3D Reinforced Blanks: Additive Solutions for Localized BIW Stiffness

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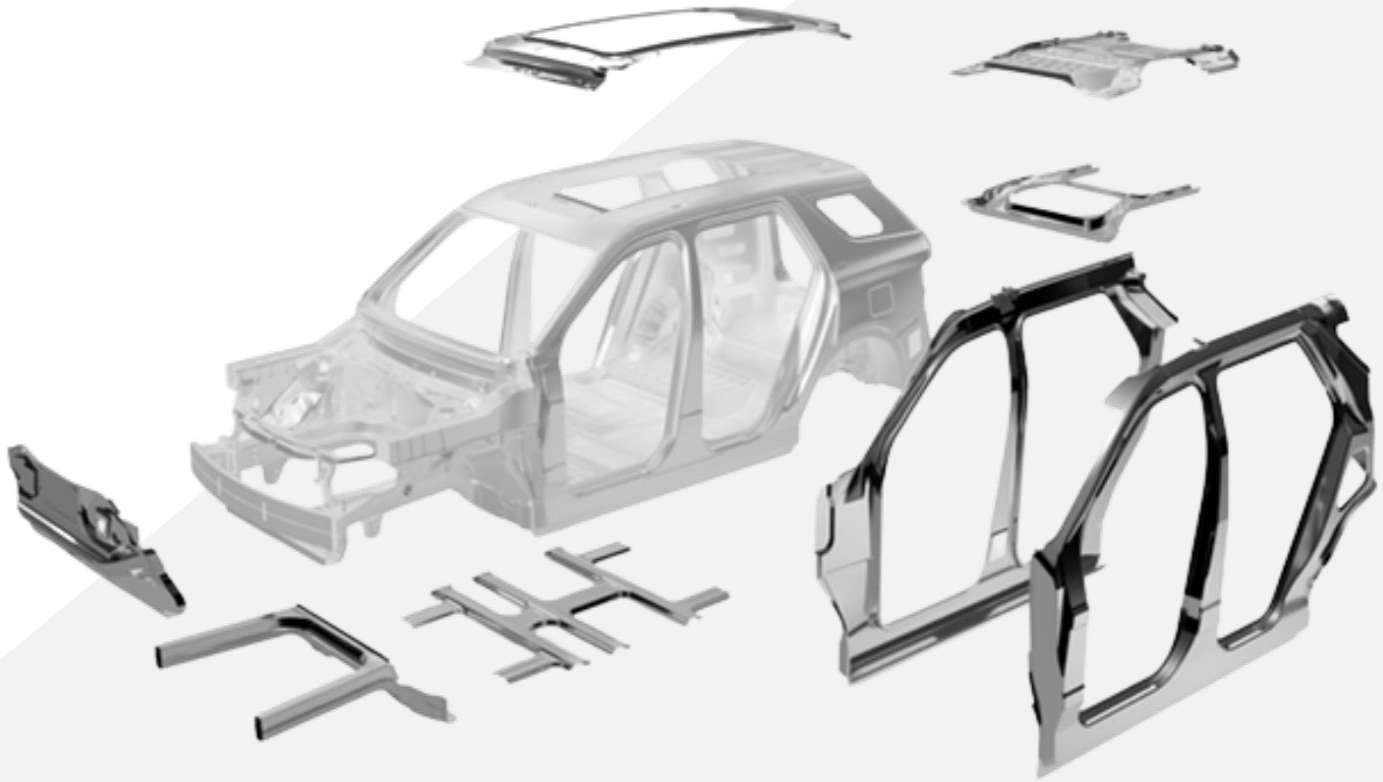
GREAT DESIGNS IN STEEL™

Agenda

1. Industry Challenges and Opportunities
2. 3D Reinforced Blanks – Introduction and Process Overview
3. Case study – Rear Underbody Stiffness
    a) Industry Benchmark
    b) Optimization
4. Conclusions



Industry Challenges & Opportunities

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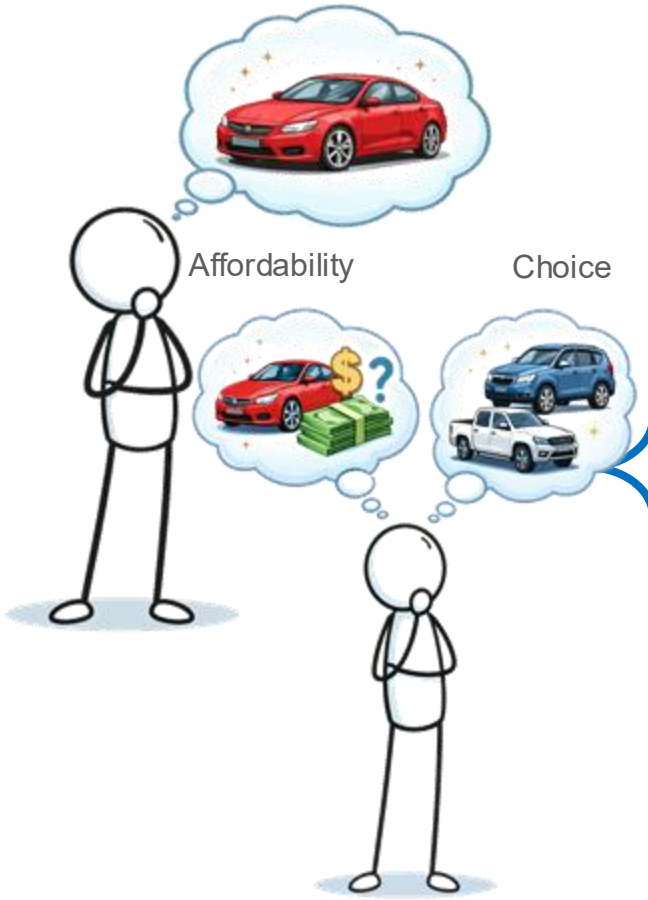
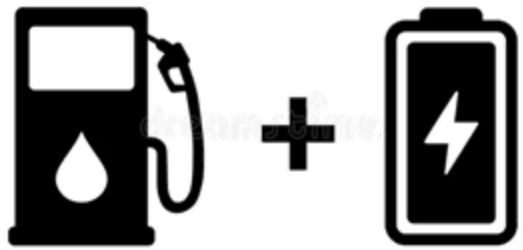
What Do Customers Want?



OEM Strategy

Mix Model Assemblies
Multiple Powertrains



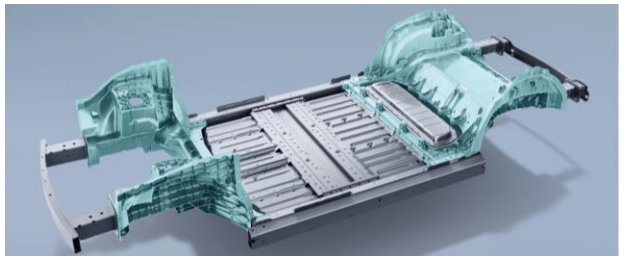
Assembly
Simplification
Part Count
Reduction
Crash Safety

ArcelorMittal Multi Part Integration®

Laser Welded Blanks

$↓

Giga Castings



Source – Xpeng G6

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Vehicle buyers want multiple affordable car options driving OEM strategy for cost reduction

Industry Challenges & Opportunities

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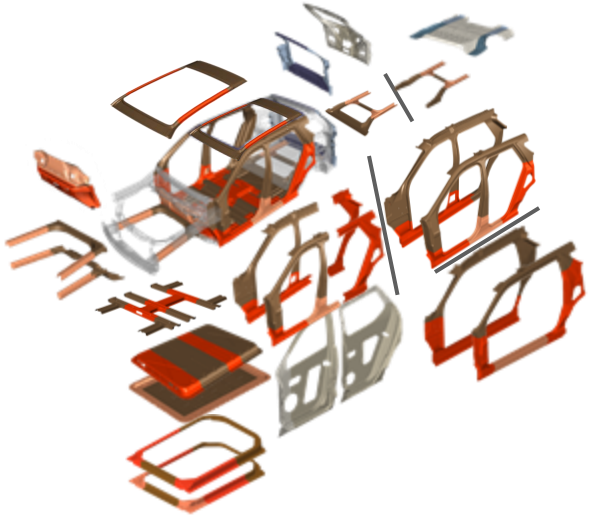
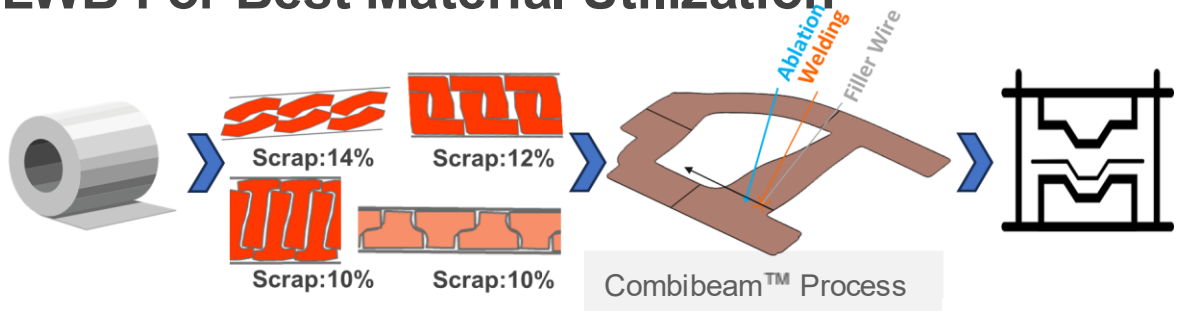
Big Consolidated Steel Stampings

