Lightweight door ring concepts using hot stamped laser welded blanks

Presenter: Gagan Tandon
ArcelorMittal Tailored Blanks Americas
Co-Author: Ivan Viaux
ArcelorMittal Global R&D Montataire

ArcelorMittal
TAILORED BLANKS

ArcelorMittal
TAILORED BLANKS

Table of contents

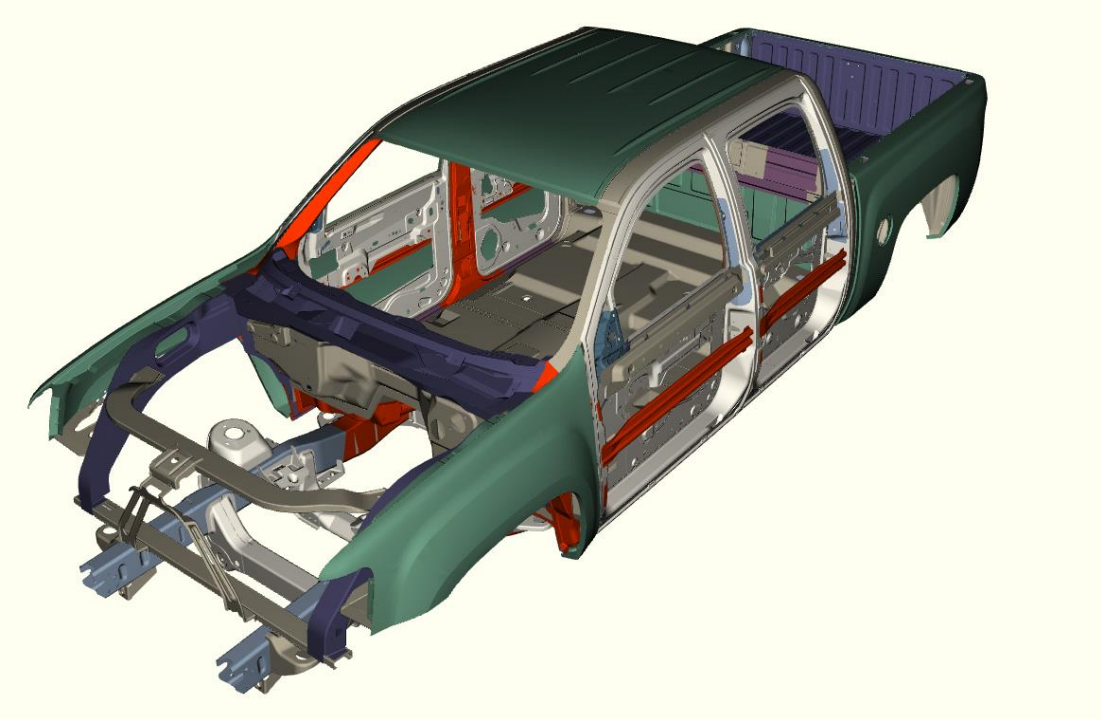
Journey to 54.5 mpg by 2025 with lighter, stronger cost-effective steel solutions

1. Introduction

- ArcelorMittal Tailored Blanks (AMTB) – Global Supplier of LWB
- Strong increase in demand for Hot Stamped Laser Welded Blanks (HS LWB)
  - HS LWB used increasingly to meet crash/safety requirements
  - Usibor®1500 HS LWB optimizes cost, weight & performance
  - AMTB developed a patented technology to weld Usibor®1500 in Europe
  - First to market in North America with 2014 Acura MDX Door Ring
    - Helped meet IIHS+ rating
    - Technology received coveted PACE award – Process Innovation
    - Honda received Pace Award for Innovation Partnership
    - Honda's Usibor®1500 HS LWB Door Ring was showcased in 2013 GDIS
- Usibor®1500 HS LWB technology is a game-changer for body design
- Usibor®1500 HS LWB allows flexibility in design to meet performance on variety of car and truck designs
- Presentation based on one such study done at ArcelorMittal Global R&D

Acknowledgments: ArcelorMittal Global R&D - Automotive Steel Solutions team

FEA model used for this study

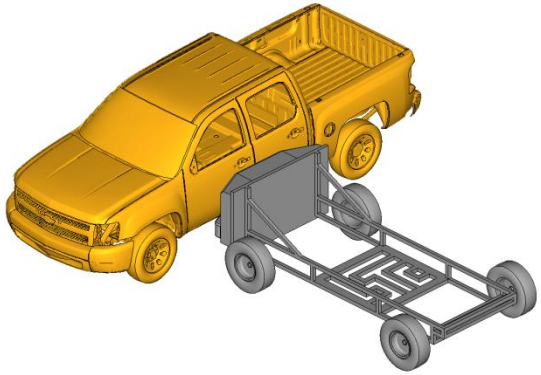


- Public Domain model – meets current crash/safety requirements
- Modified for studies – includes Usibor®1500 HS LWB solutions
- Multiple Usibor®1500 HS LWB Door Ring designs were studied for this architecture

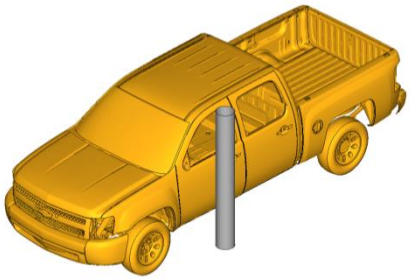
ArcelorMittal Pick-up Analytical Model

Considered load cases

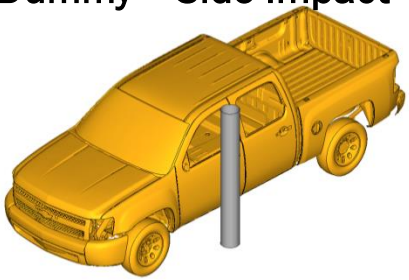
IIHS
MDB Side Impact



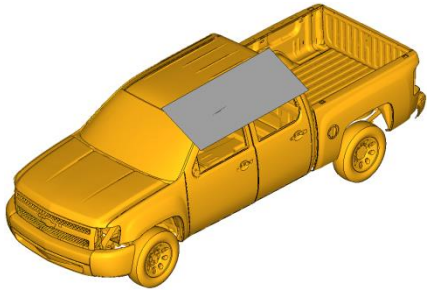
FMVSS 214
POLE 5th Percentile
Dummy - Side Impact



