GREAT DESIGNS IN STEEL

INNOVATIVE SIDE STRUCTURE ASSEMBLY USING ARCELORMITTAL MULTI PART INTEGRATION™ CONCEPTS

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2023

AGENDA

- Auto Industry Trends
- Evolution of BEV Design Concepts
- ArcelorMittal Multi Part Integrated ™ (MPI) Concepts
- AMTB NBEV Performance
- Case Study: Double Door Ring Inner (DDRI) & Double Door Ring Outer (DDRO)
  - Mass Comparison
  - Assembly benefits
  - Sustainability
  - Design Feasibility
  - Material Utilization Study
  - Cost Comparison
- Conclusions
- Coming soon! New Product

AUTO INDUSTRY TRENDS

Electrification Challenges

Cost increase

+40-50%

Fleet CO_2 targets

<100 gms per km

Assembly line upgrades

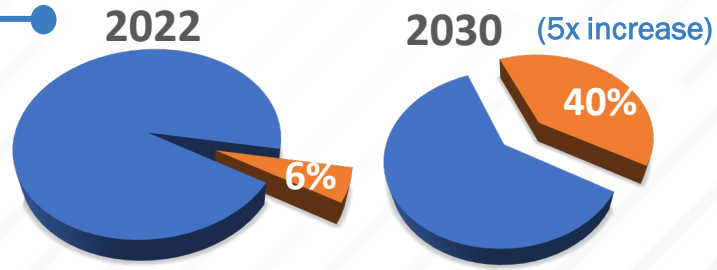
Heavy vehicles

+20-30%

Stricter safety targets

Battery Pack Logistics

BEV Production Volume



Source: S&P Forecast – March 2023

Ongoing Development & Implementation

Tailored Steel Blanks

Additive Manufacturing

Die Castings

Modular Platforms

Flexible Cell Manufacturing

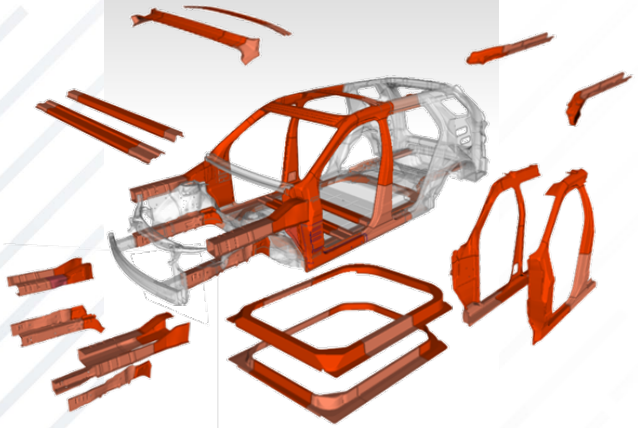
Supply Chain Sustainability

Mix Material Light-weighting

EVOLUTION OF BEV DESIGN CONCEPTS

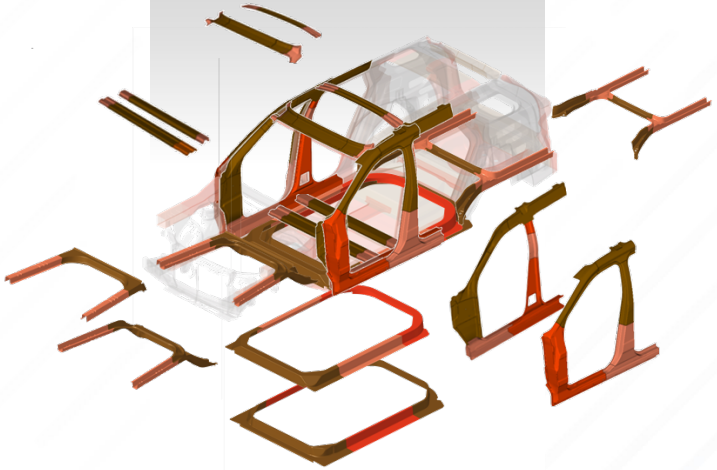
GDIS

AMTB BEV



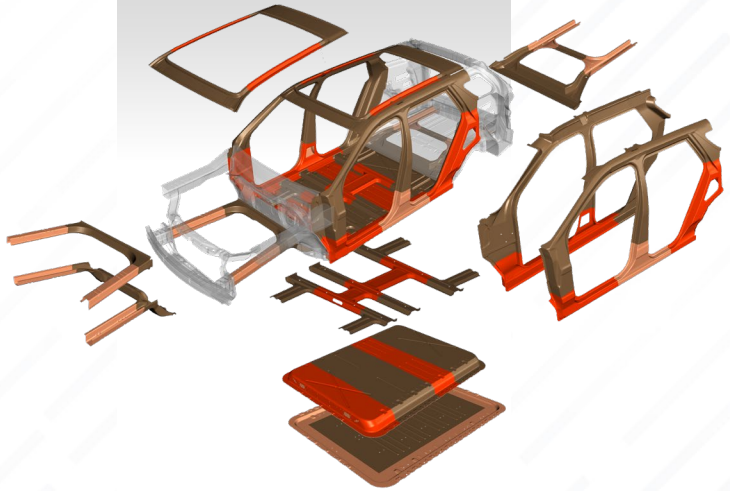
- Door rings – the first MPI
- Battery rings introduced
- PHS 1500 – PHS 1000 LWBs
- Linear PHS Laser Welded Blanks (LWB)

AMTB BEV2.0



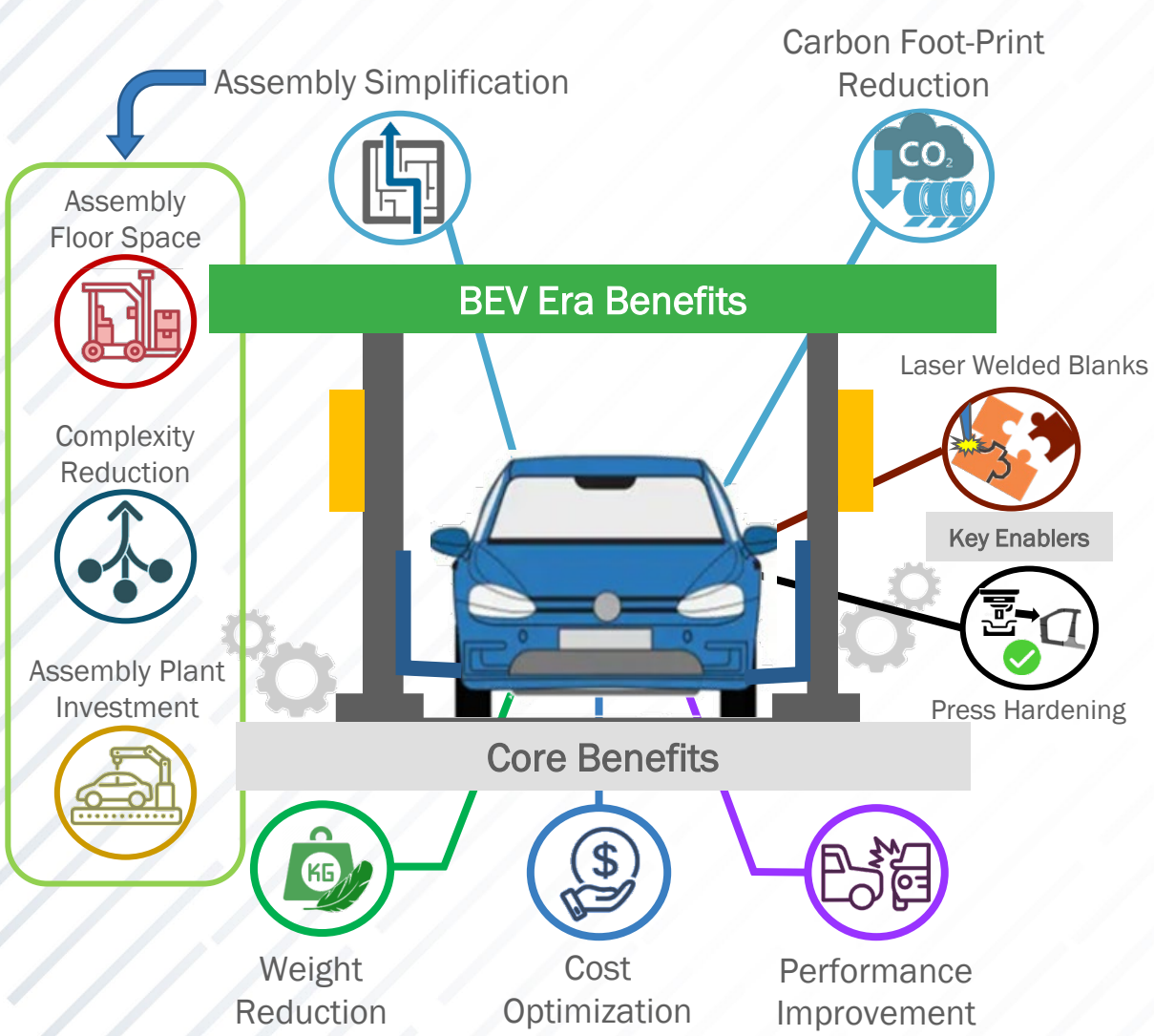
- Rear H-frame
- Front U-frame
- Door Rings
- Battery Rings
- PHS 2000 introduced (2nd gen. PHS)
- Part weight reduced = ~16 kg
- Part count improved = 14 less components

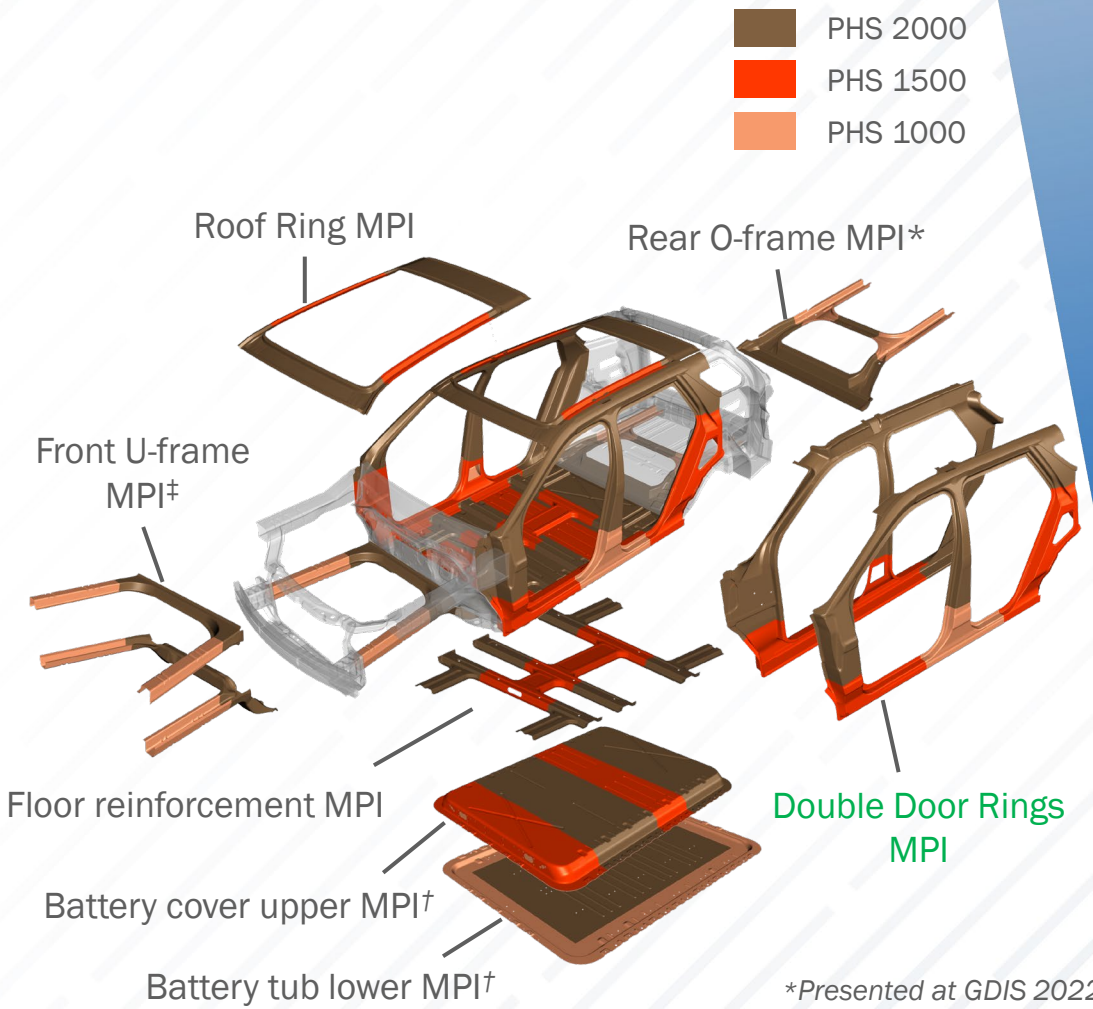
AMTB NBEV



- Double Door Rings
- Floor Integrated Battery Enclosure
- Rear H-frame
- Front U-frame
- Roof Ring
- Part weight reduced = ~39 kg (vs AMTB BEV)
- Part count reduced = 38 less components