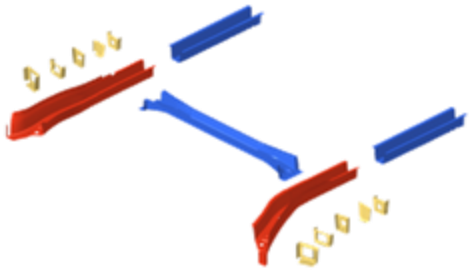


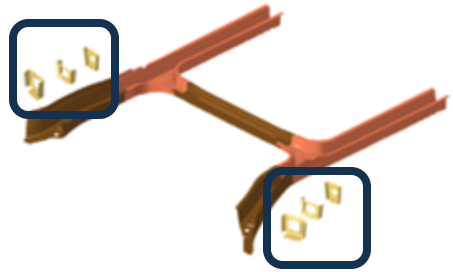
LWB For Best Material Utilization



Industry Standard

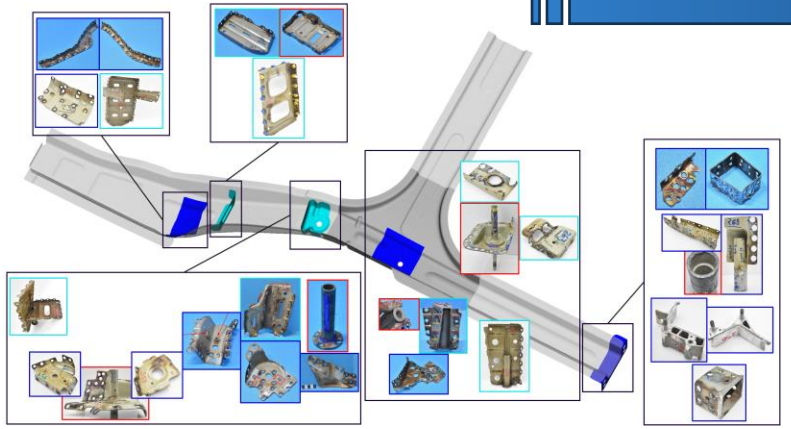
Current LWB Capability





Small Brackets and Reinforcements

How to integrate additional reinforcements?



- **Reinforcements**
- **Bulkheads**
- **Attachment brackets**

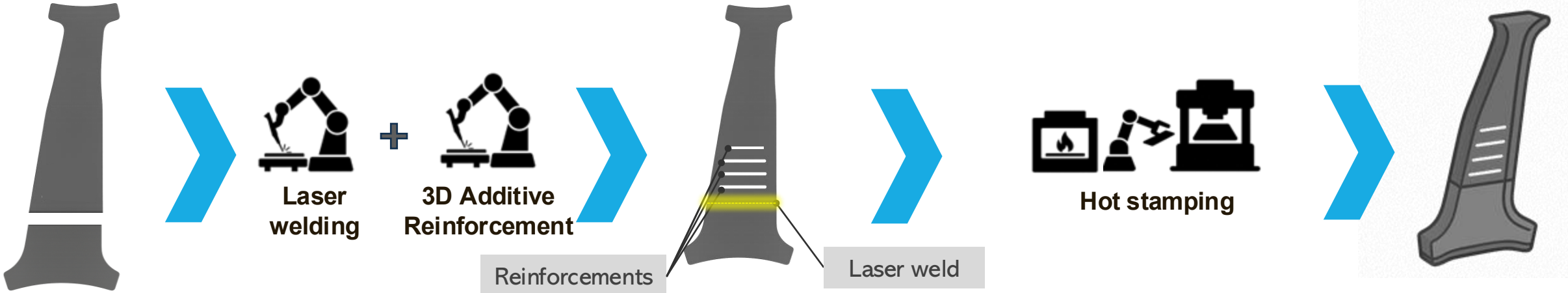
**Source - A2Mac1*

ArcelorMittal Multi Part Integration® (MPI) concepts enable powertrain agnostic crash safety

3D Reinforced Blanks – Development Goals

- Modularity and design flexibility
- Simple integration in current manufacturing flows
- Same or better performance (crash and stiffness), lower weight
- Same corrosion performance

Drive towards Increased Part Integration !!

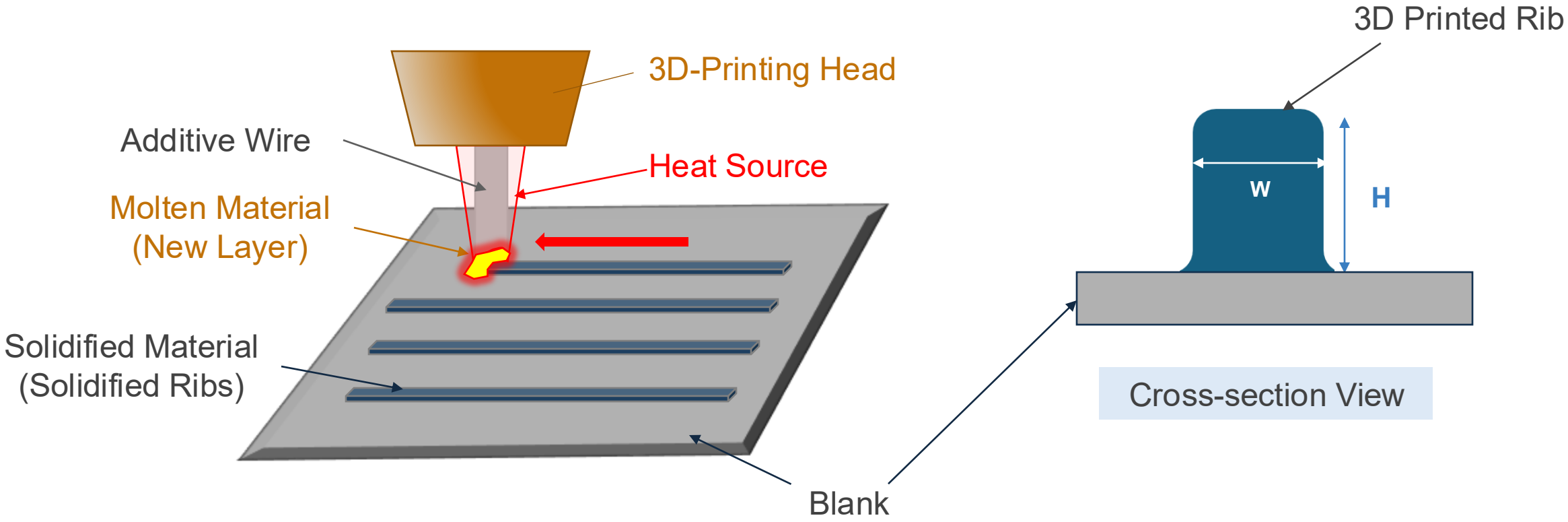


Wire Additive Manufacturing technology choice:
- ✓ Design flexibility
- ✓ Good compromise between productivity and cost
- ✓ Equivalent performance at lower weight

Hot stamping technology choice:
- ✓ Reduced residual stress and low springback on final part
- ✓ No heat affected zones on final part
- ✓ Widely used in automotive industry

3D Reinforcement of MPI blanks enables increased part integration within existing supply chain

3D Reinforced Blanks – Process Details



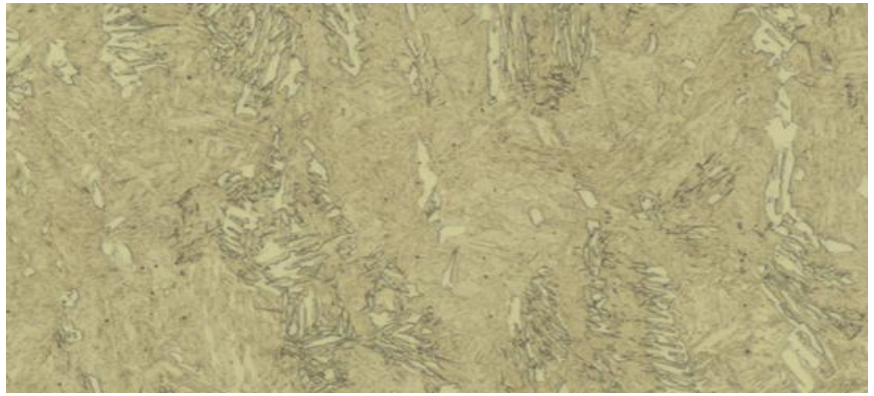
Printing process consists of a heat source that melts a wire to build 3D metal layer on the blank

3D Reinforced Blanks – Wire Selection

Mechanical Properties

- Martensitic microstructure after hot-stamping
- Maximum stiffness and reaction force
- No brittle failure of the assembly

Martensitic Microstructure

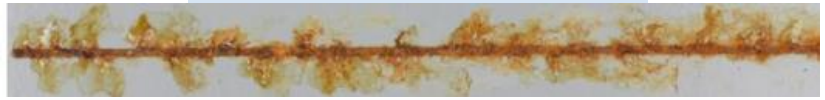


Corrosion Performance

- Low high-temperature oxidation during hot stamping
- Good paint adhesion
- Corrosion similar or better than a regular PHS LWB

Corrosion performance – 12 Weeks VDA233-102

Usibor®1500 AS150



Uncoated 22MnB5

Wire developed for high quenchability, mechanical properties and corrosion performance

3D Reinforced MPI Blanks – CAE and Validation

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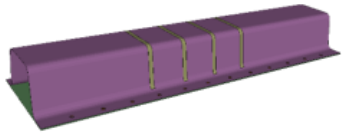
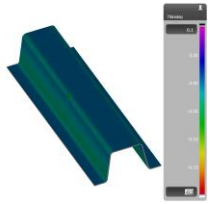
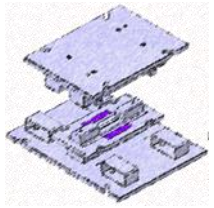
3D Reinforced Hat Section



