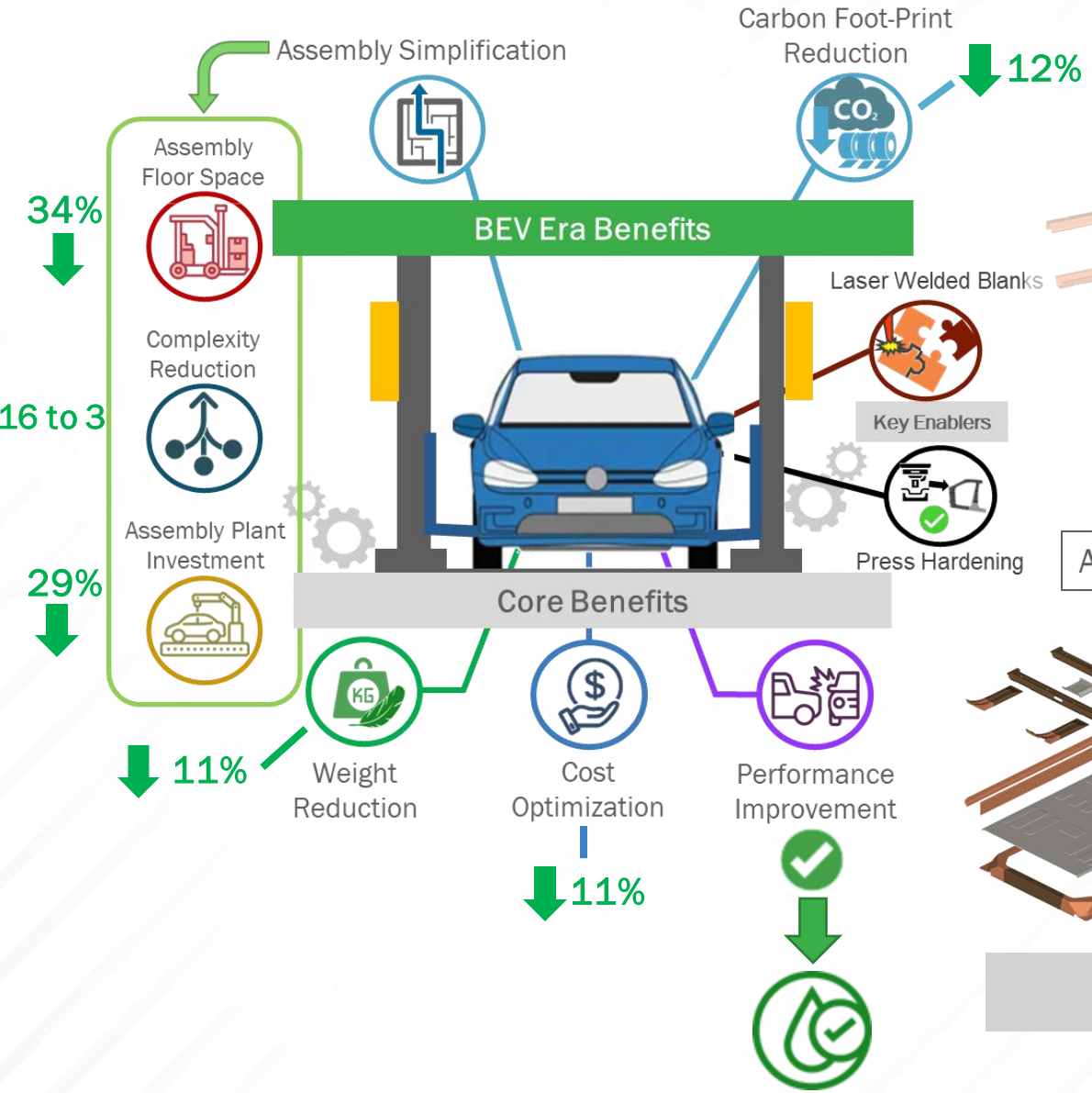
Battery tub lower MPI

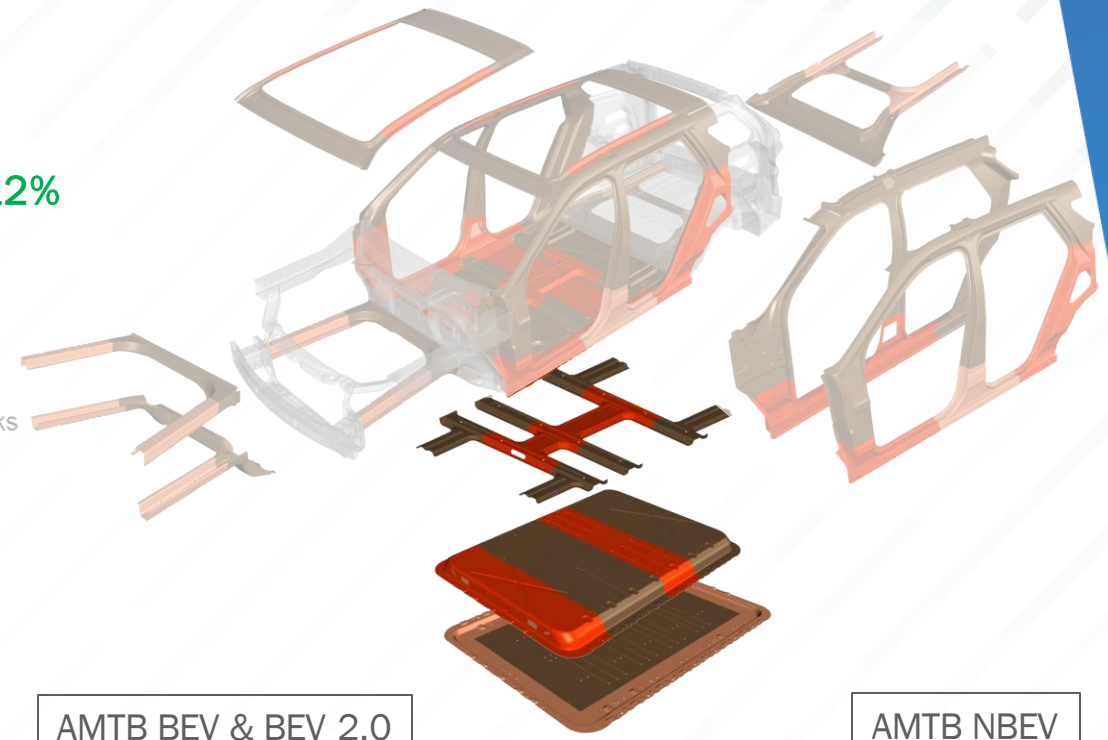


Gross Mass: 45.48 kg
Material Utilization: 88%

MPIs using Laser Welded Blanks enables minimizing scrap by maximizing Material utilization

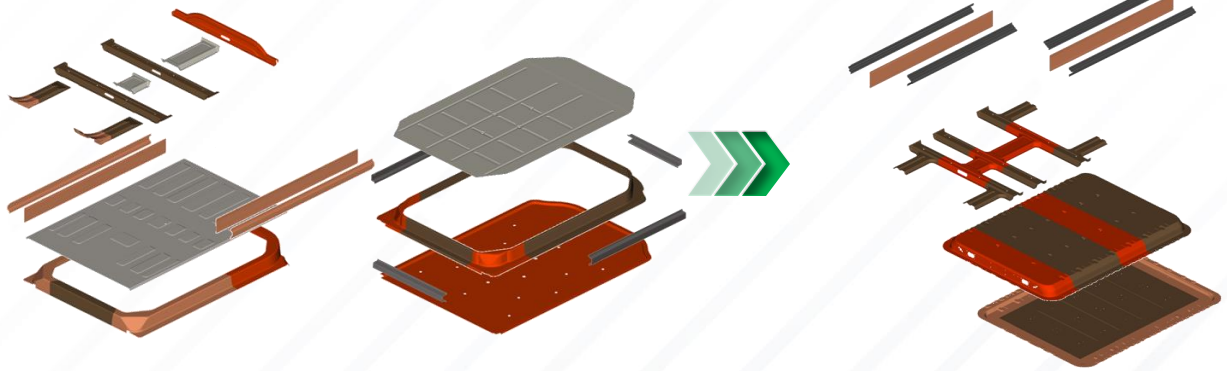
Conclusion





AMTB BEV & BEV 2.0

AMTB NBEV



This MPI design is implementation ready

Home of the most advanced Laser Welded Door Rings

ArcelorMittal

ArcelorMittal Tailored Blanks

Driving a Safer and Greener Tomorrow

GDIS

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- ✓ Concord, ON
- ✓ Woodstock, ON
- ✓ Detroit, MI
- ✓ Silao, MX

16 locations in Europe and Asia

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AMTB leading global supplier of tailored (laser welded) blanks – safer, stronger, lighter and green solution