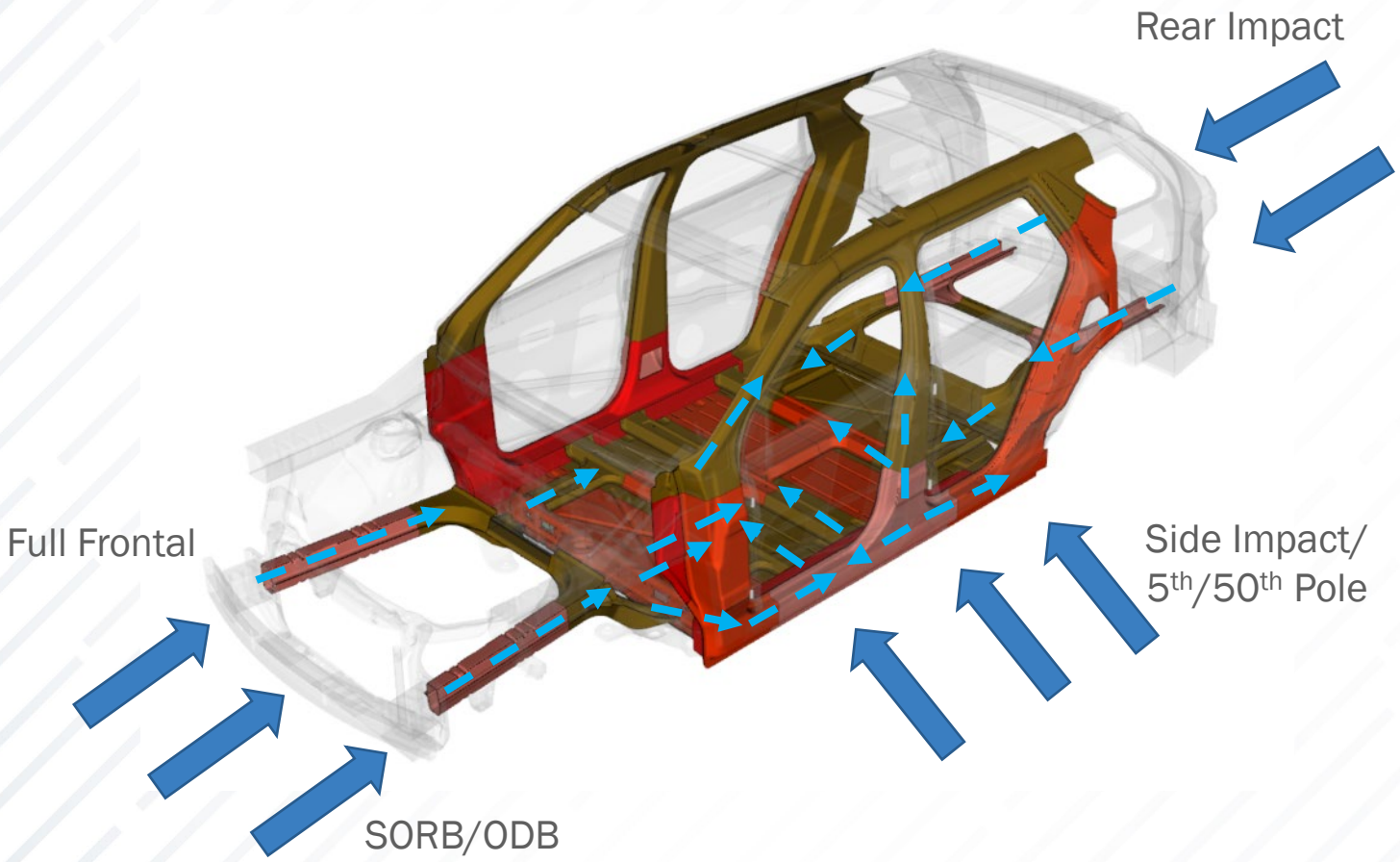
ARCELORMITTAL MULTI PART INTEGRATION™ (MPI) CONCEPTS

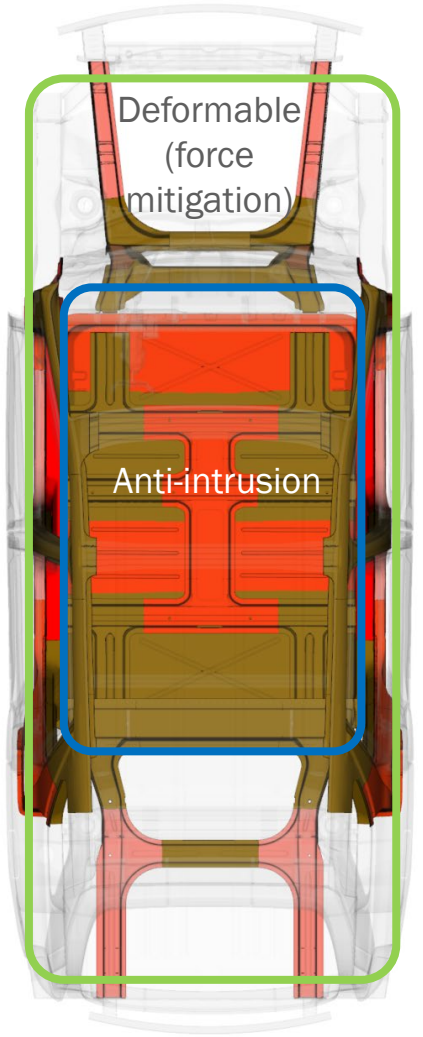




*Presented at GDIS 2022
‡Presented at IABC 2022
†Presented at CarBody Xperience 2023

DOUBLE DOOR RING INNER AND OUTER CRASH LOAD PATHS

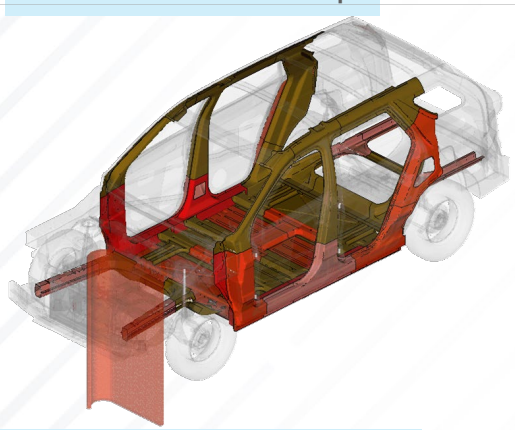




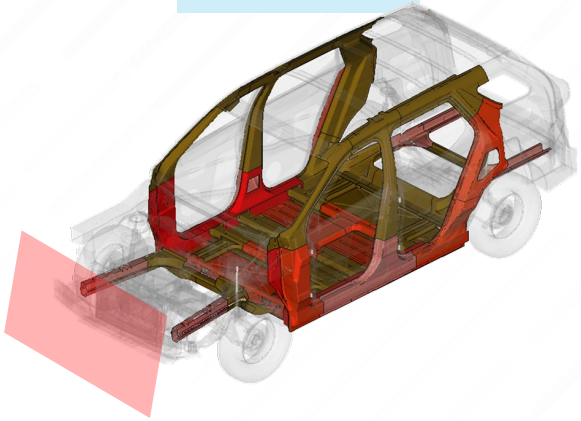
MPIs create a safety structure for occupant and battery protection

DOUBLE DOOR RING INNER AND OUTER
CRASH PERFORMANCE

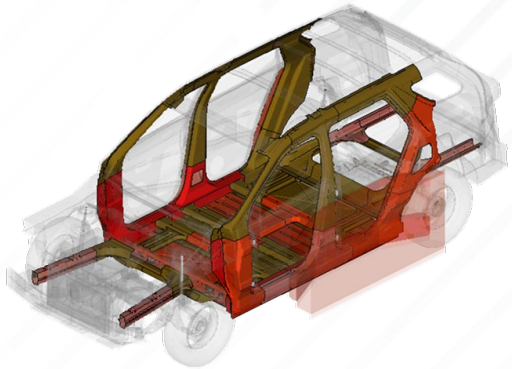
IIHS Small Overlap



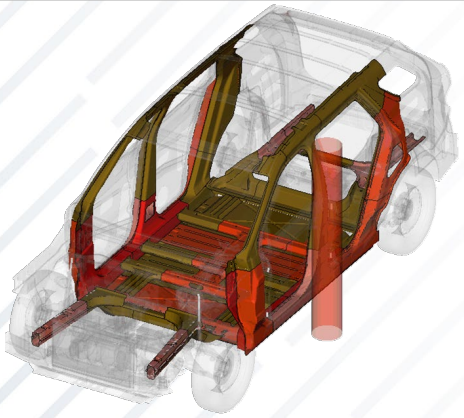
Flat Frontal



IIHS Side Impact

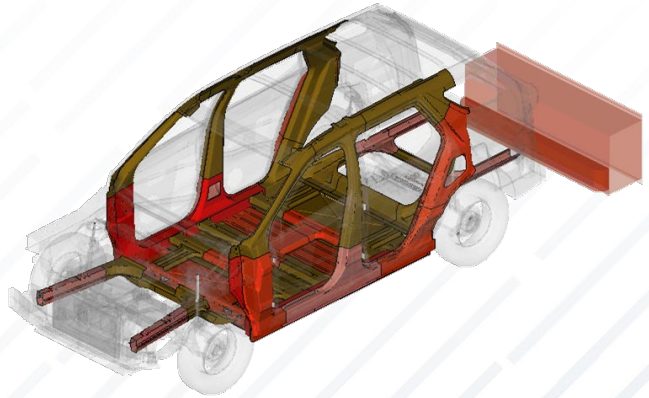


FMVSS 214 50th Pole



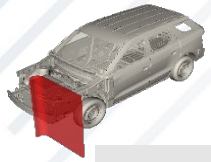
FMVSS 214 5th Pole

Rear Impact

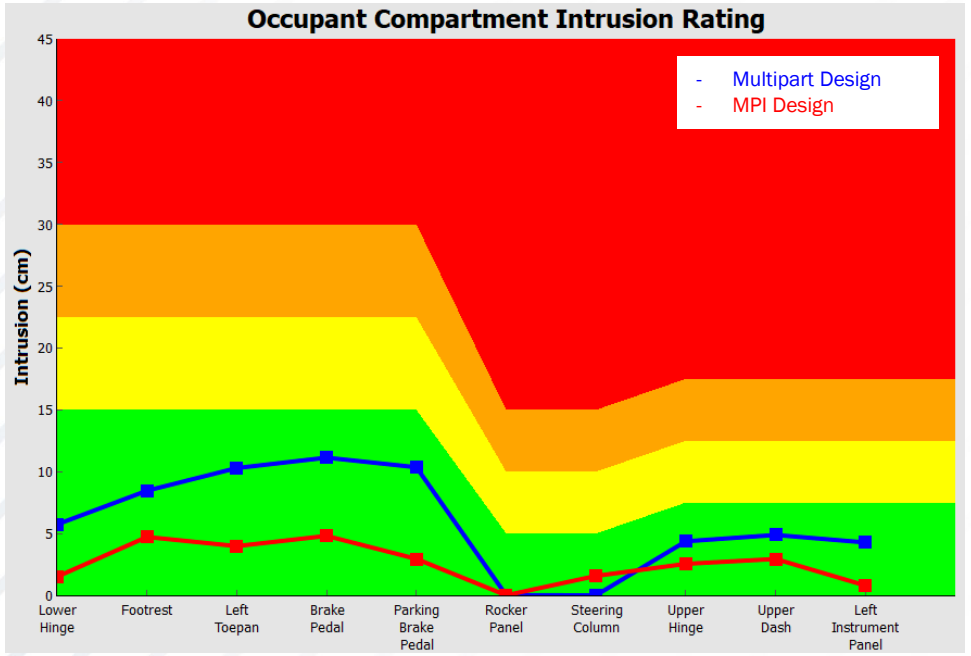


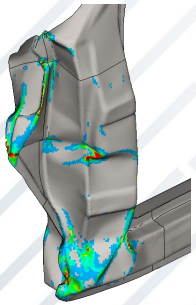
MPIs (Double door rings) help manage all crash load cases for occupant and battery protection