Stampability

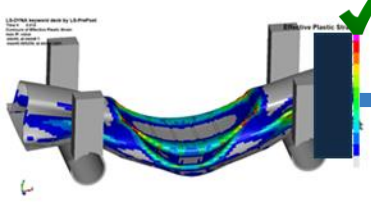
Numerical Validation ✓ → Tool Development ✓ → Tool Manufacturing ✓ → Experimental Validation ✓

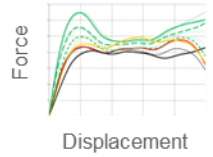


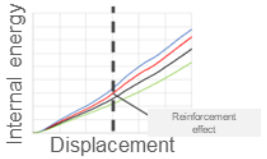


Crash - Performance

Numerical Validation ✓ → Experimental Set-Up ✓ → Experimental Trials ✓ → Numerical-Experimental Correlation ✓



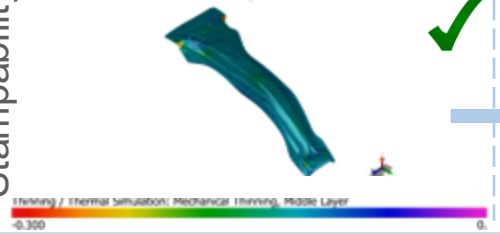




3D Reinforced LWB B-Pillar

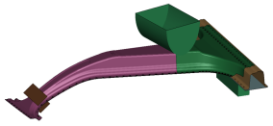
Stampability

Numerical Validation ✓ → Tool Development ✓ → Tool Manufacturing ✓ → Experimental Validation ✓



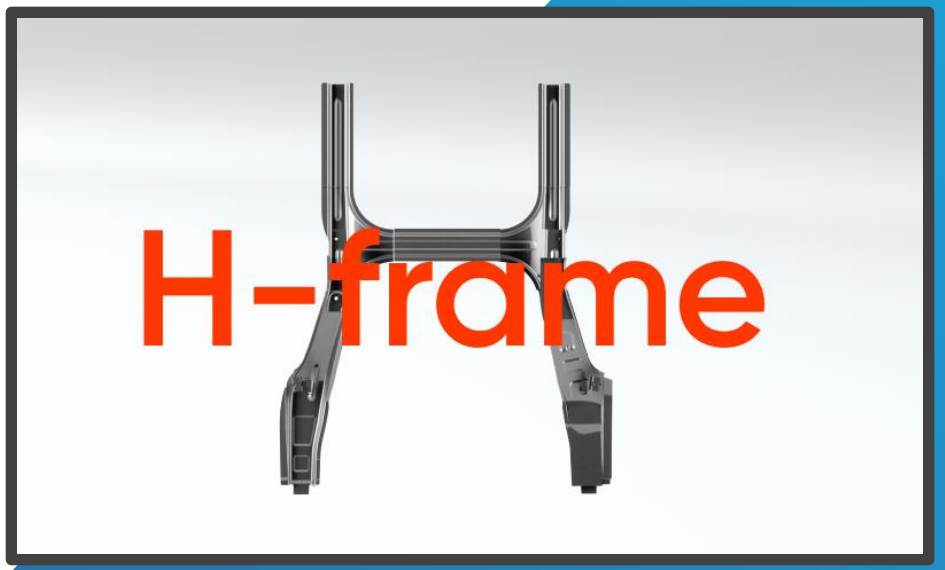
Crash - Performance

Numerical Validation On full Vehicle ✓ → Development of representative Sub-Model ✓ → Development of experimental set-up ✓ → Experimental Validation and Correlation with numerical ✓



Full numerical and experimental chain to support new part development

Case Study:
Rear H-Frame MPI with 3D Reinforced Blanks



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Rear Assembly – EV SUV Benchmark Examples

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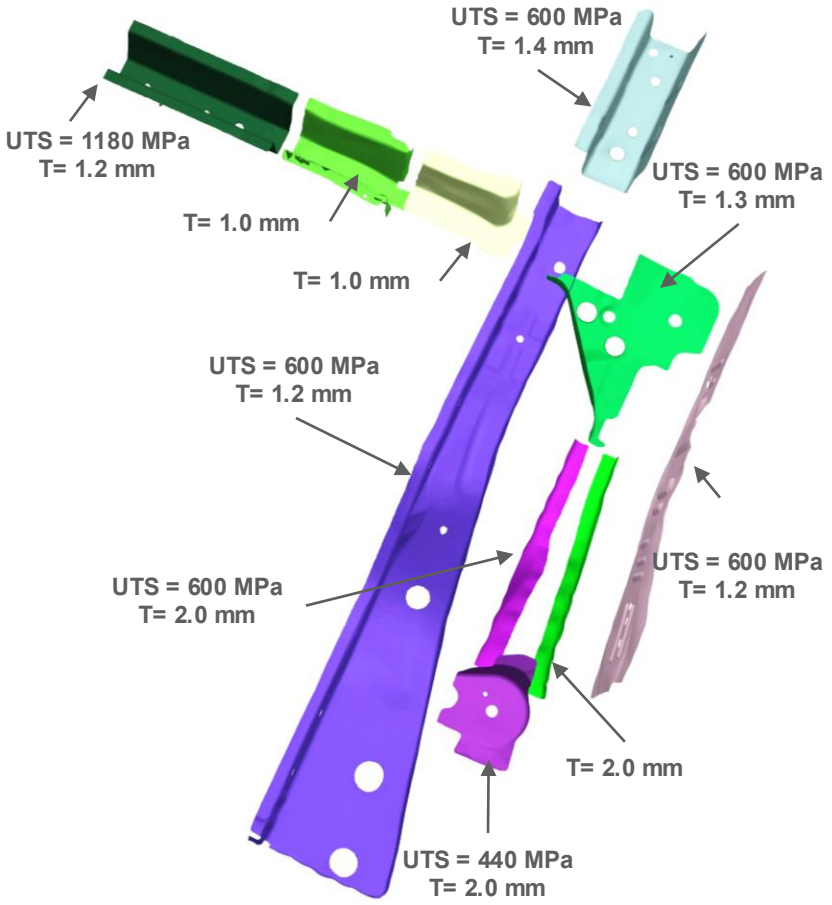
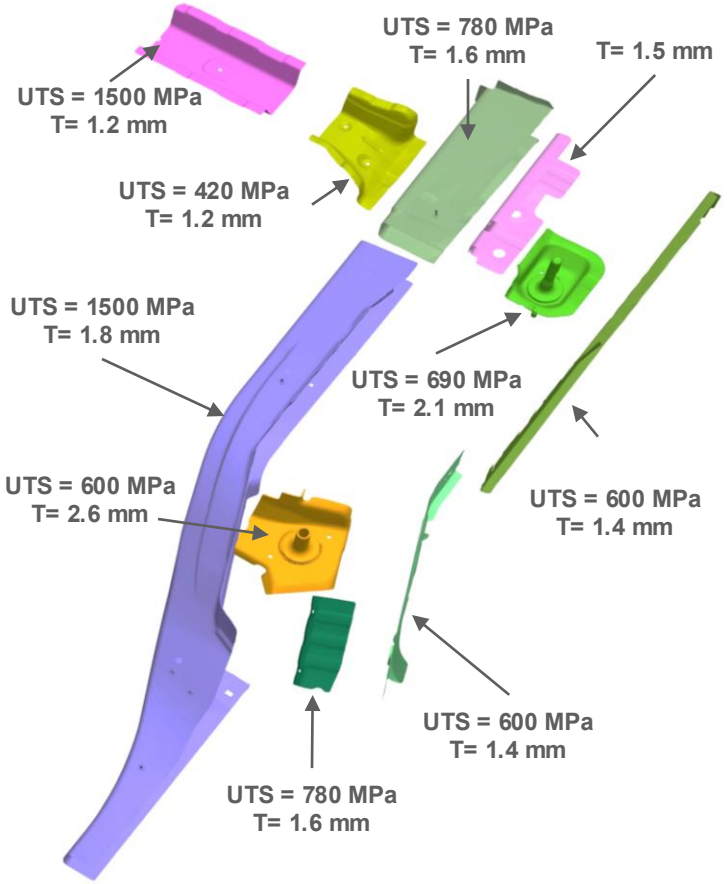
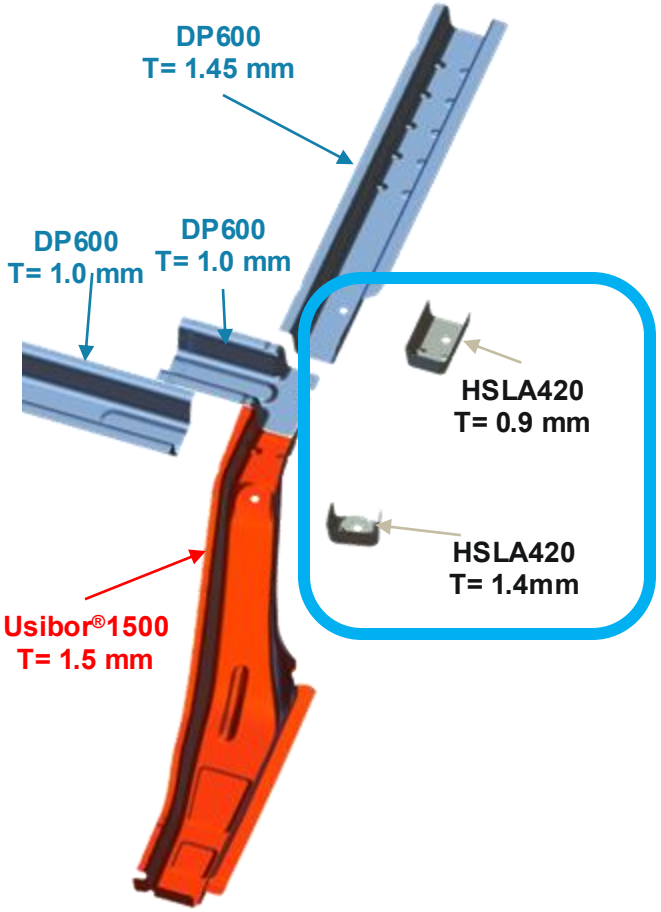
North America OEM1 CUV-BEV