FMVSS 214
POLE 50th Percentile
Dummy - Side Impact



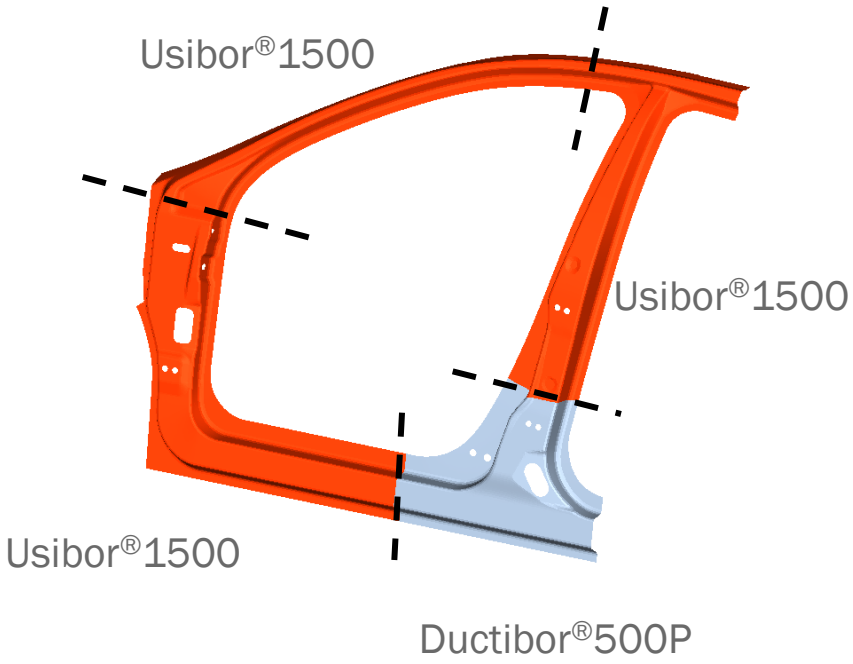
IIHS
Roof crush



Four of the most severe loadcases in the industry were evaluated

Design currently being evaluated for **narrow offset crash**

ArcelorMittal HS LWB door ring concept



S-in motion concept introduced in 2010

1 **part** instead of 4

- ✓ One stamping tool
- ✓ One stamping operation
- ✓ No post assembly operations

Lightweight concept

- ✓ Hot stamping steel grades
- ✓ Optimized thickness distribution
- ✓ Laser weld continuous links (no overlap)

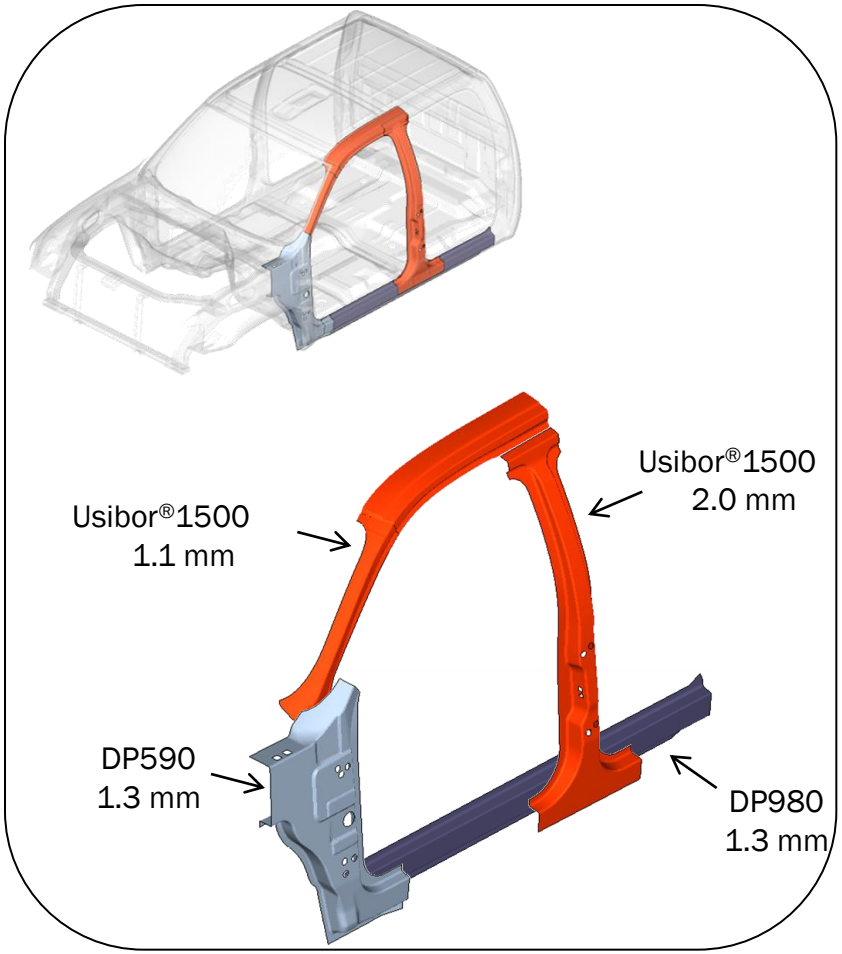
Hot-stamping geometry accuracy

Flexible - Material thicknesses, number of welds and their locations can be tuned

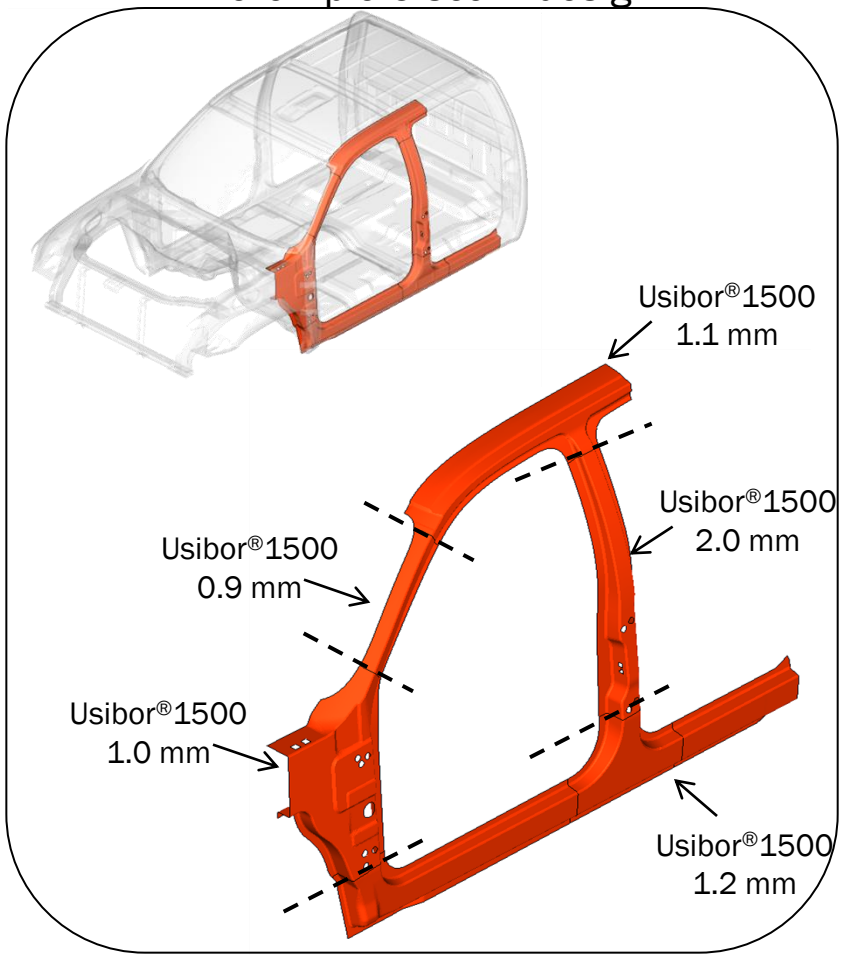
Optimize - Allows design to meet the needed technical crash/safety requirements