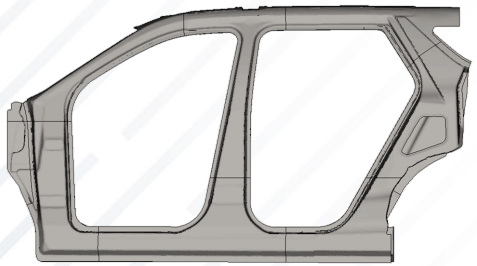
DOUBLE DOOR RING INNER AND OUTER
CRASH PERFORMANCE



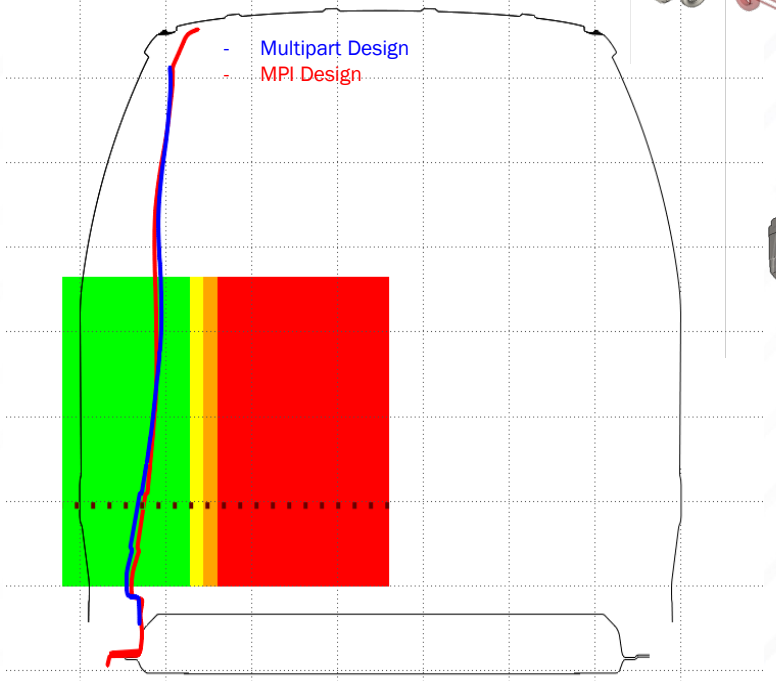
IIHS Small Overlap Rigid Barrier

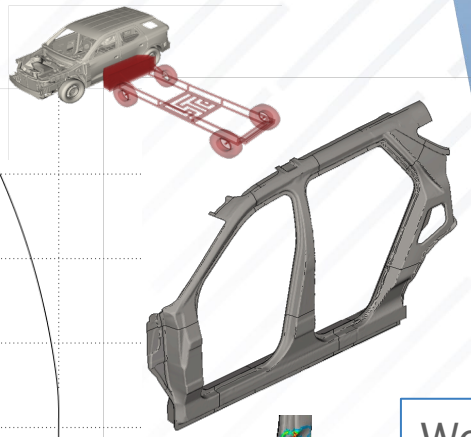






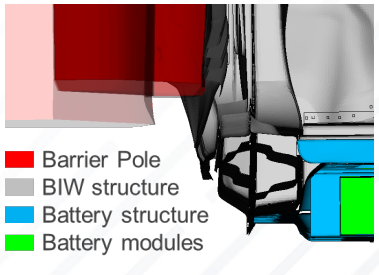
IIHS Side Impact



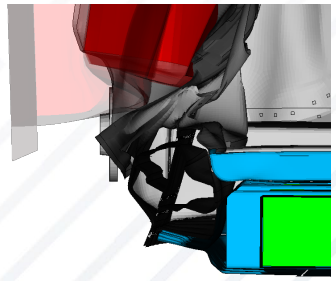


Weight saving per vehicle: 22 kgs

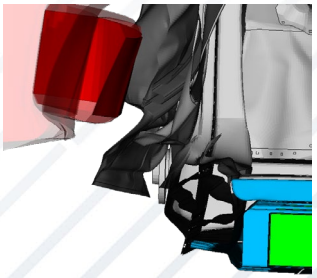
10ms Sill starts crushing



75ms midway through crush



150ms end of crush

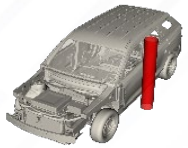


Enhanced protection for battery and occupant achieved using the double door rings