North America OEM2 SUV-BEV



Baseline Multipart S-In Motion®



*Source - A2Mac1 (RH shown. LH/RH symmetric)

Current industry standard is multi part construction with overlapping sections

3D Reinforced Rear H-Frame MPI

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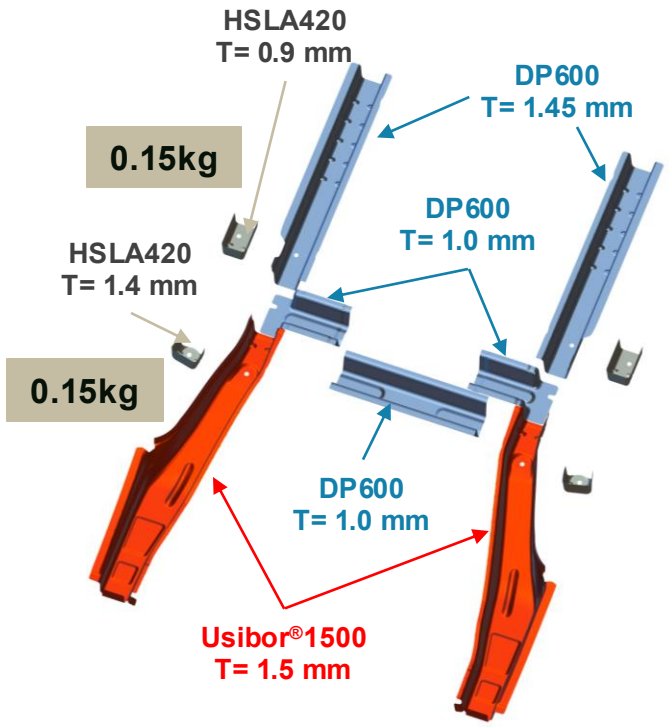
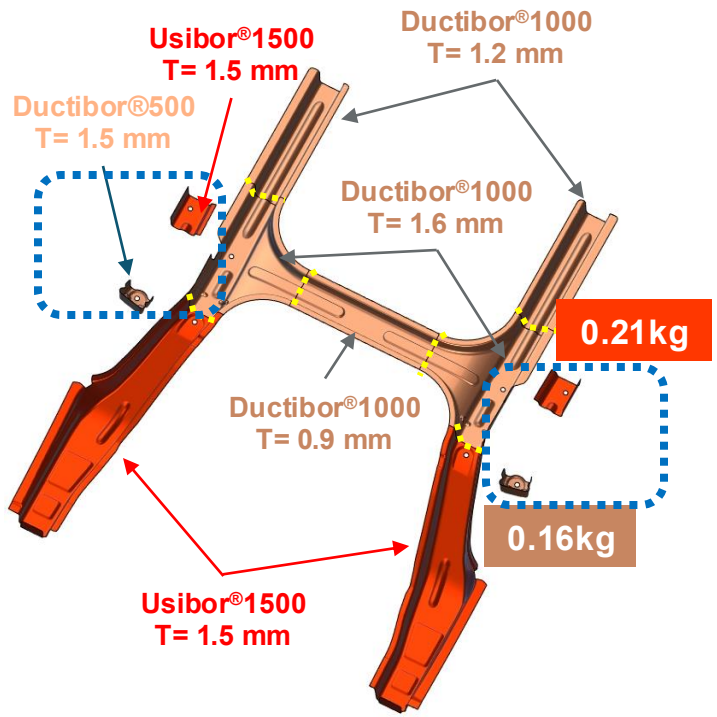
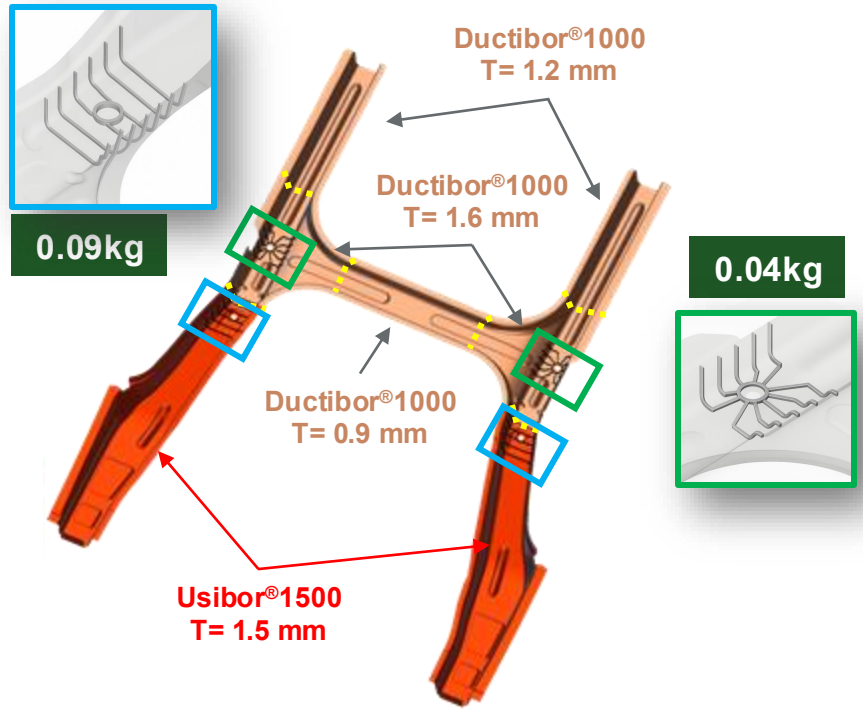
Baseline Multipart



Rear H-Frame MPI Solution + Patch Reinforcements



3D Reinforced H-Frame MPI Solution



11 Parts per vehicle
Part Weight 12.92 kg/vehicle

→

5 Parts per vehicle
Part Weight 12.44 kg/vehicle (-3.7%)

→

1 Part per vehicle
Part Weight 11.98 kg/vehicle (-7.3%)

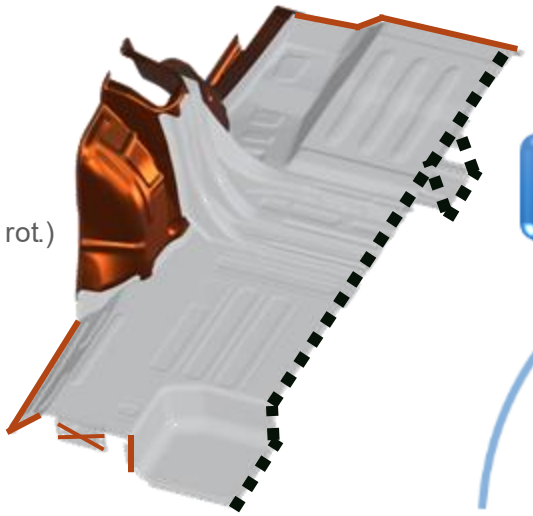
**Source – GDIS 2022 (link)*

3D Reinforcement of MPI blanks enable part integration of separate reinforcements

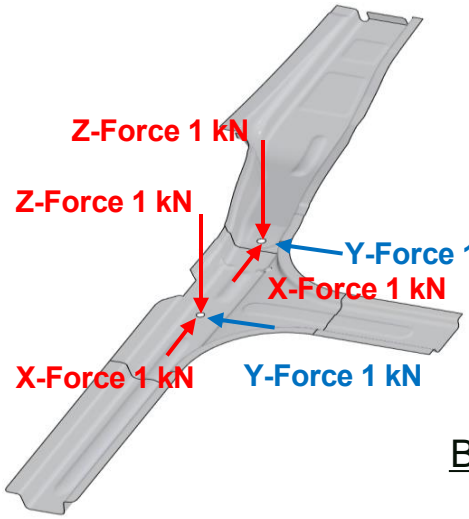
3D Reinforced Rear H-Frame MPI: Load cases

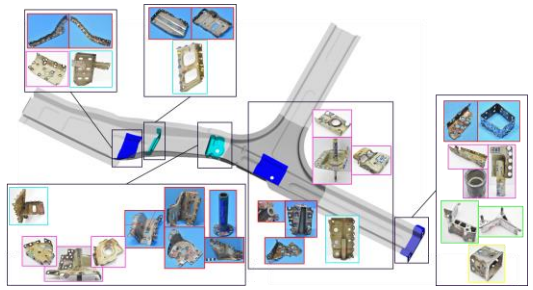
Fixed

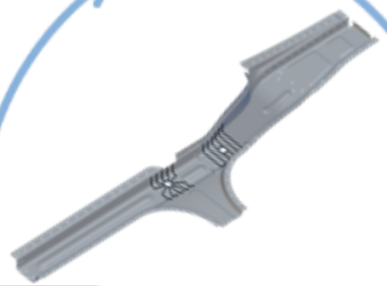
Symmetry
(Locked y transl. + xz rot.)