Body side reinforcement outer design

Multi-part Design



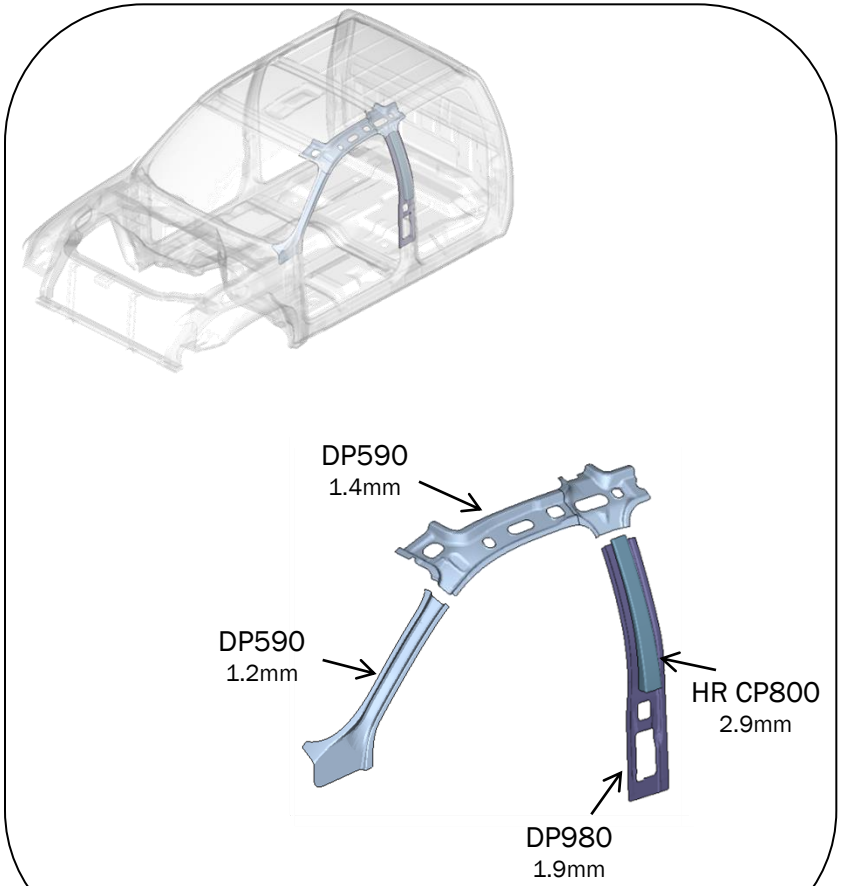
Usibor®1500 HS LWB solutions:
example 5-seam design



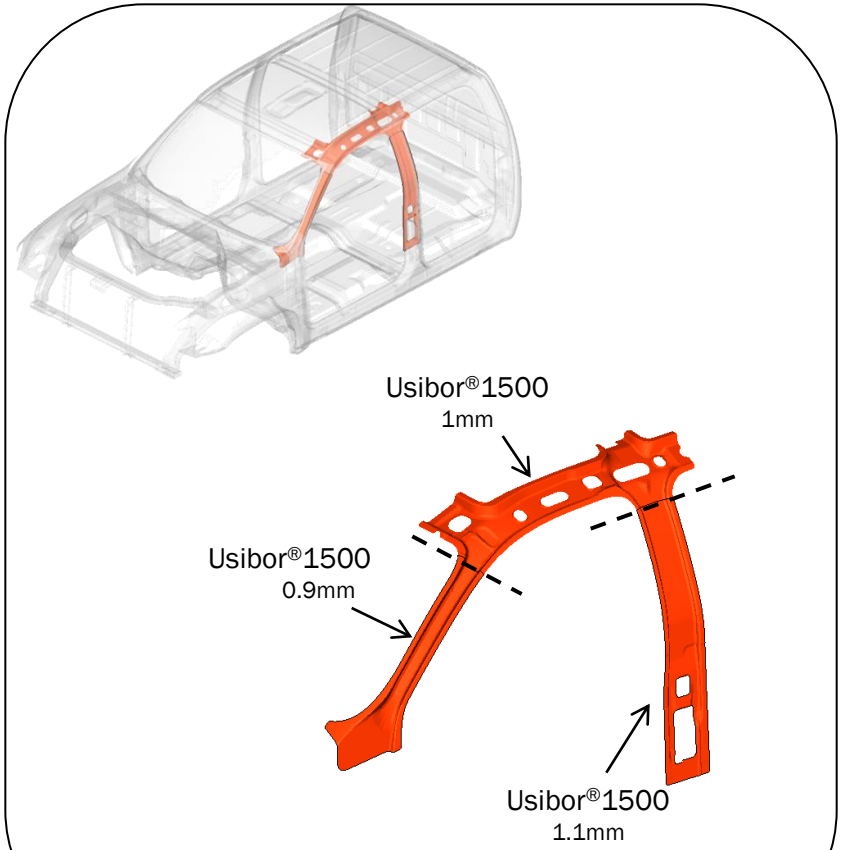
Usibor® 1500 HS LWB door ring is key enabler for a safety cage design

“T-bone” inner reinforcement design

Multi-part cold stamped and spot welded design



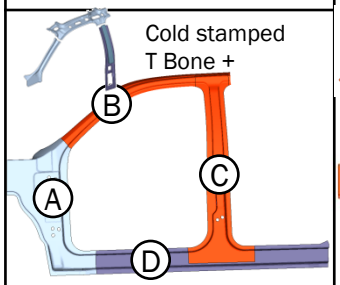
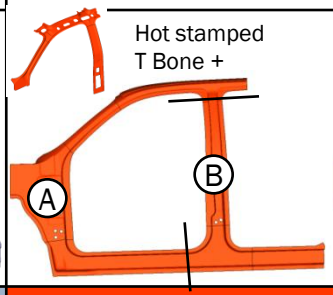
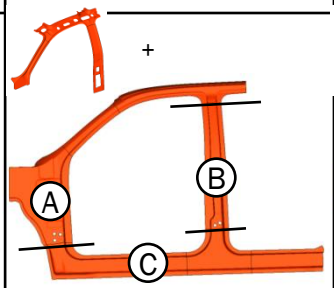
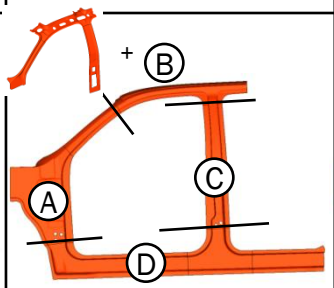
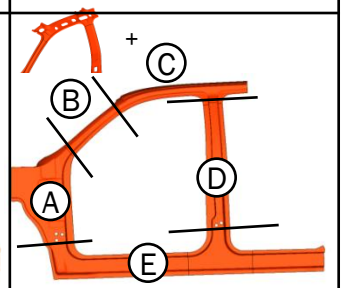
Usibor®1500 HS LWB solution