DOUBLE DOOR RING INNER AND OUTER
CRASH PERFORMANCE

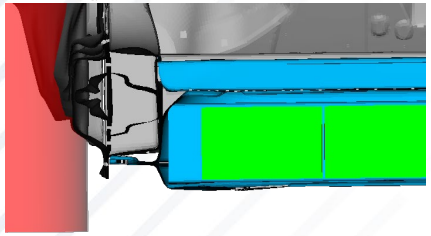
FMVSS 214 5th Pole

Barrier Pole
BIW structure
Battery structure
Battery modules

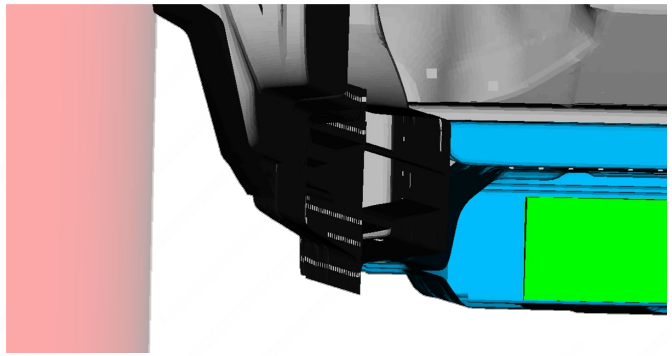


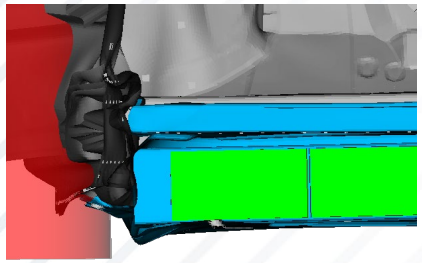
FMVSS 214 50th Pole

Weight saving per vehicle: 22 kgs

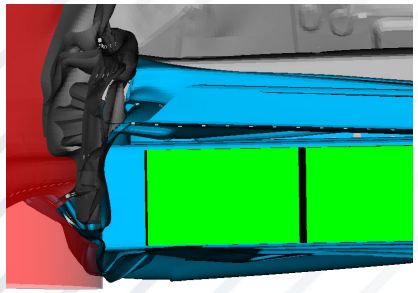


20 ms: Sill start crushing

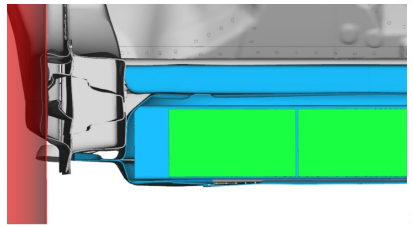




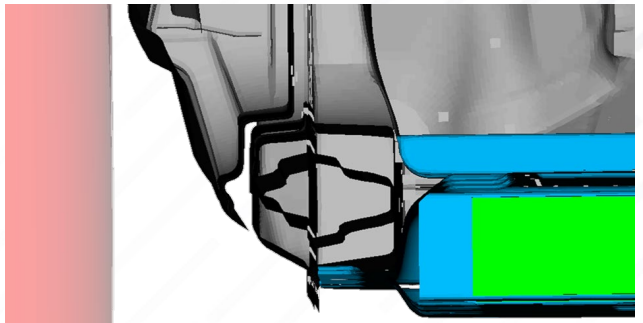
35 ms: Midway through crush

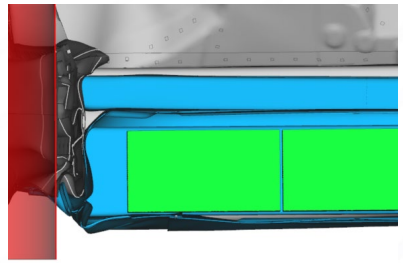


65 ms: Max. deformation, no contact with battery modules

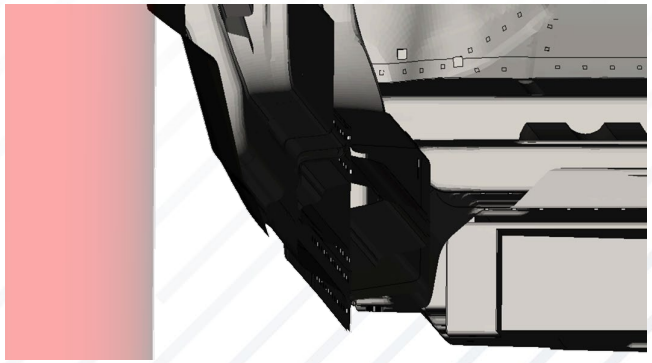


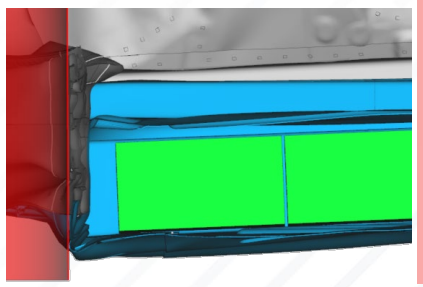
20 ms: Sill start crushing





35 ms: Midway through crush

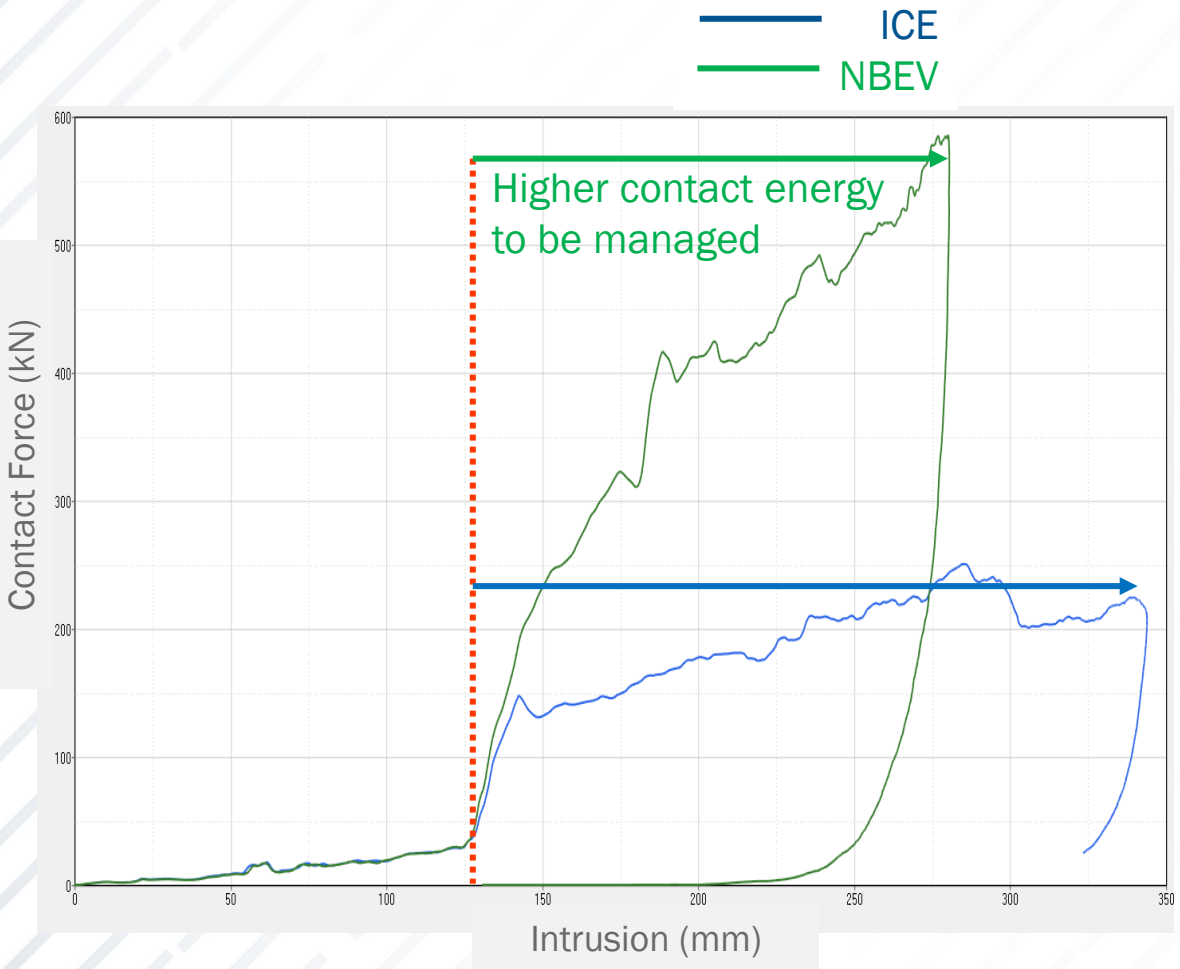


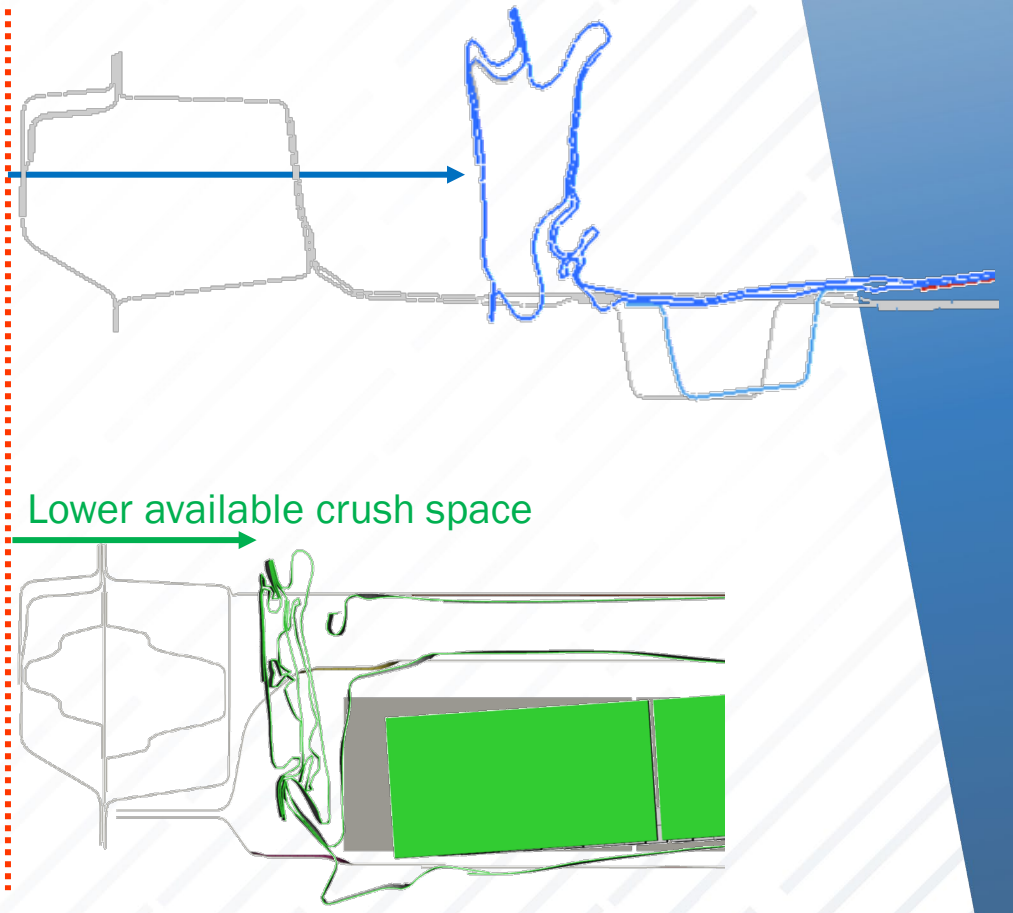


65 ms: Max. deformation, no contact with battery modules

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

DOUBLE DOOR RING INNER AND OUTER
POLE CRASH COMPARISON – ICE VS BEV CHALLENGES



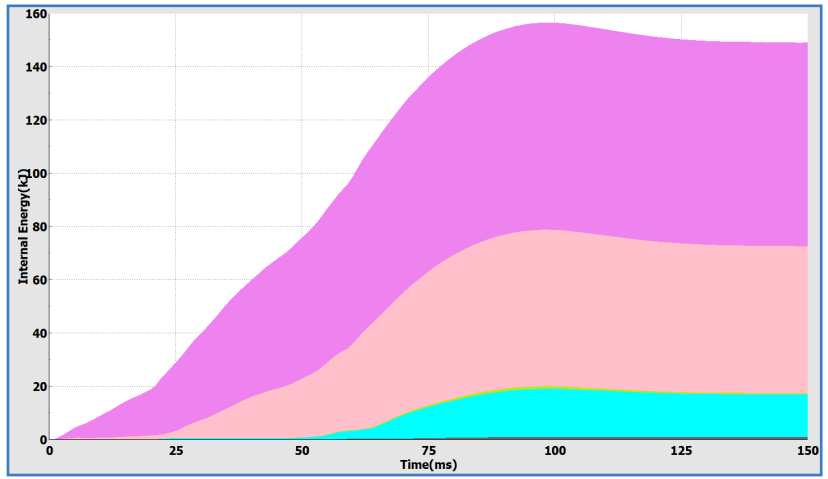


NBEV: 40% higher kinetic energy, 20% lower cabin intrusions → 230% resultant contact force