Local Stiffness





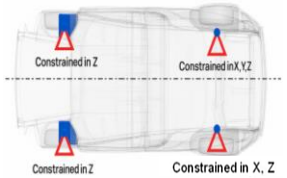


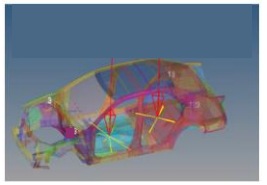
Crash

Global Stiffness

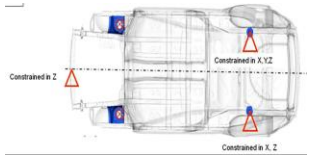
Rear Crash (FMVSS 305)

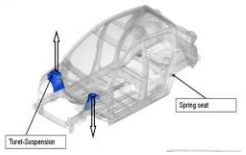
Bending Stiffness





Torsional Stiffness





Designs evaluated using local and global stiffness with rear crash for additional performance validation

Local Stiffness Topology Optimization

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Front 3D reinforcement

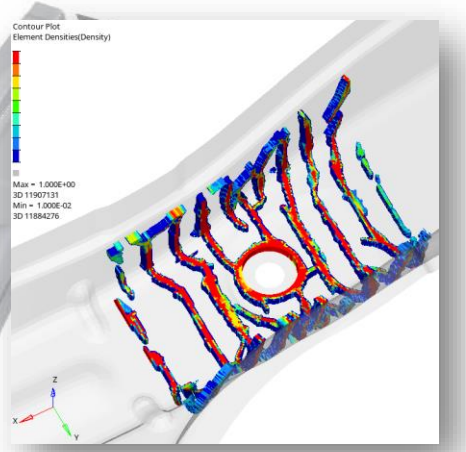
Rear 3D reinforcement

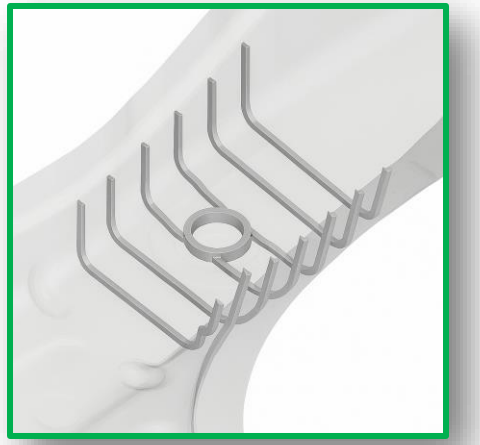
Optimization Results

Interpreted Design

4.2kN/mm

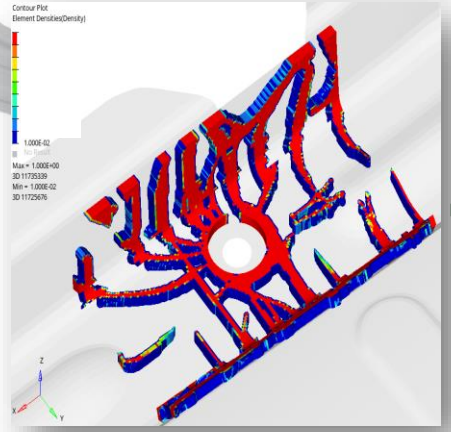
0.16 kg

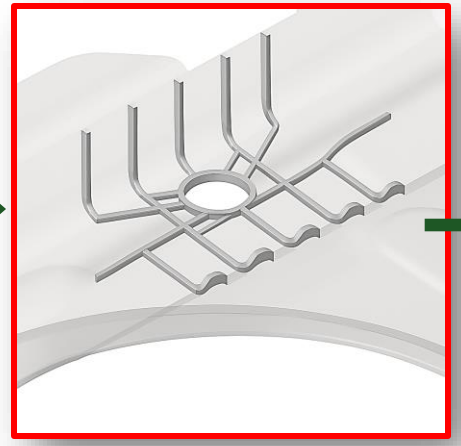


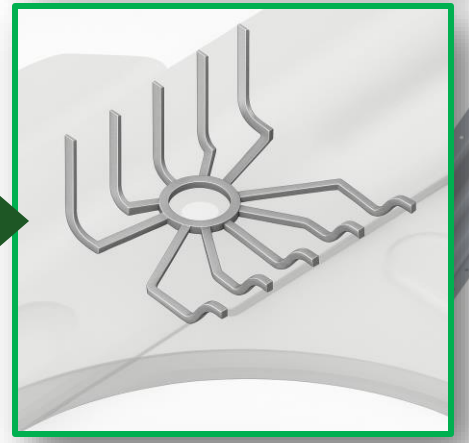


0.21 kg

2.3kN/mm





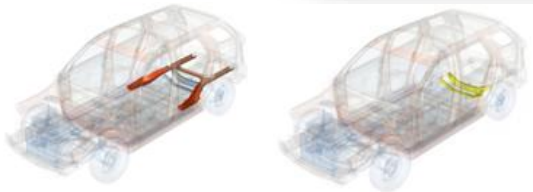


4.5kN/mm

0.09kg

0.04kg

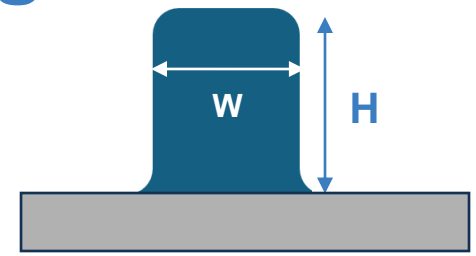
2.3kN/mm



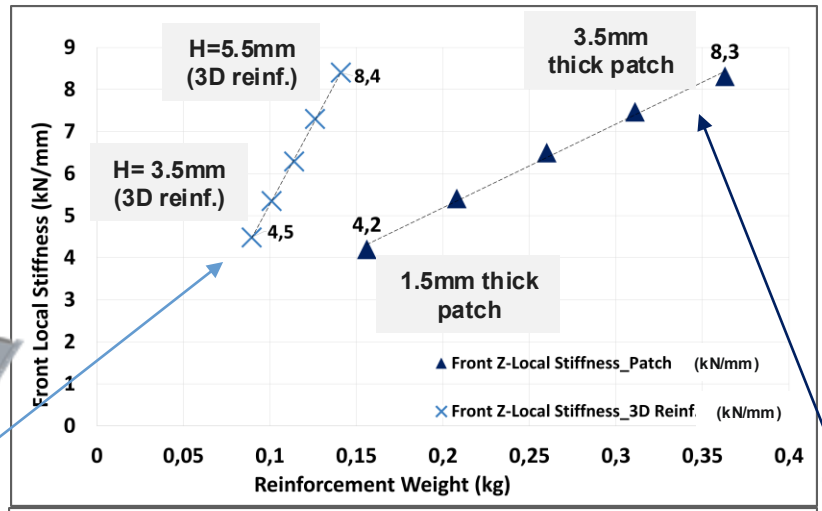
Limitation on Stamping and process constraints

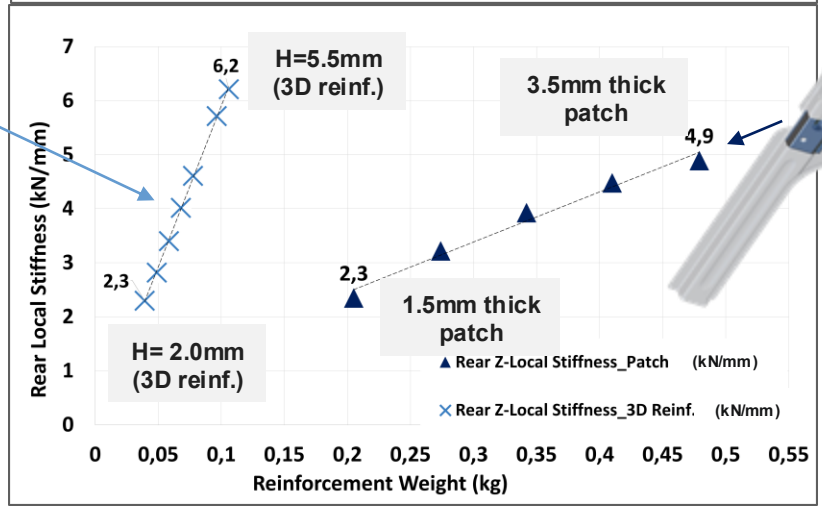
Feasible for Stamping and process constraints

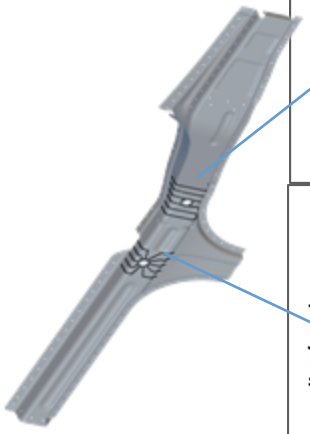
Rib Height Sensitivity

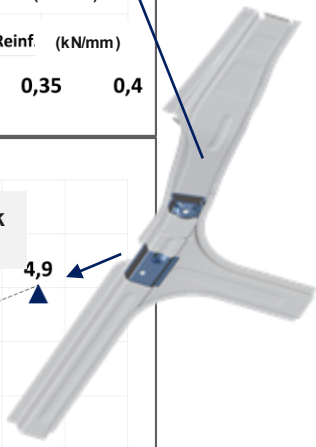


Side	Attribute	Modality	
		Patch + Reinf.	3D Reinf. (Variable H x W)
Front	**Reinf.** Weight **(kg)**	**0.16**	**0.09**
	Z-Displacement **(mm)**	0.024	0.022
	Z-Local Stiffness **(kN/mm)**	4.2	4.5
Rear	**Reinf.** Weight **(kg)**	**0.21**	**0.04**
	Z-Displacement **(mm)**	0.043	0.044
	Z-Local Stiffness **(kN/mm)**	2.3	2.3









Multitude of variations evaluated to improve on local stiffness for optimized weight to performance ratio

Global Stiffness

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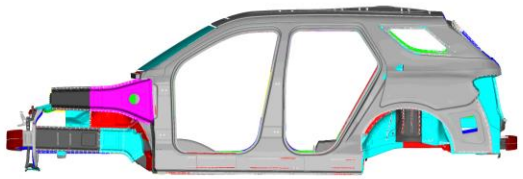
Rear H-Frame MPI Solution + Patch & Reinfs.