New “T-bone” Usibor® 1500 HS LWB design further optimizes cost, weight and performance

ArcelorMittal
TAILORED BLANKS

Weight comparison

	Multi-part design	2-seam HS LWB	3-seam HS LWB	4-seam HS LWB	5-seam HS LWB
Proposal					
	A DP 590 1.3 mm	A Usibor® 1500 1.2 mm	A Usibor® 1500 1.1 mm	A Usibor® 1500 1.0 mm	A Usibor® 1500 1.0 mm
	B Usibor® 1500 1.1 mm	B Usibor® 1500 2.0 mm	B Usibor® 1500 2.0 mm	B Usibor® 1500 1.1 mm	B Usibor® 1500 0.9 mm
	C Usibor® 1500 2.0 mm		C Usibor® 1500 1.2 mm	C Usibor® 1500 2.0 mm	C Usibor® 1500 1.1 mm
	D DP 980 1.3 mm			D Usibor® 1500 1.2 mm	D Usibor® 1500 2.0 mm
					E Usibor® 1500 1.2 mm
$M_{door\ ring}$	17.30 kg	18.21 kg	15.92 kg	15.62 kg	15.57 kg
$M_{T\text{-}Bone}$	6.90 kg	3.60 kg	3.60 kg	3.60 kg	3.60 kg
M_{total}	24.20 kg	21.81 kg	19.52 kg	19.22 kg	19.17 kg
Weight savings	-	2.39 kg (9.9 %)	4.68 kg (19.3 %)	4.98 kg (20.6 %)	5.03 kg (20.8 %)
Material utilization	56%	50%	62%	68%	70%

Usibor®1500 HS LWB solutions are lighter and allow better material utilization

ArcelorMittal
TAILORED BLANKS

2. Detailed crash performances

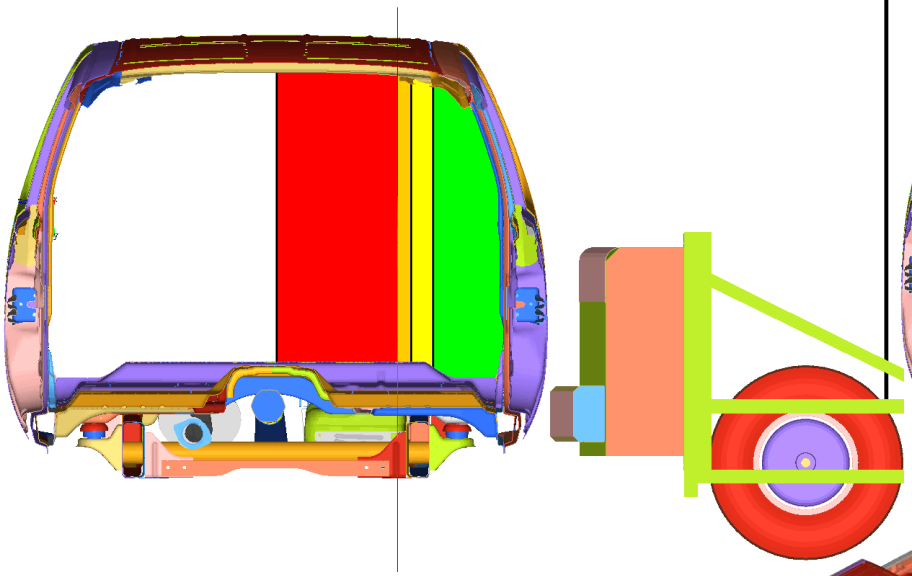
- IIHS MDB side impact
- FMVSS 214 pole side impact – 50th Percentile Dummy position
- FMVSS 214 pole side impact – 5th Percentile Dummy position
- IIHS roof crush

IIHS moving deformable barrier (MDB) side impact

ArcelorMittal
TAILORED BLANKS

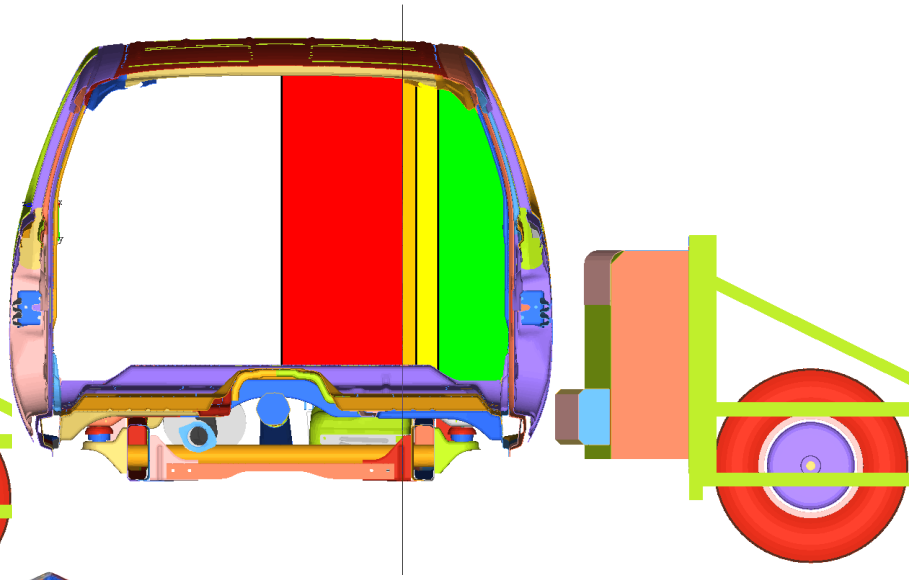
Structure behavior

Multi-part design

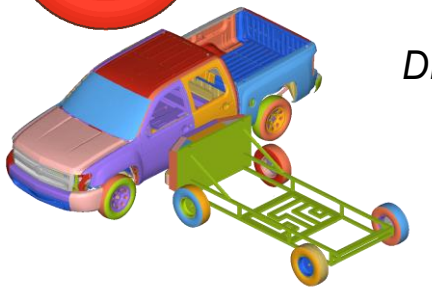


Driver seat centerline

Usibor® 1500 5-seams HS LWB



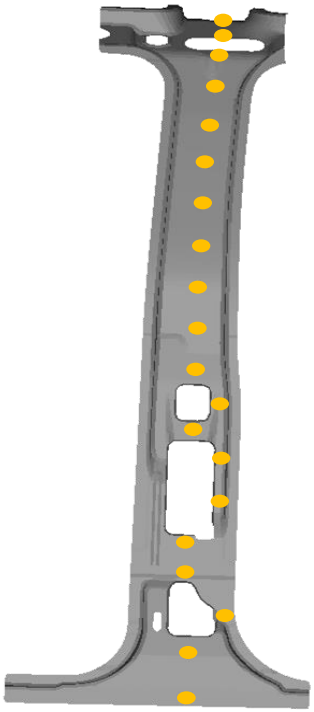
Driver seat centerline



Multi-part and Usibor® 1500 HS LWB solutions have similar behavior - IIHS good rating