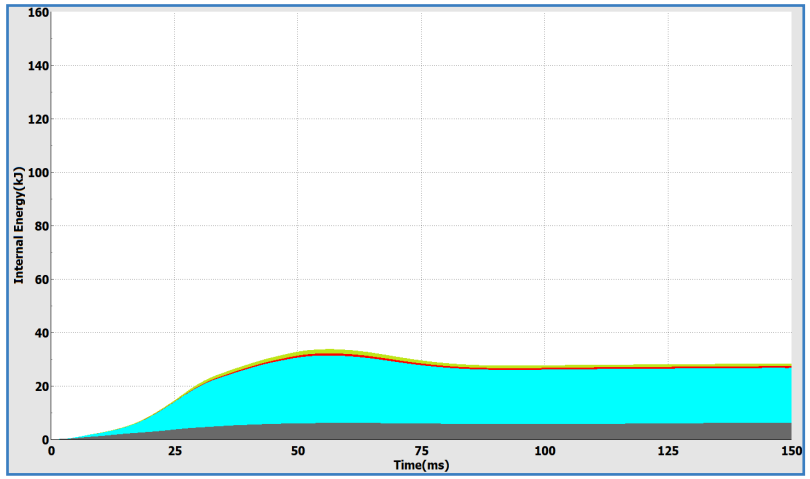
DOUBLE DOOR RING INNER AND OUTER

ENERGY DISTRIBUTION

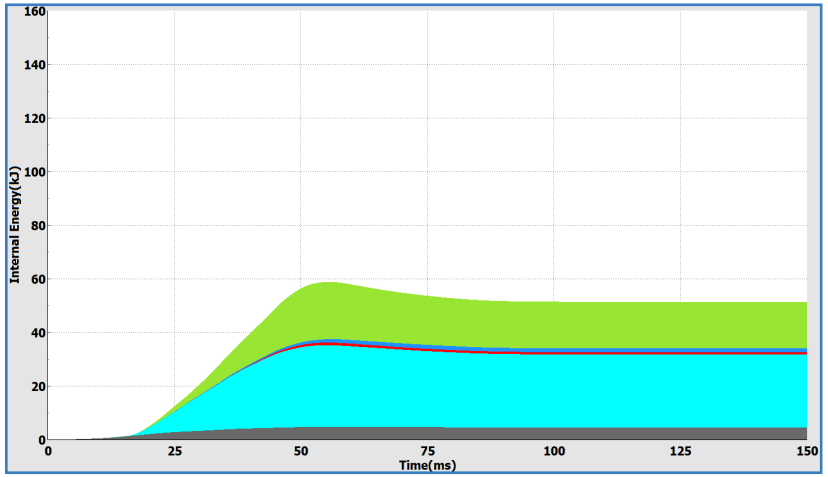
IIHS Small Overlap



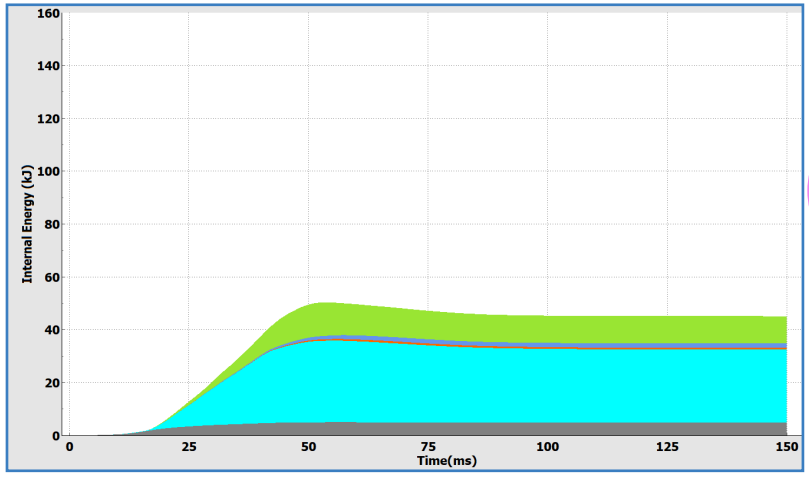
IIHS Side Impact

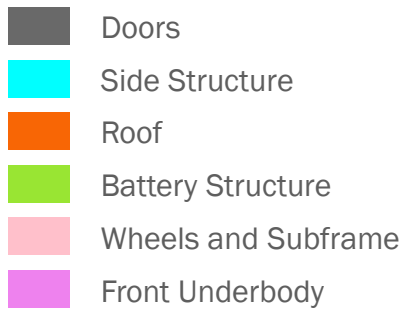


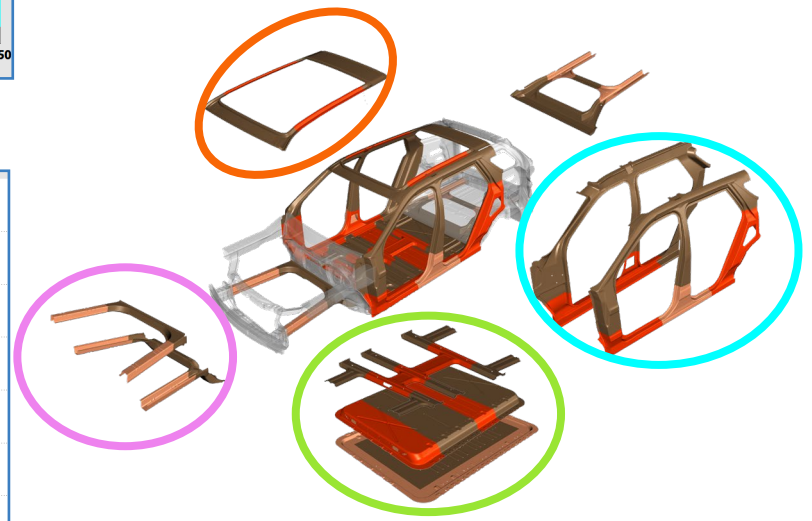
FMVSS 214 5th Pole



FMVSS 214 50th Pole

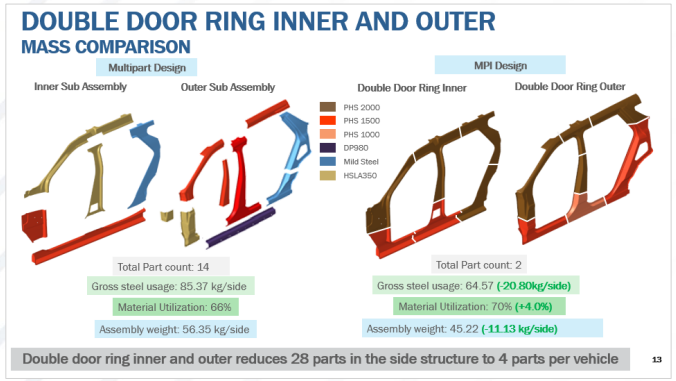


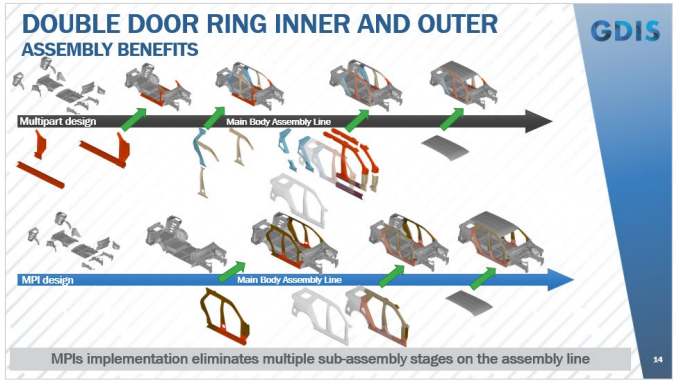


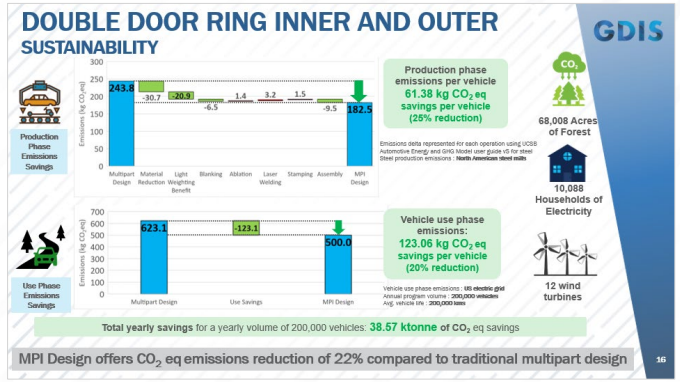


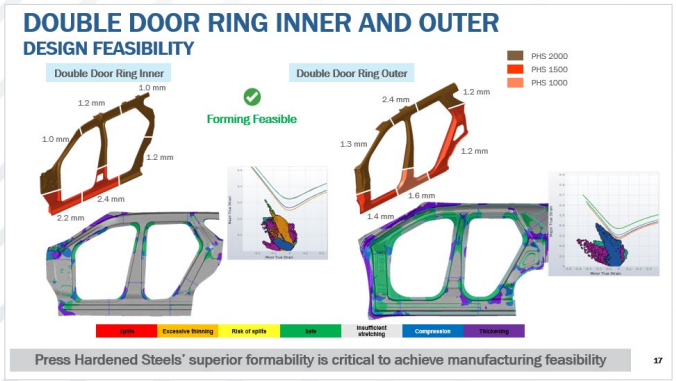
The double door ring inner and outer structure is integral for safety in all load cases

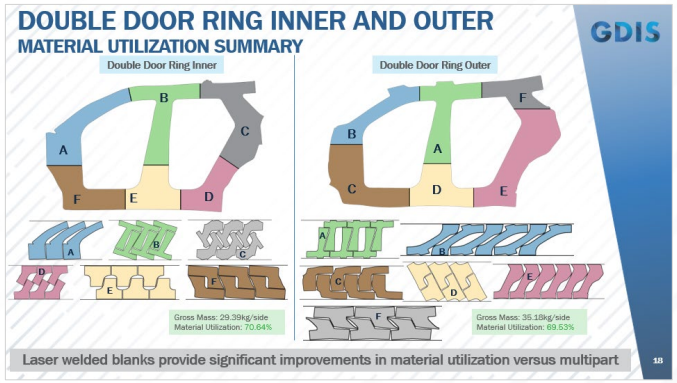
BENEFITS CASE STUDY: DOUBLE DOOR RING INNER AND OUTER

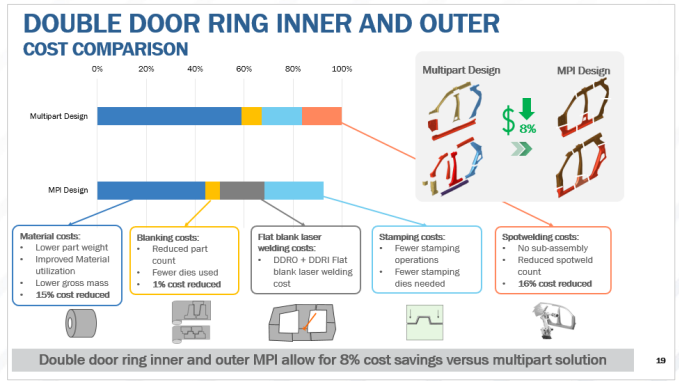










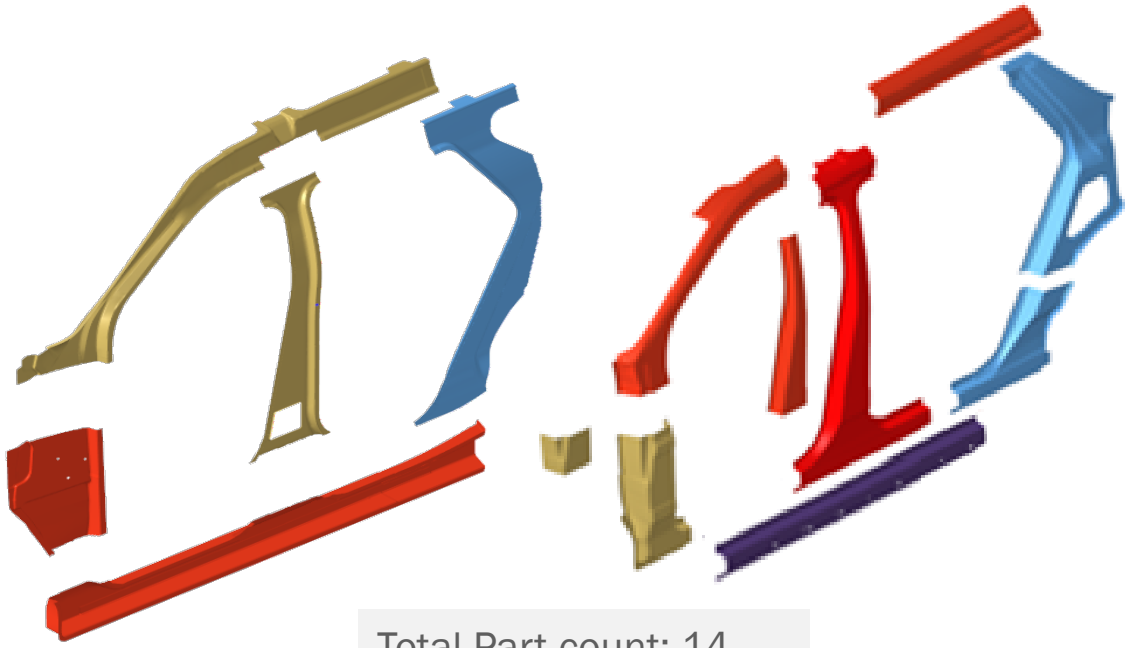


DOUBLE DOOR RING INNER AND OUTER
MASS COMPARISON

Multipart Design

Inner Sub Assembly

Outer Sub Assembly



PHS 2000
PHS 1500
PHS 1000
DP980
Mild Steel
HSLA350

Total Part count: 14

Gross steel usage: 85.37 kg/side

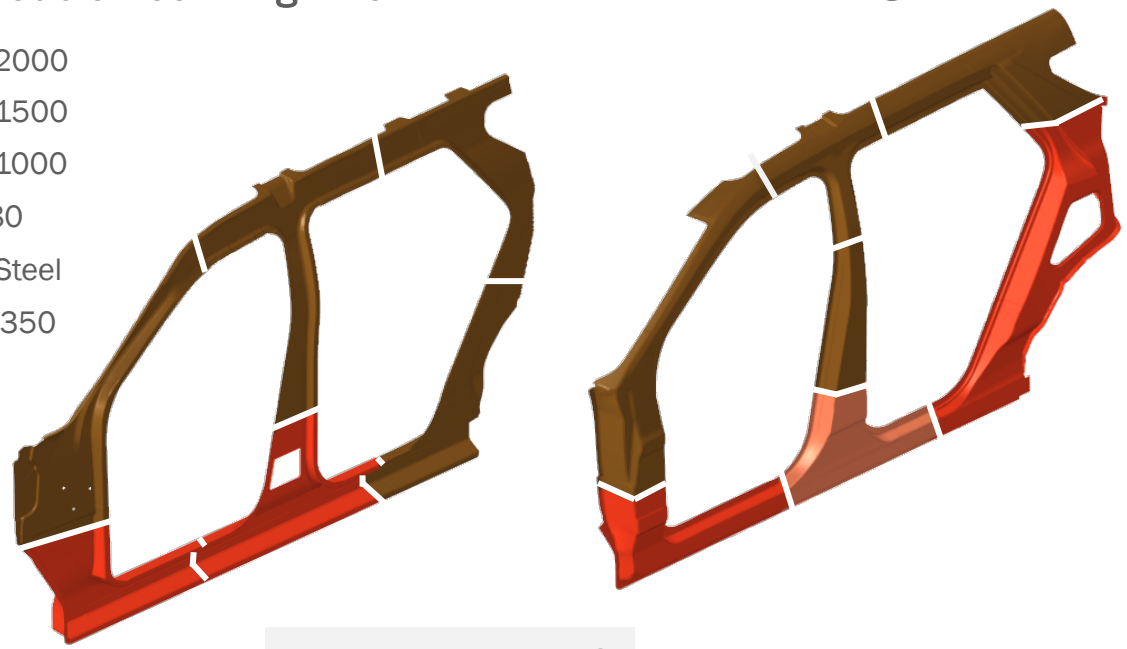
Material Utilization: 66%

Assembly weight: 56.35 kg/side

MPI Design

Double Door Ring Inner

Double Door Ring Outer



Total Part count: 2

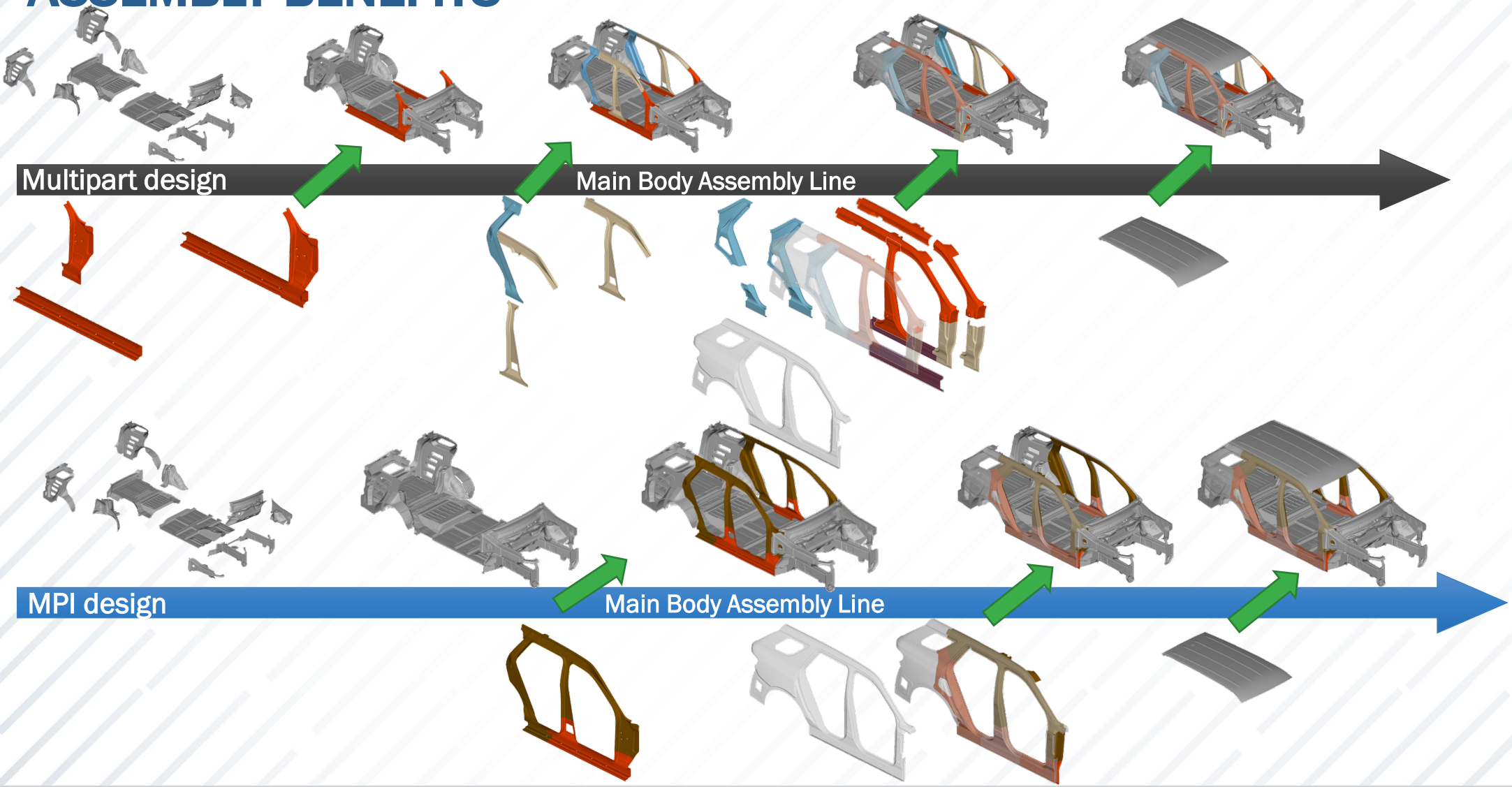
Gross steel usage: 64.57 (-20.80kg/side)