3D Reinforced H-Frame MPI Solution

Bending

Torsion

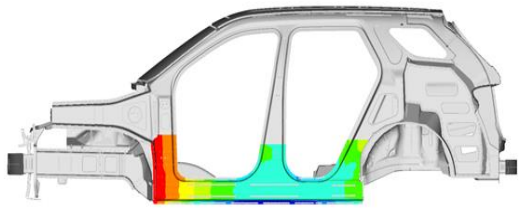


Modal

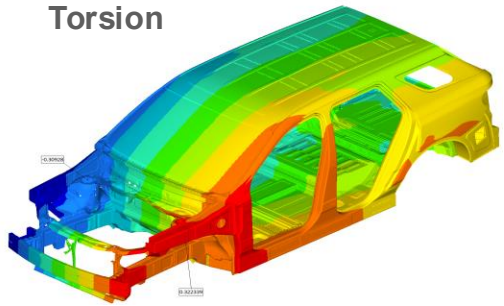
Bending

Torsion

Bending

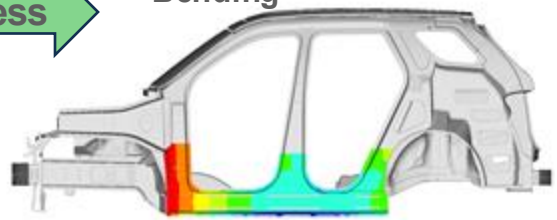


Torsion

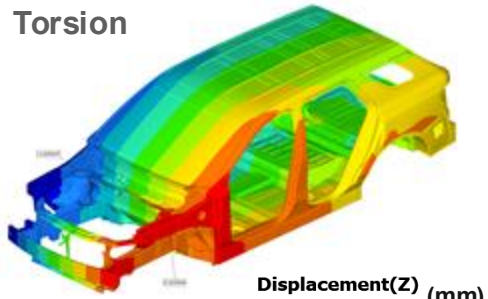


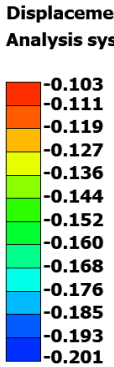
Stiffness

Bending

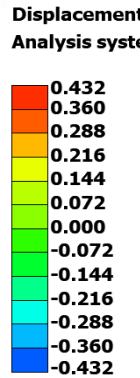


Torsion





Load case	Patch Reinforced H-Frame MPI	3D Reinforced H-Frame MPI	Units
Modal (1st mode) – Bending	40.4	40.5 (+0.1%)	Hz
Modal (1st mode) – Torsion	45.2	45.2 (0%)	Hz
Stiffness – Bending	21.1	21.1 (0%)	kN/mm
Stiffness – Torsion	33.4	33.3 (-0.1%)	kNm/°

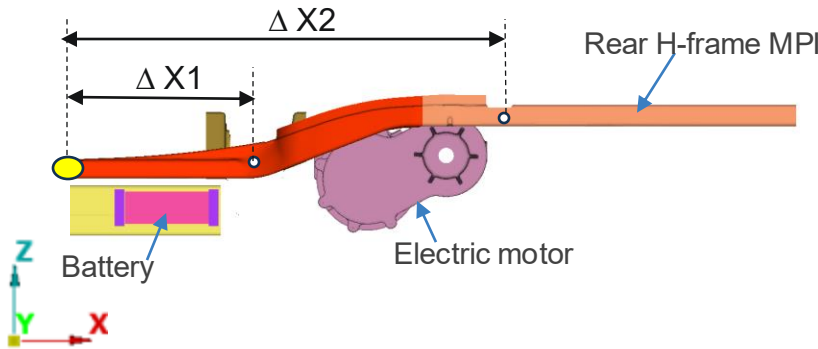


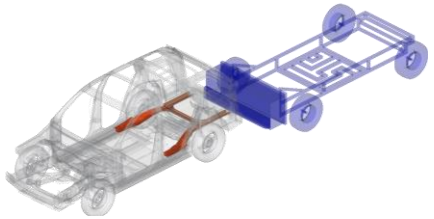
3D reinforced H-frame MPI results are validated using global stiffness load cases on full vehicle

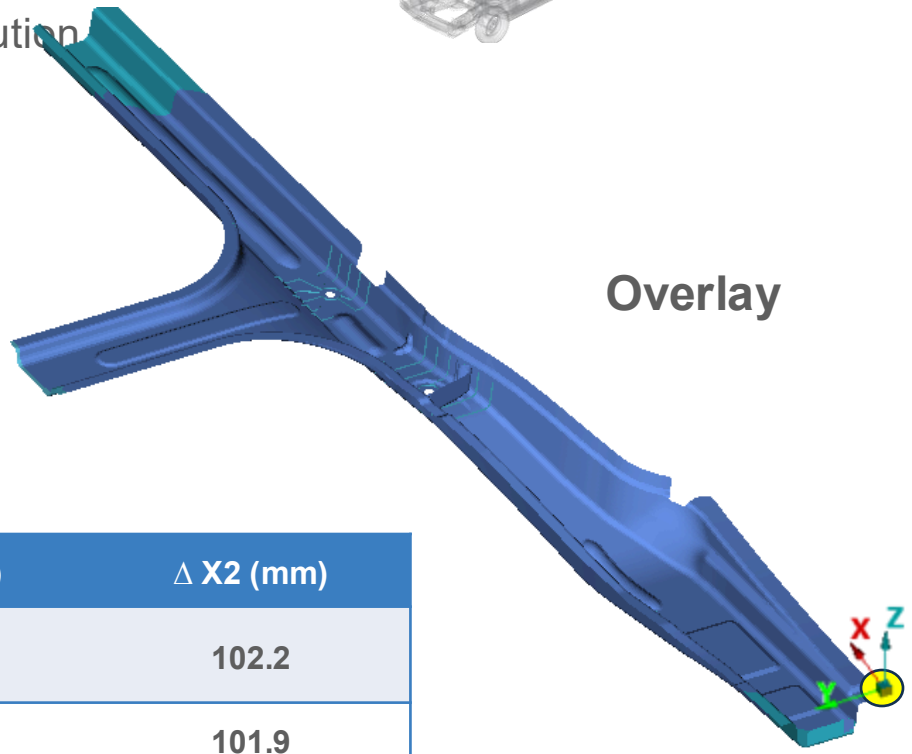
Rear Crash – FMVSS 305

Rear H-Frame MPI Solution + Patch Reinforcements

3D Reinforced H-Frame MPI Solution



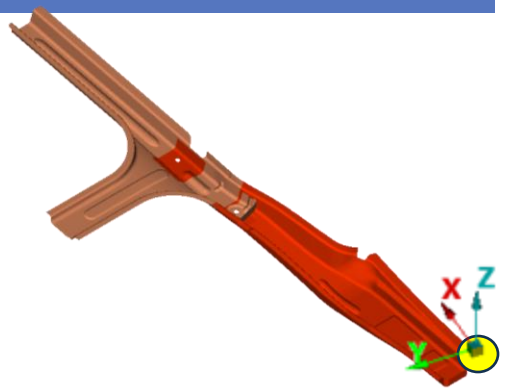




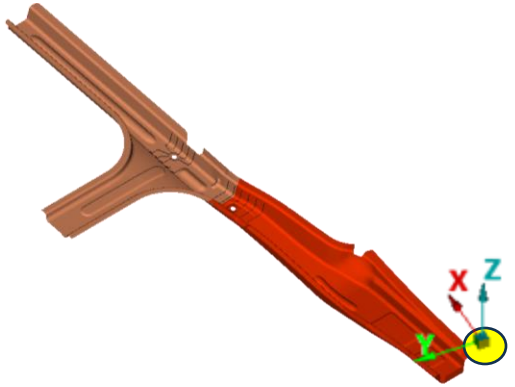
Overlay

P0

Rear H-Frame MPI Solution + Patch Reinforcements



3D Reinforced H-Frame MPI Solution



Design	Δ X1 (mm)	Δ X2 (mm)
Rear H-Frame MPI Solution + Patch Reinforcements	45.7	102.2
3D Reinforced H-Frame MPI Solution	44.9	101.9
Delta	-0.8	-0.3

The kinematics and intrusions for both designs are comparable

The Need for Local Stiffness Tuning

What Changes by Variant?

- ✓ **Curb weight and Load cases** (powertrain, battery, AWD, towing)

- ✓ **NVH targets**

- ✓ **Ride & Handling** Character

- ✓ **Crash & Rating** requirements

- ✓ **Regional usage** & durability demands

Why Local Stiffness?

- ✓ **Meet variant performance targets** on common underbody

- ✓ **Avoid global over-design**, mass and cost penalties

- ✓ **Enable differentiation** without new platforms

- ✓ **Supports late variants** and **mid-cycle updates**

- ✓ **Preserves platform** reuse and validation efficiency

Local stiffness tuning allows OEMs to differentiate attributes, while retaining a shared platform

Reinforcement Performance Tuning

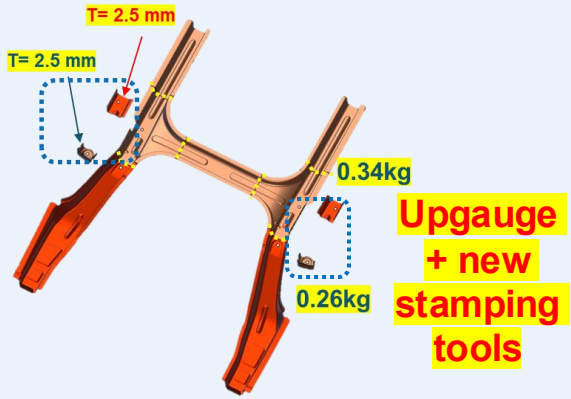
GDIS

Rear H-Frame MPI Solution + Patch Reinforcement

As is – design performance

Part Weight 12.44 kg per veh.