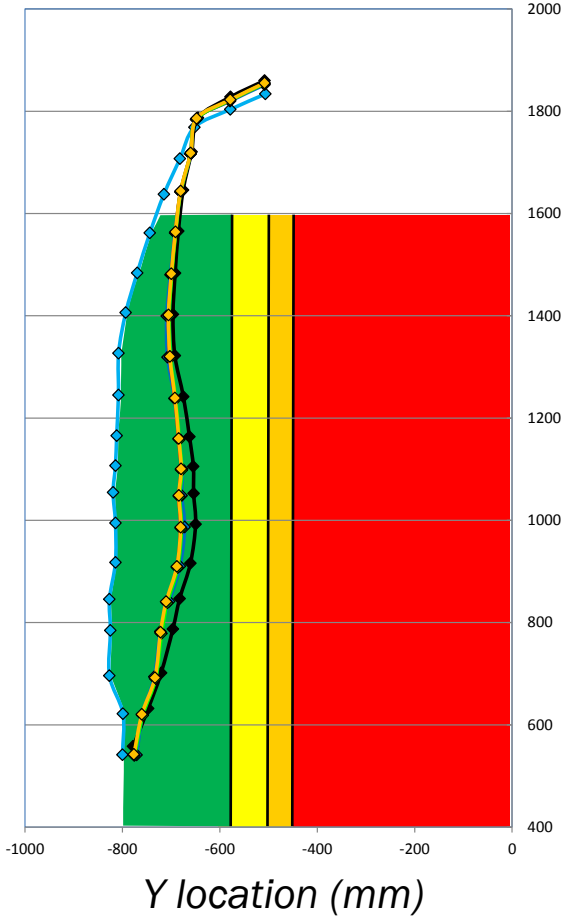
MDB Side Impact B-Pillar intrusions

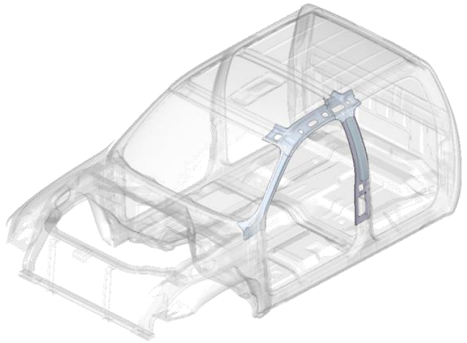
Location of the points used to measure intrusions



Inner B-Pillar

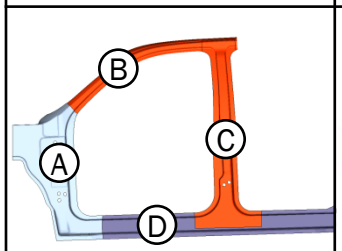
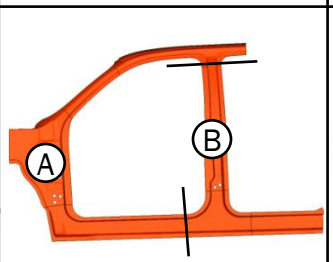
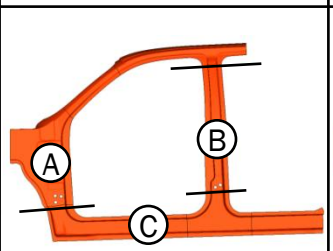
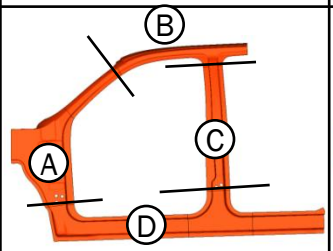
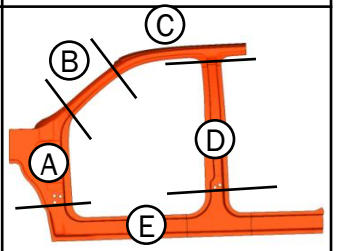
Final B-Pillar intrusions

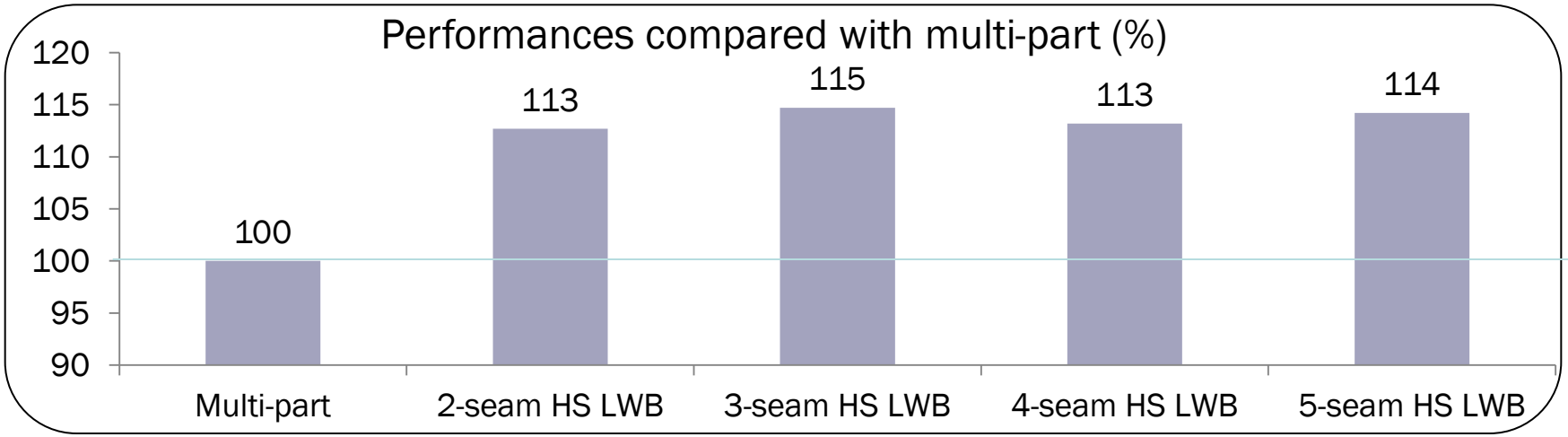




Usibor®1500 HS LWB solutions have better side intrusion performance

IIHS - MDB Side performance overview

	Multi-part design	2-seam HS LWB	3-seam HS LWB	4-seam HS LWB	5-seam HS LWB
Proposal					
IIHS Criteria	GOOD	GOOD	GOOD	GOOD	GOOD
B-Pillar to driver seat centerline distance	197 mm	222 mm	226 mm	223 mm	225 mm