Material Utilization: 70% (+4.0%)

Assembly weight: 45.22 (-11.13 kg/side)

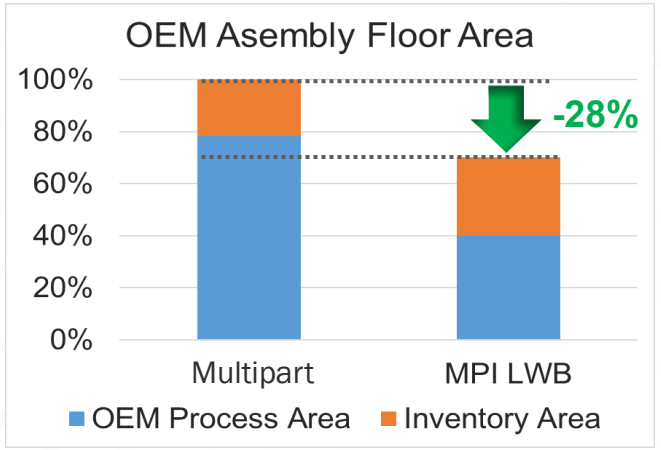
Double door ring inner and outer reduces 28 parts in the side structure to 4 parts per vehicle

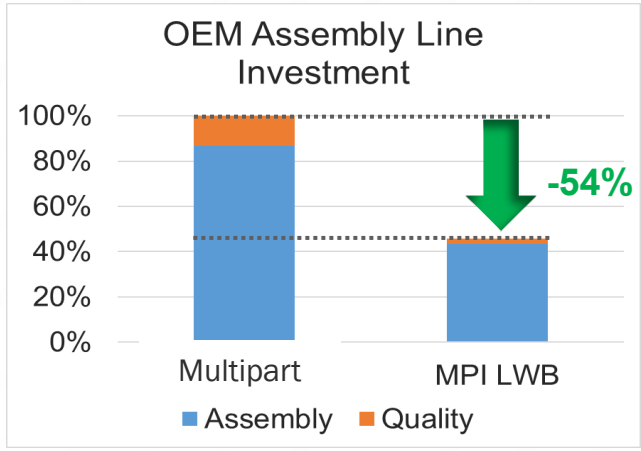
DOUBLE DOOR RING INNER AND OUTER
ASSEMBLY BENEFITS

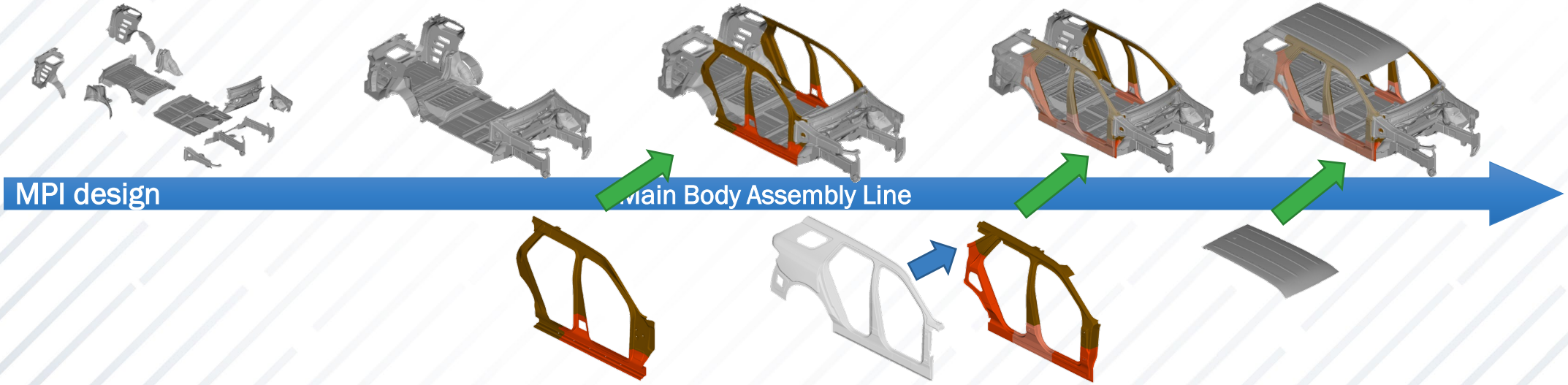


MPIs implementation eliminates multiple sub-assembly stages on the assembly line

DOUBLE DOOR RING INNER AND OUTER
ASSEMBLY BENEFITS



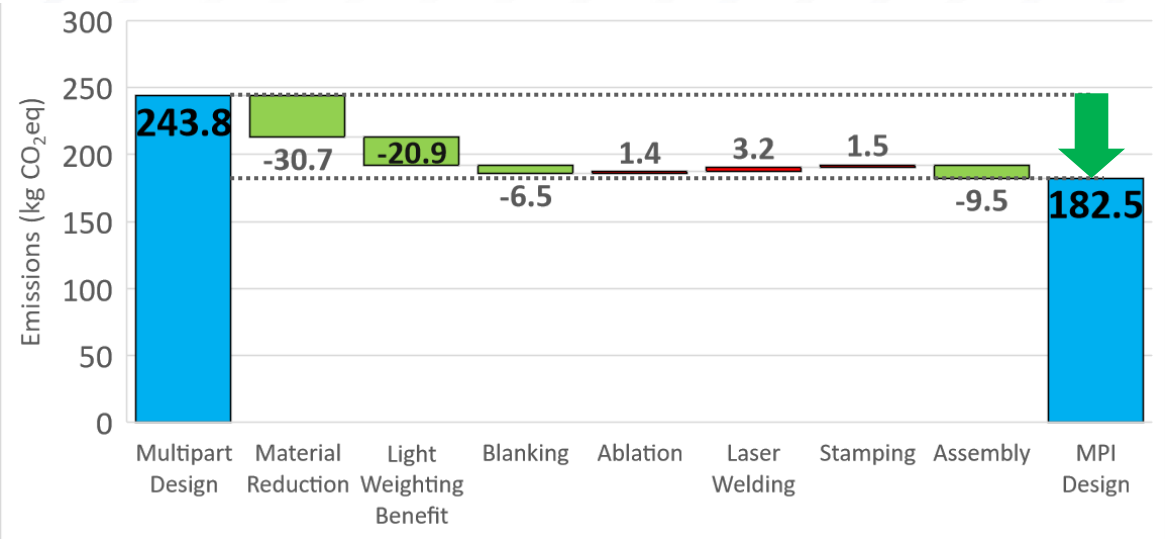




MPIs implementation eliminates multiple sub-assembly stages on the assembly line

DOUBLE DOOR RING INNER AND OUTER
SUSTAINABILITY

Production Phase Emissions Savings



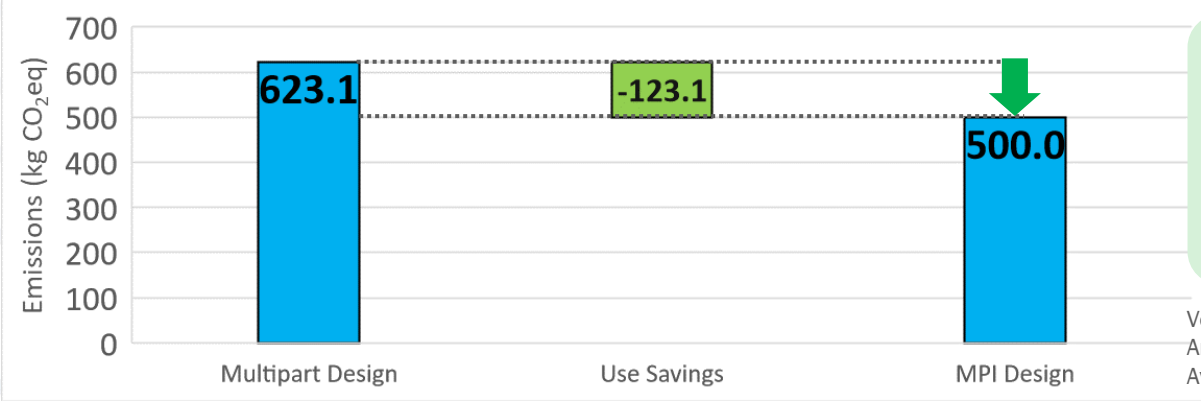
Production phase emissions per vehicle
61.38 kg CO_2 eq savings per vehicle (25% reduction)

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**

68,008 Acres of Forest

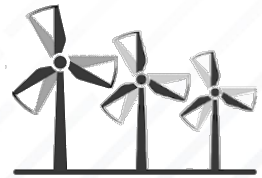
10,088 Households of Electricity

Use Phase Emissions Savings



Vehicle use phase emissions:
123.06 kg CO_2 eq savings per vehicle (20% reduction)

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



12 wind turbines

Total yearly savings for a yearly volume of 200,000 vehicles: **38.57 ktonne of CO_2 eq savings**

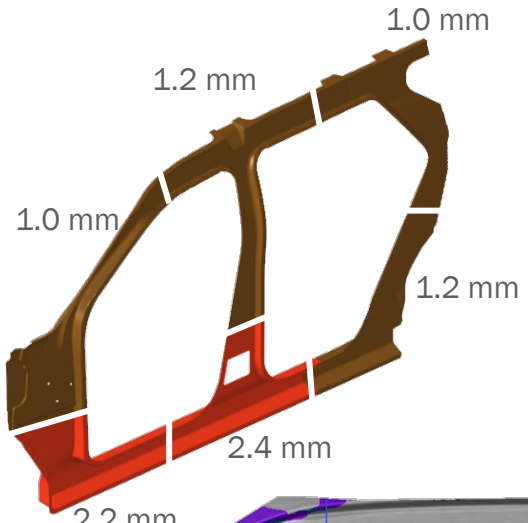
MPI Design offers CO_2 eq emissions reduction of 22% compared to traditional multipart design