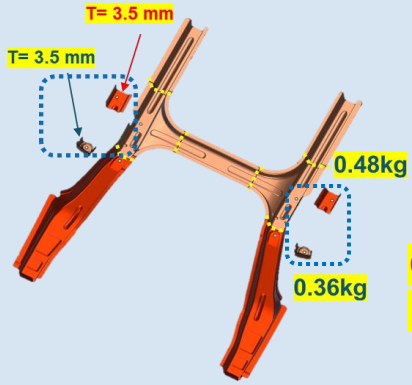
-30% local displacement



Upgauge + new stamping tools

+0.46 kg per veh. (+3.7%)

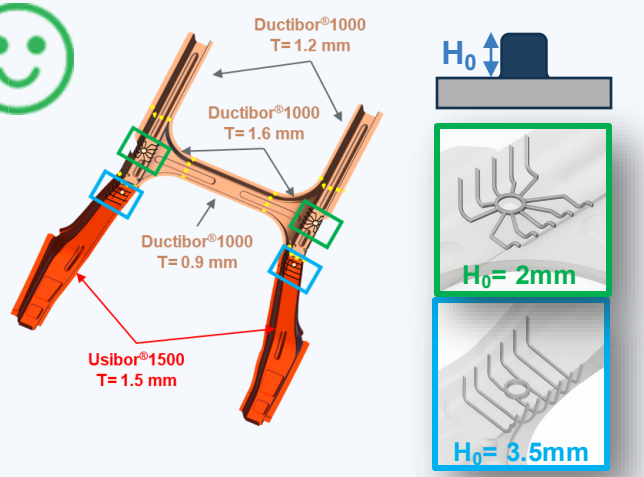
-50% local displacement



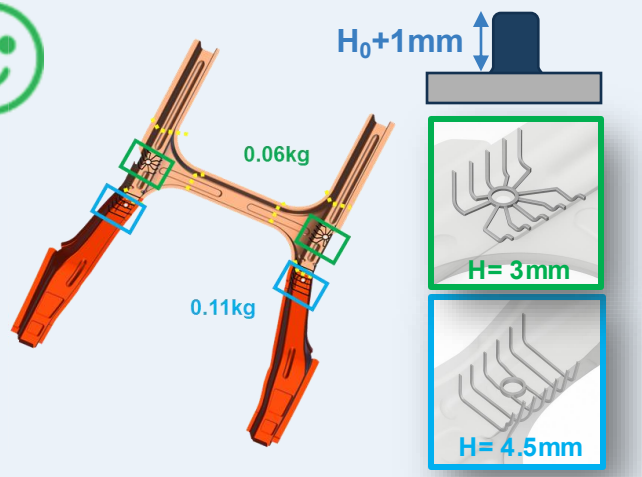
Gauges (>3mm)

+0.94 kg per veh. (+7.6%)

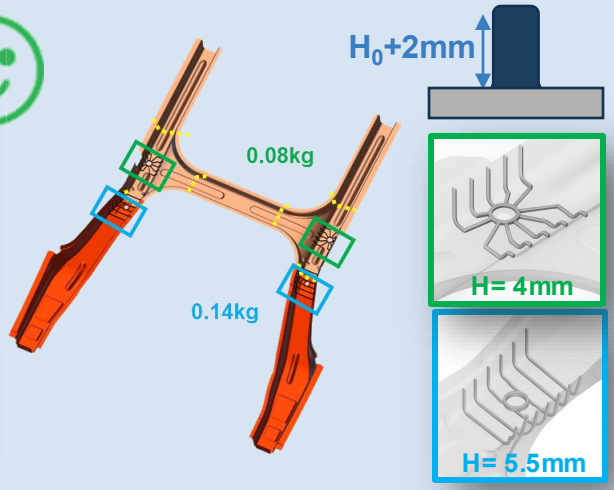
Rear H-Frame MPI Solution + 3D Reinforced Blanks



Part Weight 11.98 kg per veh.



+0.08 kg per veh. (+0.7%)



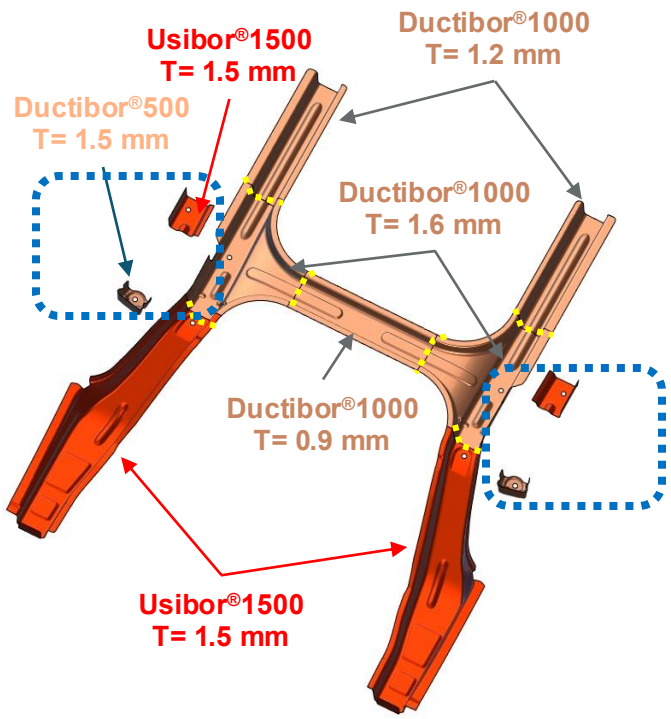
+0.18 kg per veh. (+1.5%)

3D Reinforced: No extra tooling required to increase stiffness for different variants and much more weight efficient

Optimization of Rear H-frame MPI Assembly

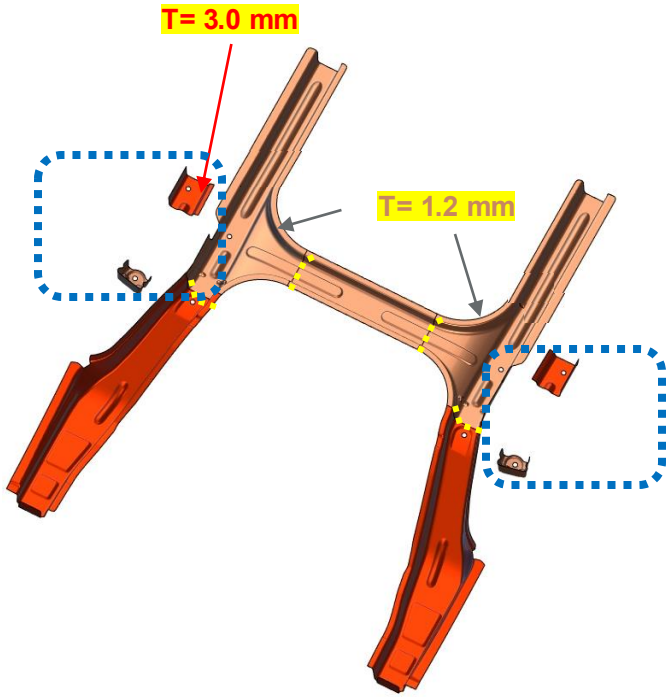
GDIS

Patch Reinforced H-Frame MPI Solution (6-seam)



5 Parts per vehicle
Part Weight 12.44 kg/vehicle (-3.7%)

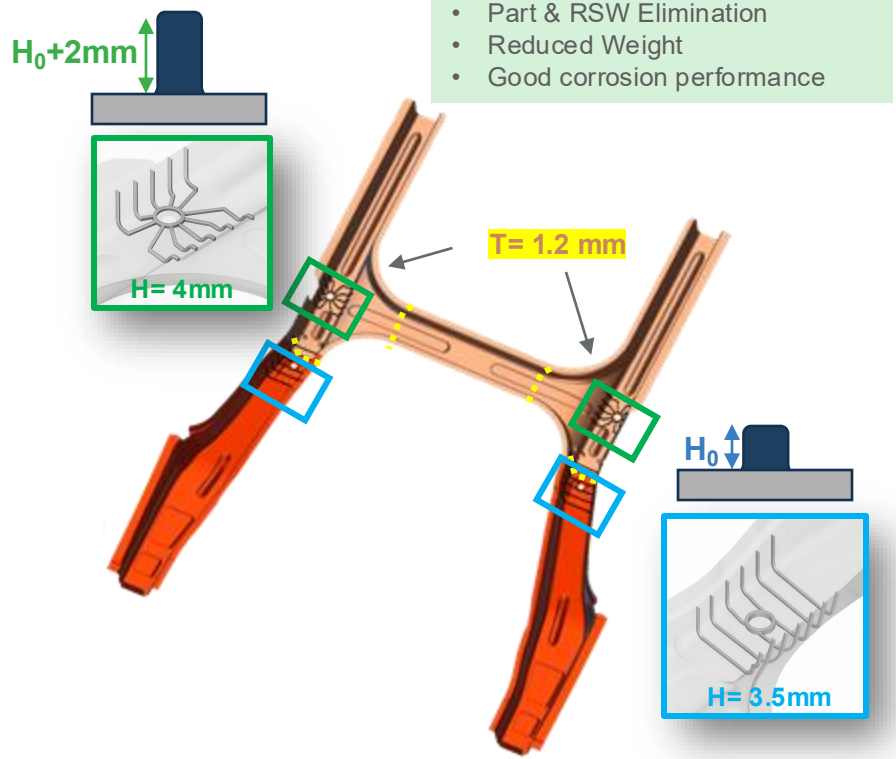
Patch Reinforced H-Frame MPI Solution (4-seam)



5 Parts per vehicle
Part Weight 12.01 kg/vehicle (-3.5%)

3D Reinforced H-Frame MPI Solution (Full Optimization)