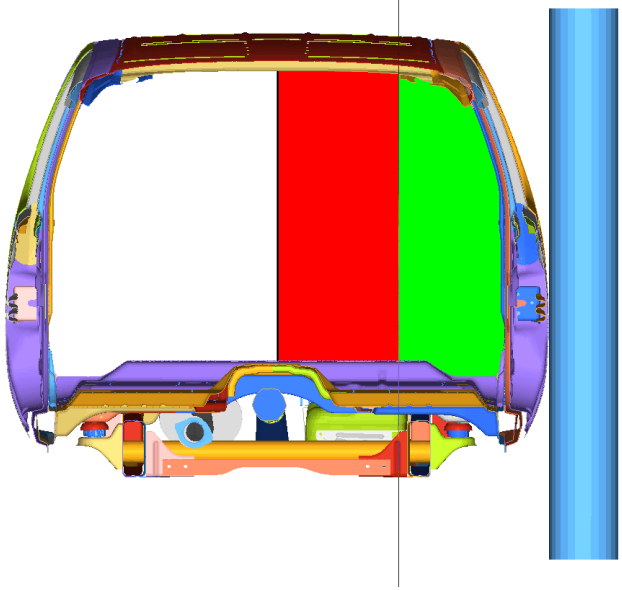


Usibor®1500 HS LWB solutions have better performance
All solutions reach IIHS good rating level

FMVSS 214 – POLE 5th Percentile dummy impact results

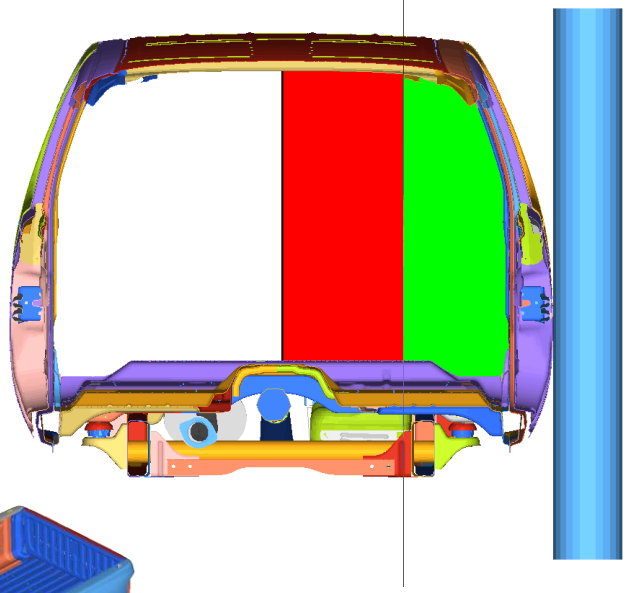
FMVSS 214 - POLE 5th Structure behavior

Multi-part design

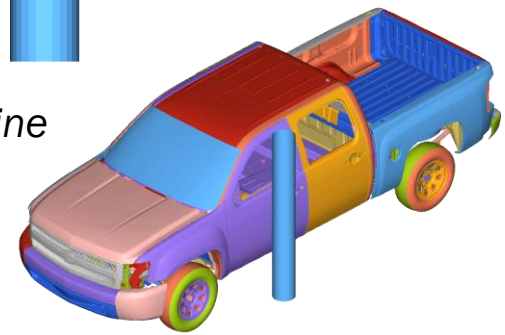


Driver seat centerline

Usibor®1500 5-seam HS LWB



Driver seat centerline



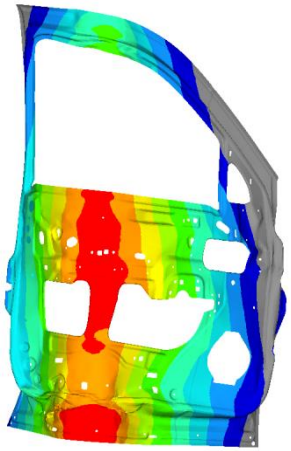
Multi-part design and Usibor®1500 HS LWB solutions have similar behavior and stay in the area delimited by the driver seat centerline

FMVSS 214 - POLE 5th - door intrusions

Intrusion (mm)

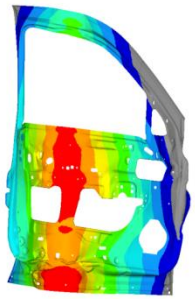
400
360
320
280
240
200
160
120
80
40
0

Multi-part design



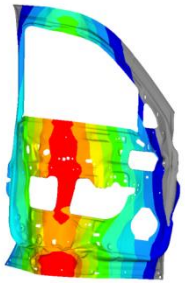
Max : 413 mm

2-seam HS LWB



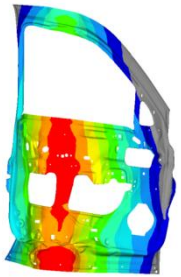
Max : 413 mm

3-seam HS LWB



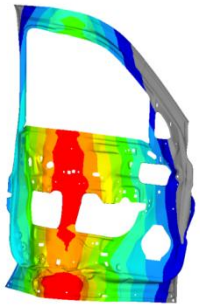
Max : 413 mm

4-seam HS LWB



Max : 414 mm

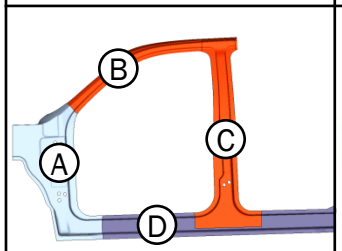
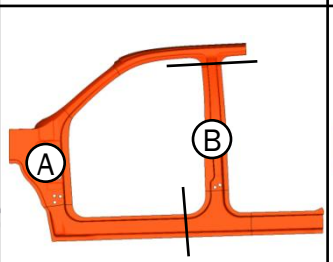
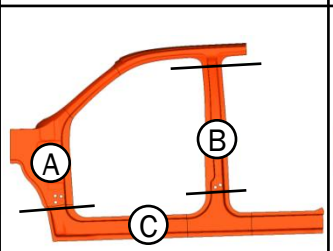
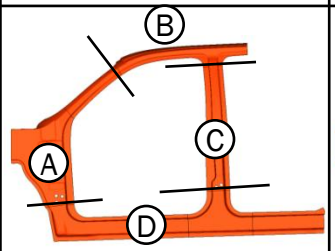
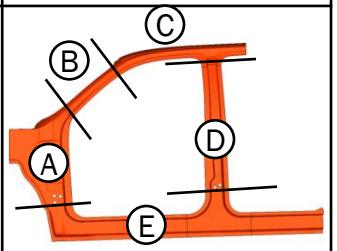
5-seam HS LWB