DOUBLE DOOR RING INNER AND OUTER

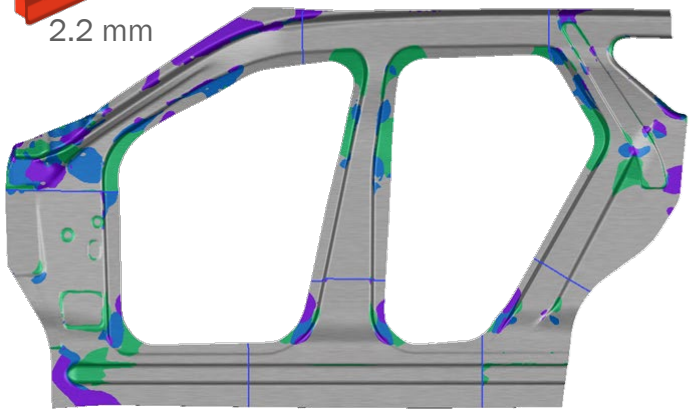
DESIGN FEASIBILITY

PHS 2000
PHS 1500
PHS 1000

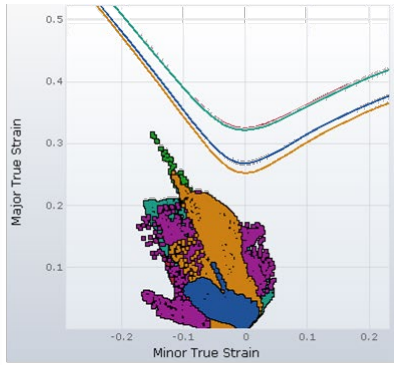
Double Door Ring Inner



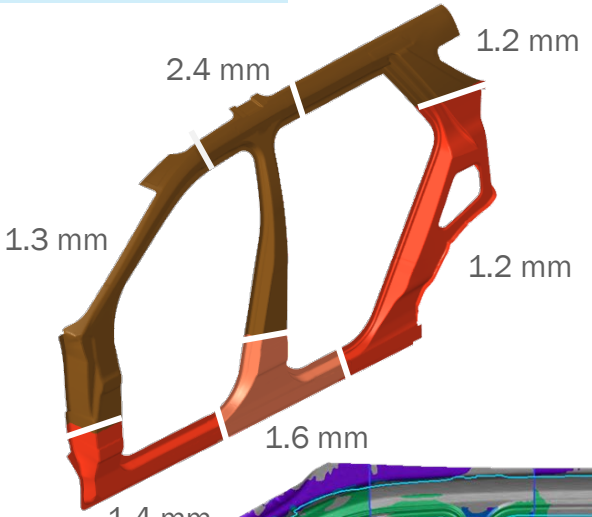
2.2 mm



Forming Feasible

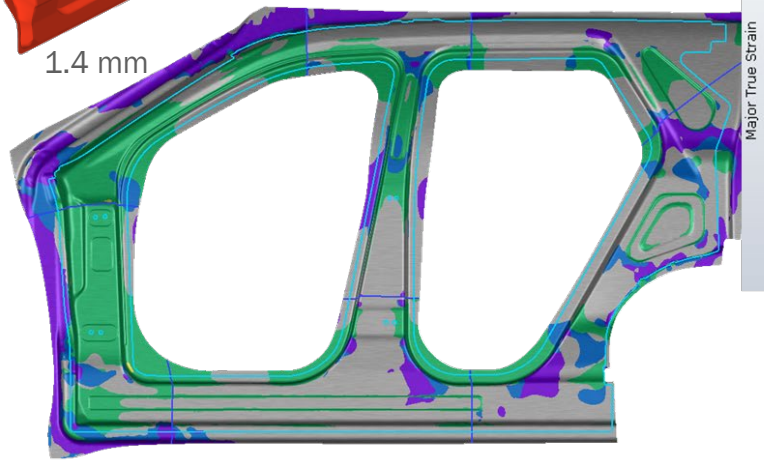


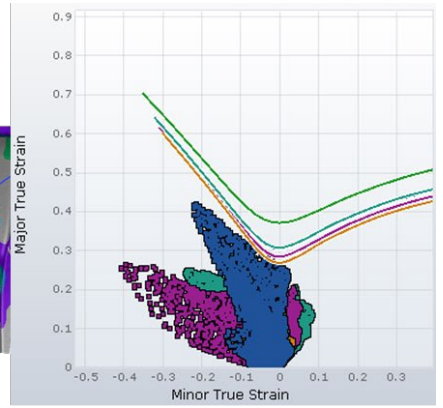
Double Door Ring Outer



1.6 mm

1.4 mm



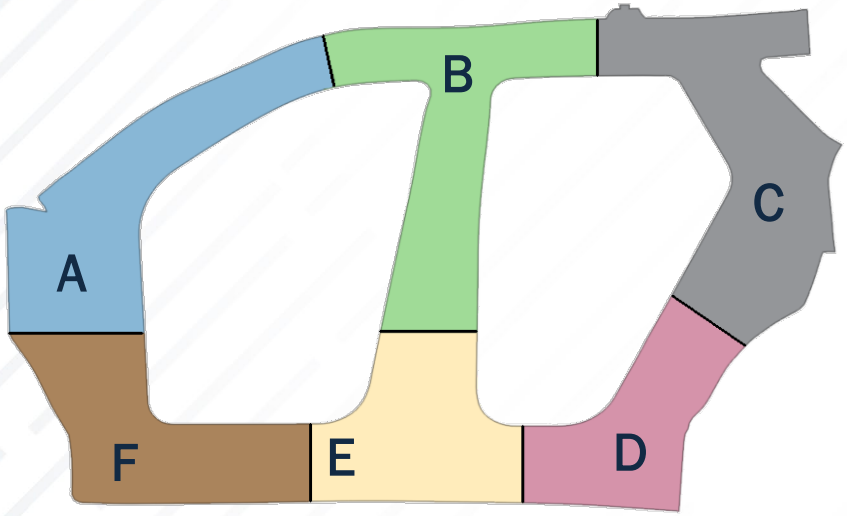


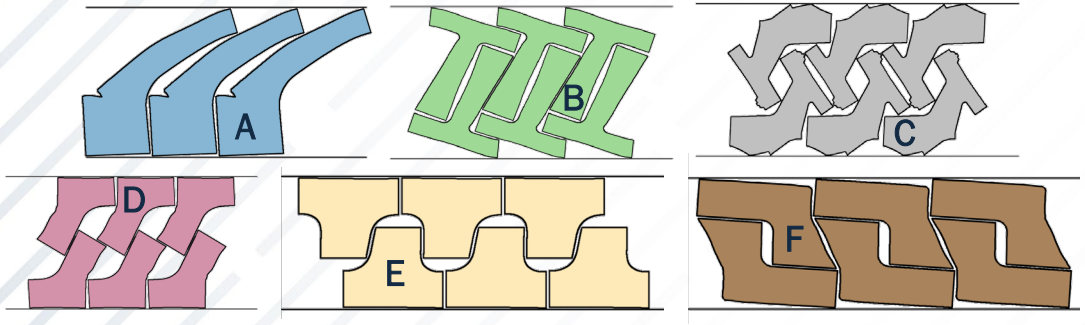
Splits	Excessive thinning	Risk of splits	Safe	Insufficient stretching	Compression	Thickening

Press Hardened Steels' superior formability is critical to achieve manufacturing feasibility