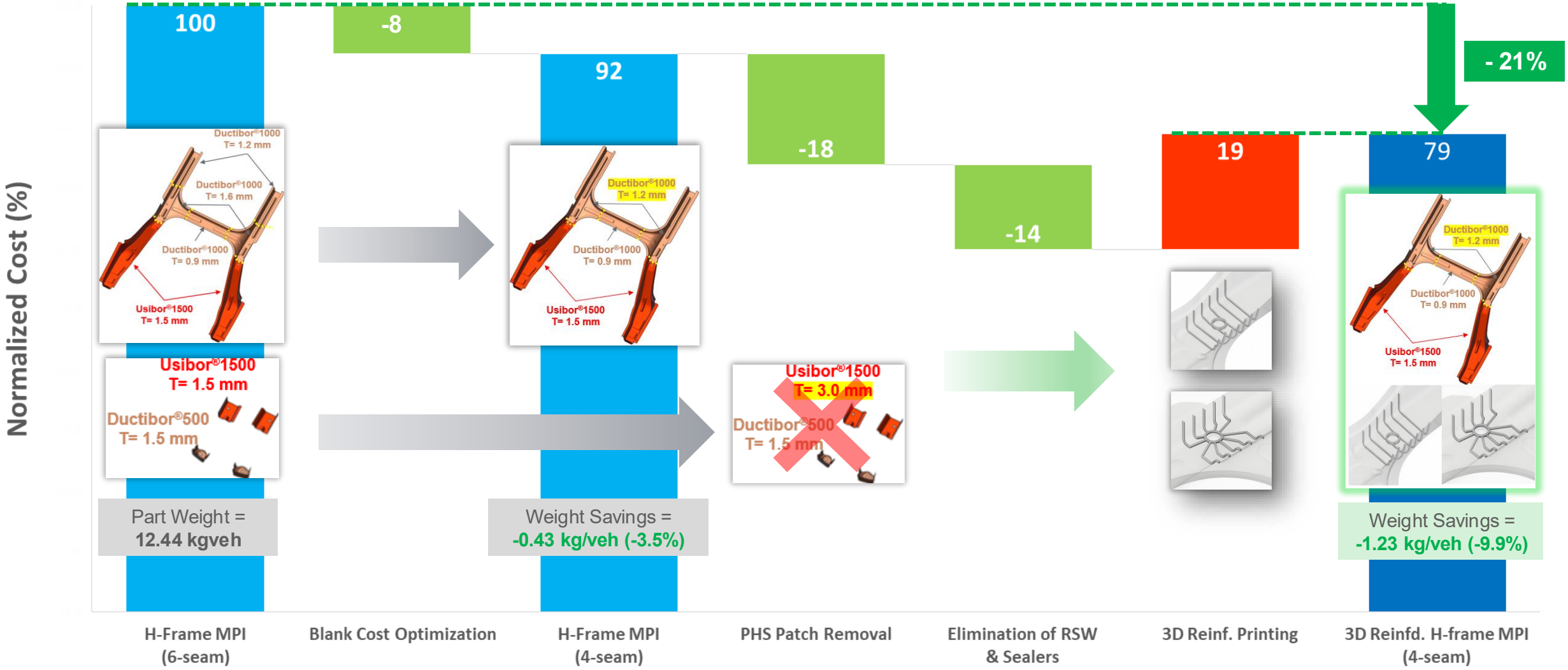
Benefits
- Part & RSW Elimination
- Reduced Weight
- Good corrosion performance



1 Part per vehicle
Part Weight 11.21 kg/vehicle (-9.9%)

3D reinforced blank MPI enables further part integration, assembly simplification, and weight savings

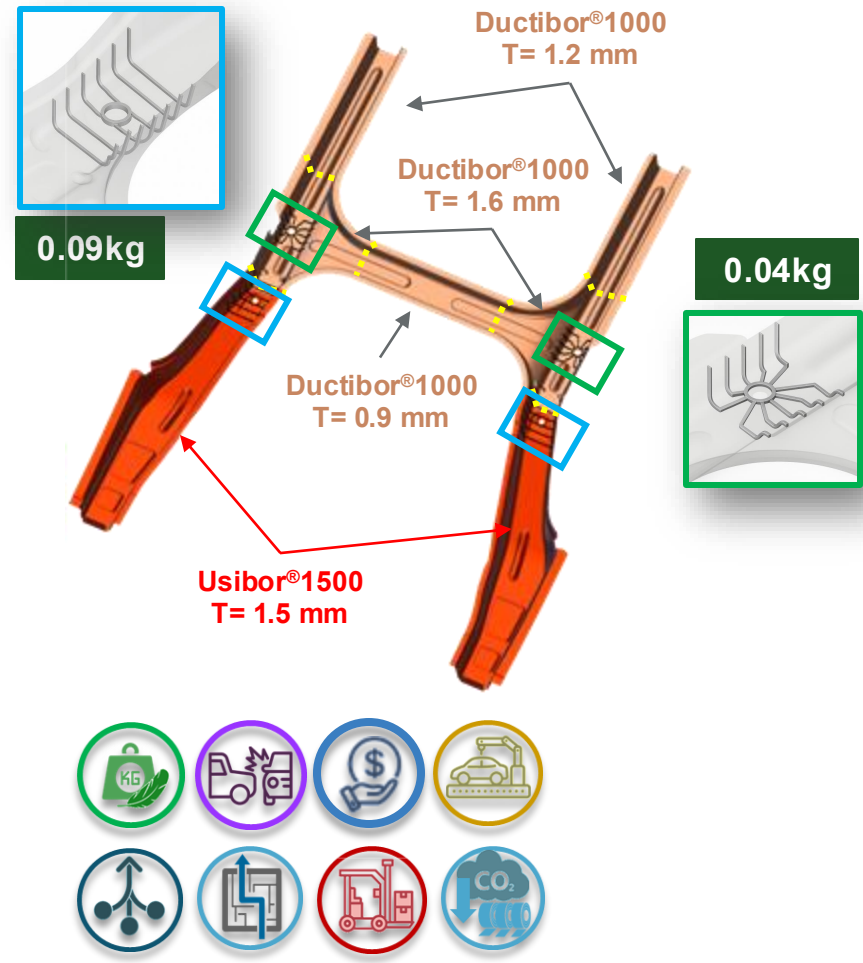
Cost Comparison for Optimized Rear H-frame MPI Assembly



Estimated 21% cost reduction, part elimination and ~10% weight reduction

Conclusions

- ArcelorMittal 3D Reinforced Blanks + Multi Part Integration® enable the combination of assembly simplification, part reduction, cost reduction and lightweighting
- Case Study for a 3D Reinforced H-Frame MPI shows the following benefits
  - Reduced assembly part count to 1, **minus 4 parts/veh**
  - Reduced cost by **21%**
  - Reduced weight by **10%**
  - Good corrosion performance
  - Enables variant-specific local stiffness without additional tooling
- Next steps
  - Study process improvements and industrialization path
  - Study similar part integration in OEM environment



3D Reinforced Blanks with MPIs provide fastest, safest and optimized solution to automotive industry

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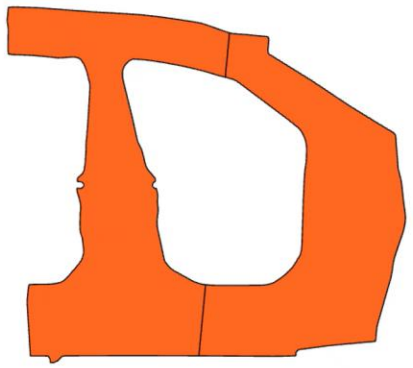
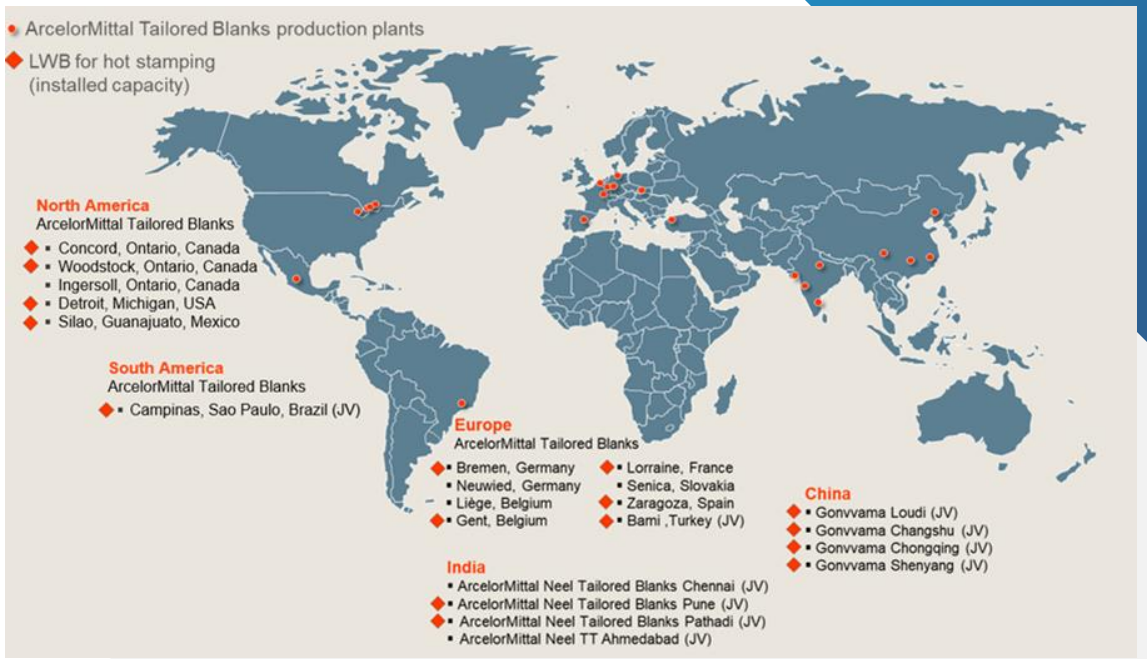
ArcelorMittal Tailored Blanks



1st LWB



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Stop by our booth for more information!

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