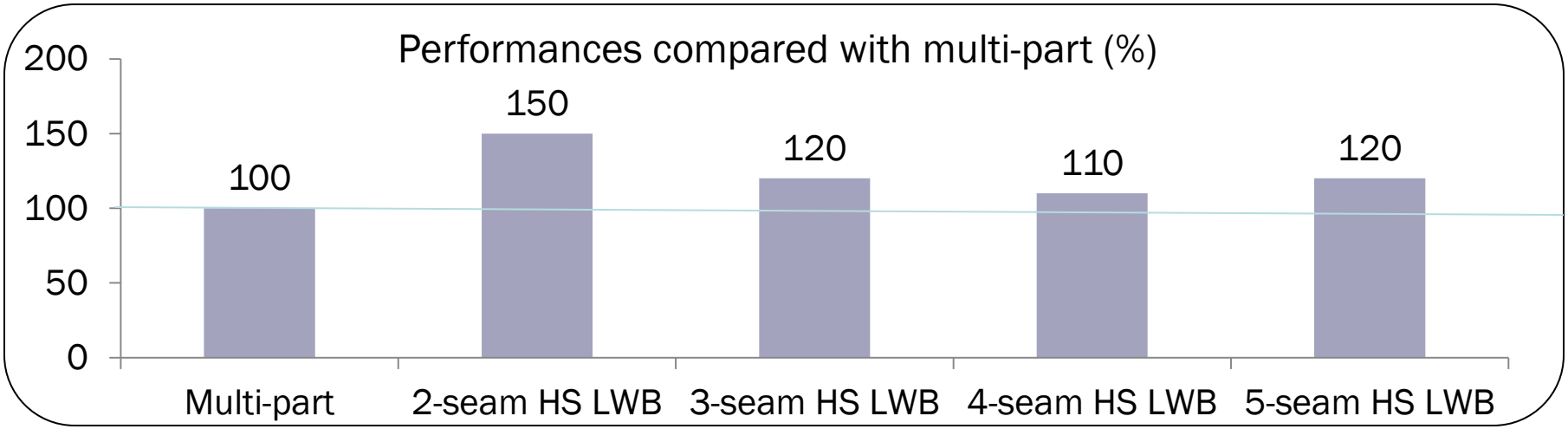


Max : 415 mm

Multi-part design and Usibor®1500 HS LWB solutions have similar performance

FMVSS 214 - POLE 5th impact summary

	Multi-part design	2-seam HS LWB	3-seam HS LWB	4-seam HS LWB	5-seam HS LWB
Proposal					
Door to driver seat centerline distance	10 mm	15 mm	12 mm	11 mm	12 mm

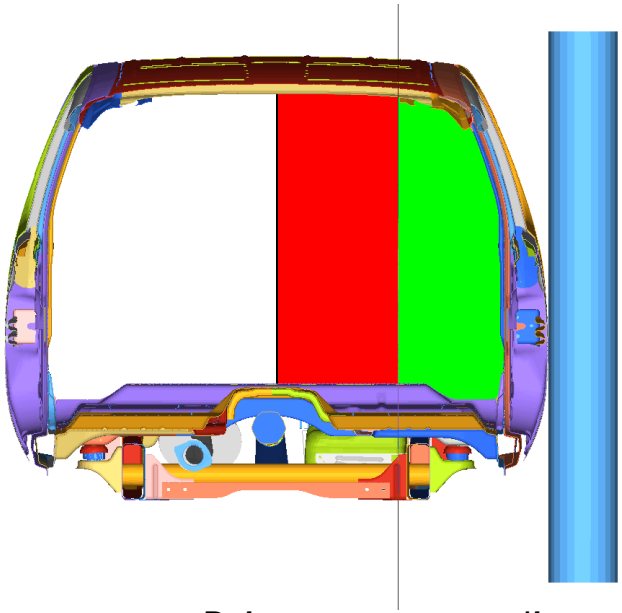


Multi-part and Usibor®1500 HS LWB solutions reach good IIHS level ratings
Usibor®1500 HS LWB solutions have better performances than the multi-part design

FMVSS 214 – POLE 50th Percentile dummy impact results

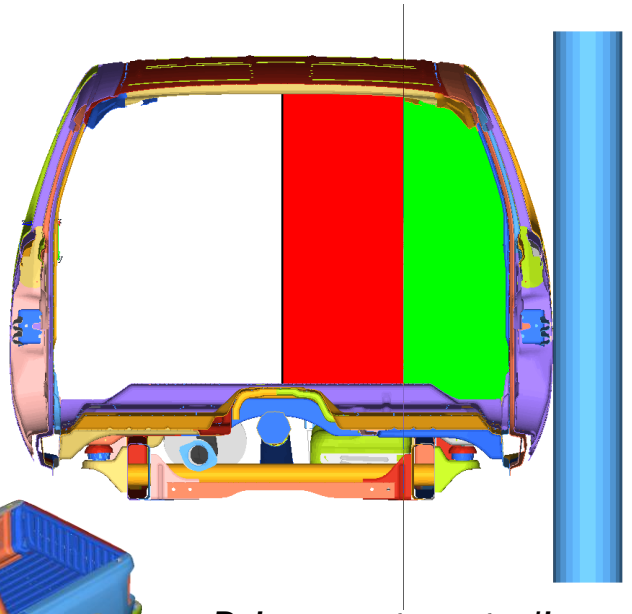
FMVSS 214 - POLE 50th impact - behavior

Multi-part design

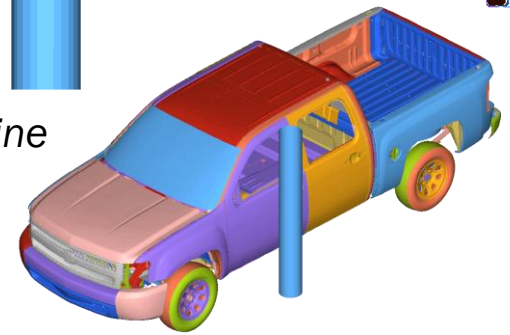


Driver seat centerline

Usibor®1500 5-seam HS LWB



Driver seat centerline



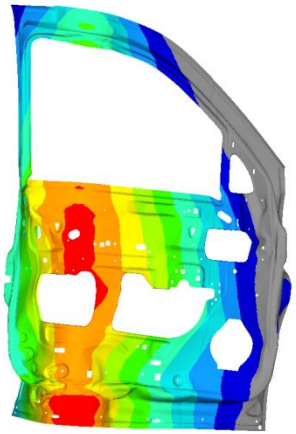
Multi-part design and Usibor®1500 HS LWB solution have similar behavior and meet IIHS good rating

FMVSS 214 - POLE 50th - door intrusions

Intrusion (mm)