DOUBLE DOOR RING INNER AND OUTER
MATERIAL UTILIZATION SUMMARY

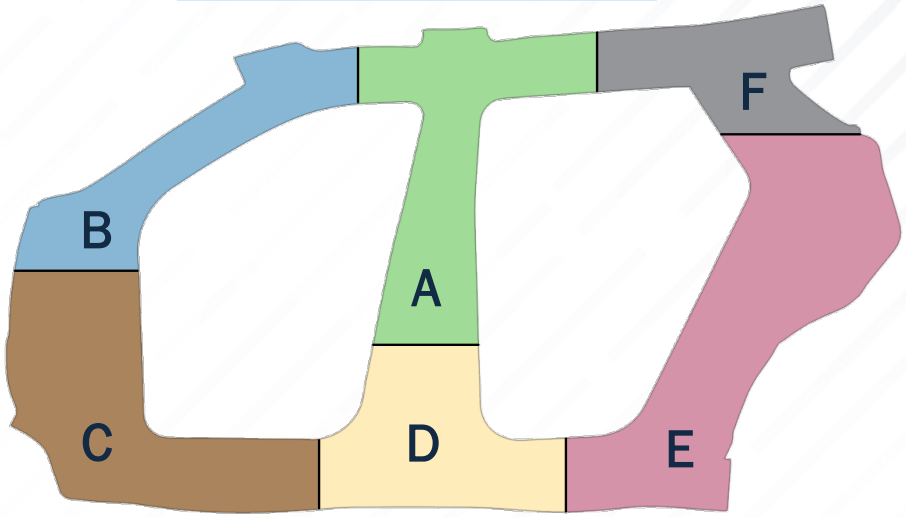
Double Door Ring Inner

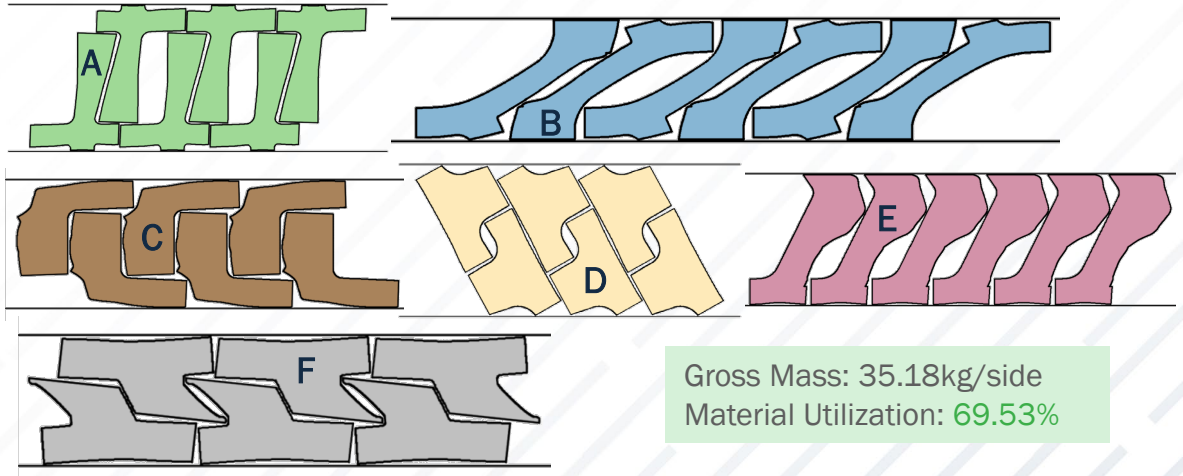




Gross Mass: 29.39kg/side
Material Utilization: 70.64%

Double Door Ring Outer

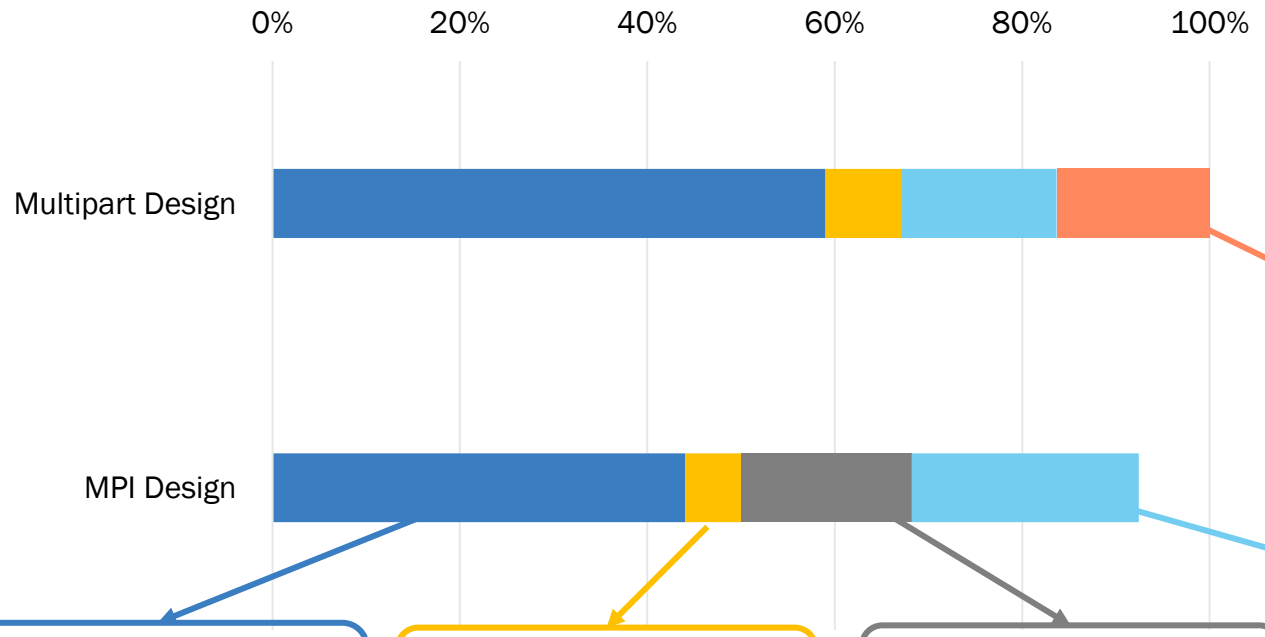


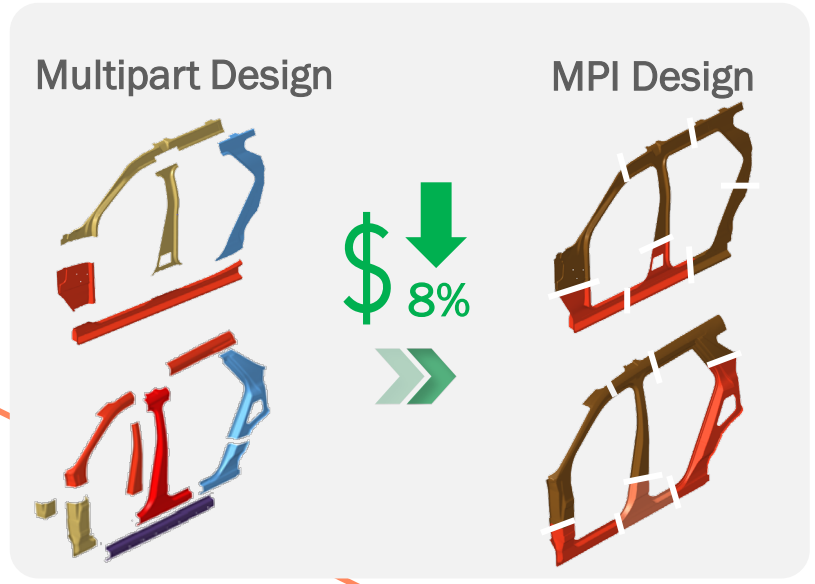


Gross Mass: 35.18kg/side
Material Utilization: 69.53%

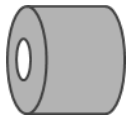
Laser welded blanks provide significant improvements in material utilization versus multipart

DOUBLE DOOR RING INNER AND OUTER
COST COMPARISON

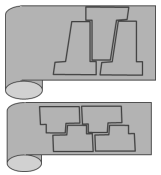




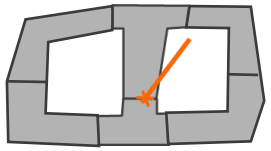
Material costs:
- Lower part weight
- Improved Material utilization
- Lower gross mass
- **15% cost reduced**



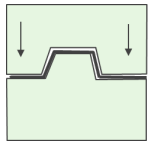
Blanking costs:
- Reduced part count
- Fewer dies used
- **1% cost reduced**



Flat blank laser welding costs:
- DDRO + DDRI Flat blank laser welding cost



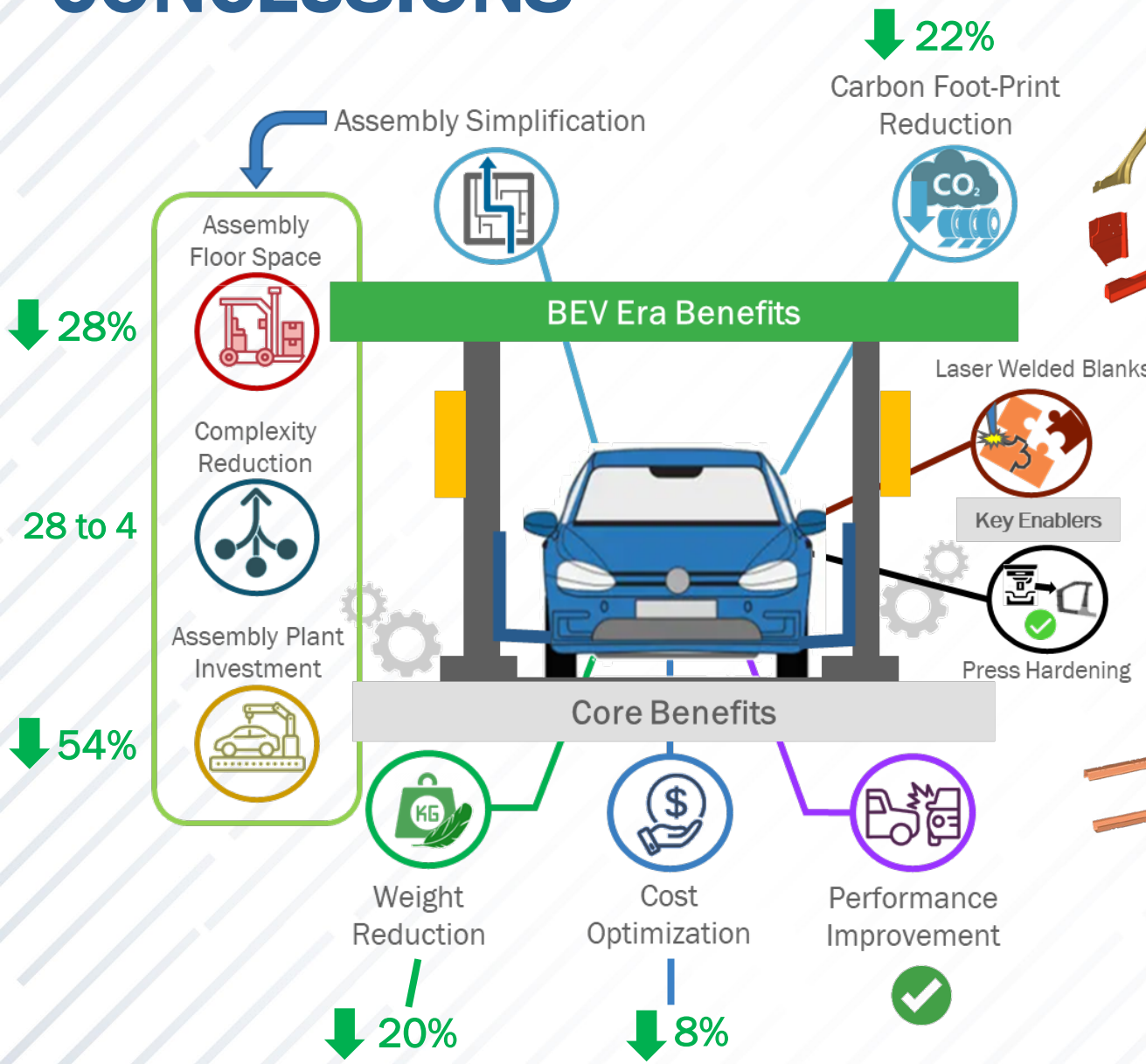
Stamping costs:
- Fewer stamping operations
- Fewer stamping dies needed

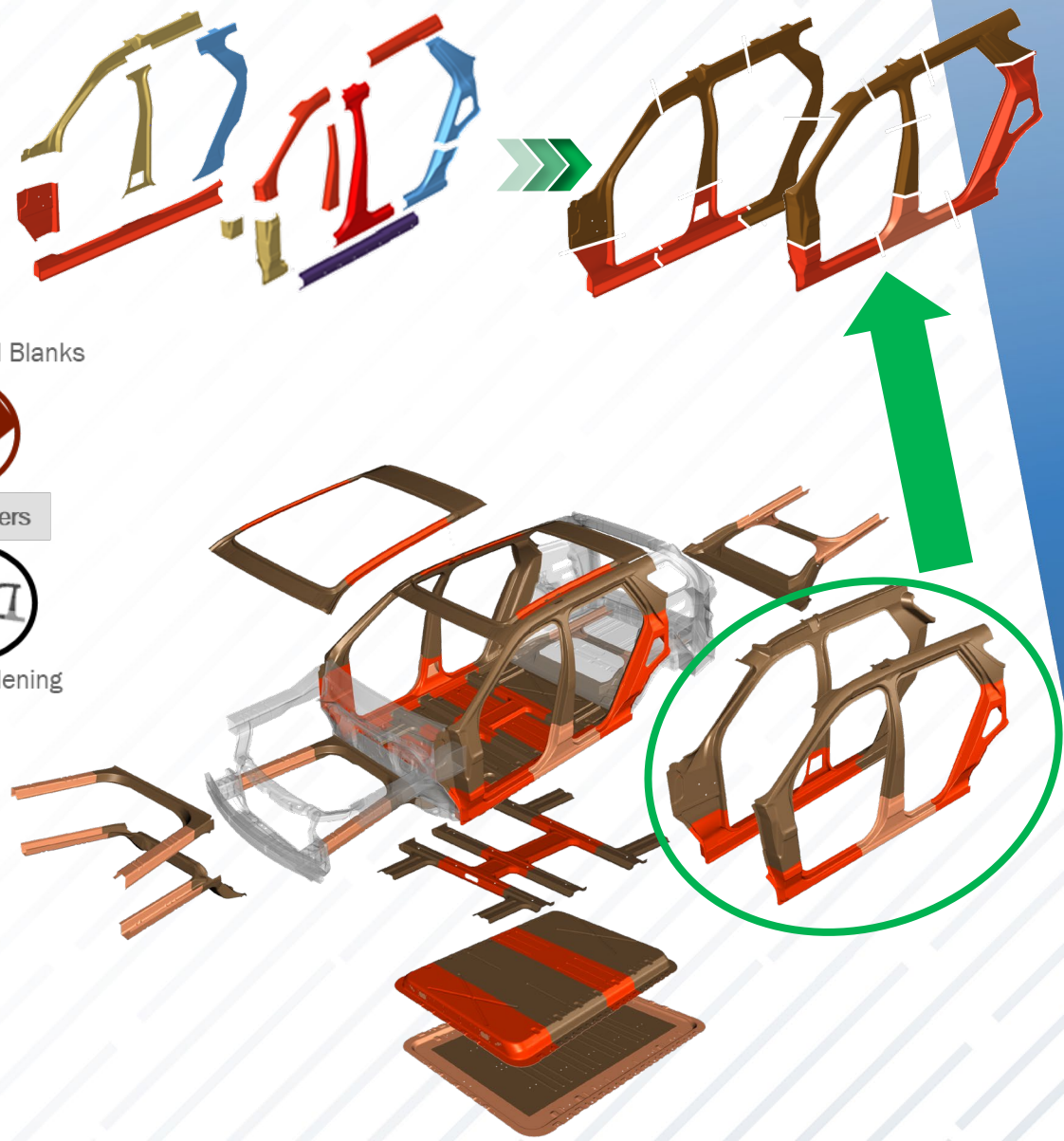


Spotwelding costs:
- No sub-assembly
- Reduced spotweld count
- **16% cost reduced**

Double door ring inner and outer MPI allow for 8% cost savings versus multipart solution

CONCLUSIONS



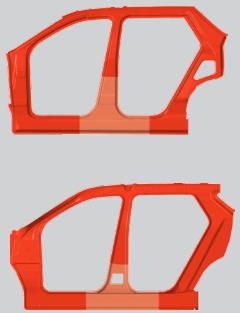


IT HAS ALREADY BEGUN!

Why apply Hot Stamped (HS) LWB door ring solution? - Safer, Lighter & Greener

- Evolution of Door Ring design to Double Door Ring Designs
- Incorporates 14 parts into 2 stamped parts
- Press Hardened Steel enables stamping of the complex shapes
- Excellent load transfer through continuous seams in crash events
- Acts as part of an integrated battery and occupant protection system
- Reduced manufacturing footprint
- Cheaper and lighter solution
- Validated through prototypes and production vehicle assembly
- **Coming soon!**
- **First of many currently in design**

Coming soon!



Weight Saved = 18.0 kg/vehicle

*expecting top IIHS rating for crash and safety evaluations

Emissions savings per year = 63,617,598 kg CO_2eq

Wind turbines = 13

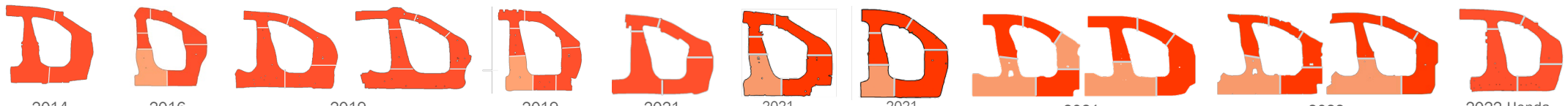
Household electricity = 11,103

Acres of forest = 74,844

World's first Door Ring Inner & Outer

Door ring Execution

Door ring design variation & complexity



Implemented door ring solutions & LWBs make the vehicles – safer, stronger, lighter and greener

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