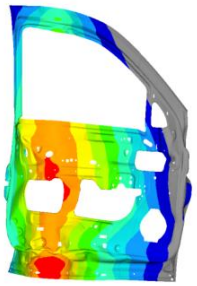
400
360
320
280
240
200
160
120
80
40
0

Multi-part design



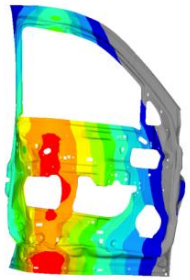
Max : 399 mm

2-seam HS LWB



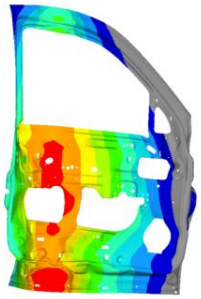
Max : 390 mm

3-seam HS LWB



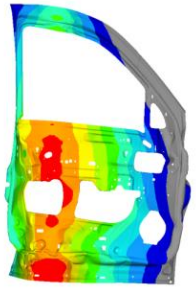
Max : 402 mm

4-seam HS LWB



Max : 402 mm

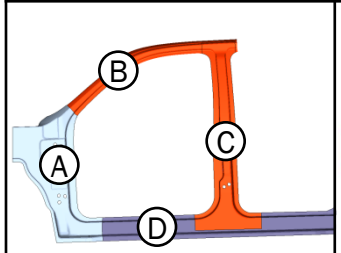
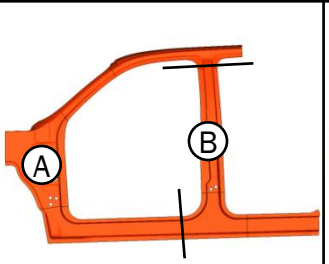
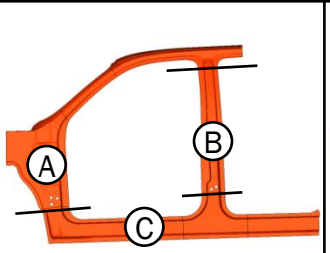
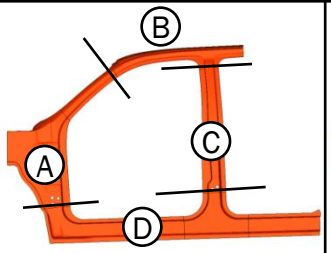
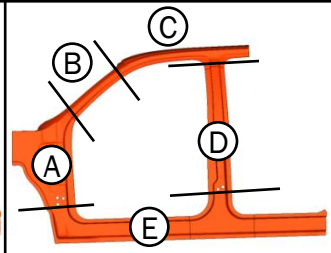
5-seam HS LWB

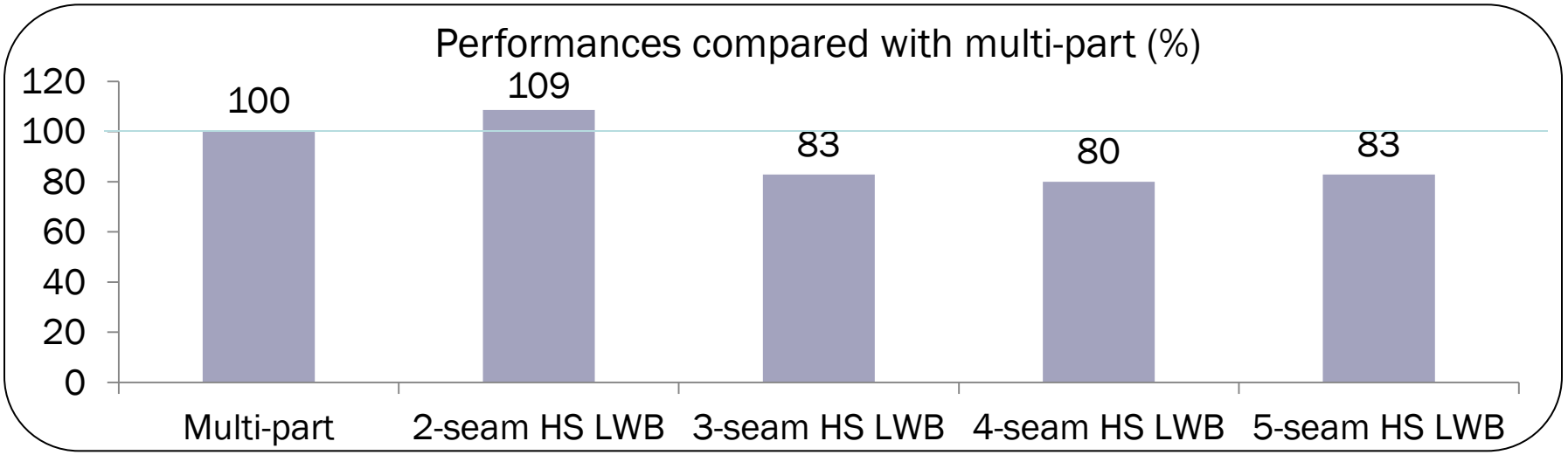


Max : 402 mm

Multi-part design and Usibor®1500 HS LWB solutions have similar performance

FMVSS 214 - POLE 50th impact - summary

	Multi-part design	2-seam HS LWB	3-seam HS LWB	4-seam HS LWB	5-seam HS LWB
Proposal					
Door to driver seat centerline	35 mm	38 mm	29 mm	28 mm	29 mm

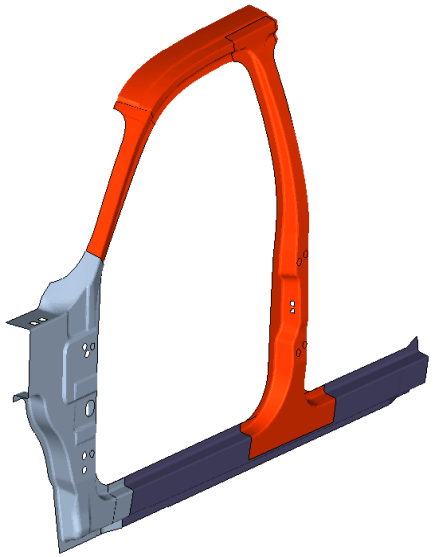


Multi-part design and Usibor®1500 HS LWB solutions meet IIHS good level rating
Performances are similar and not as critical as pole 5th test **(30mm to center line versus 10mm)**

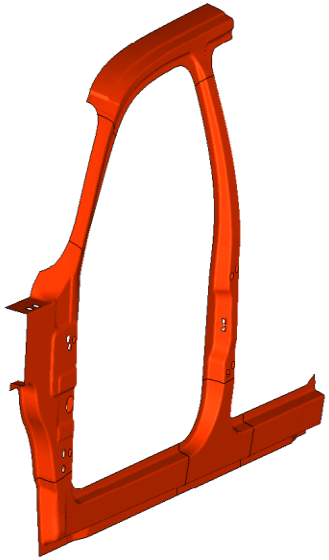
IIHS – Roof crush results

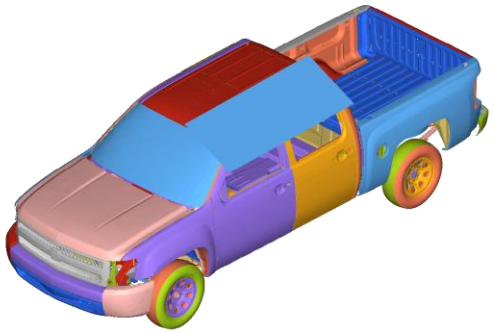
IIHS – Roof crush - structure behavior

Multi-part design



Usibor®1500 5-seam HS LWB

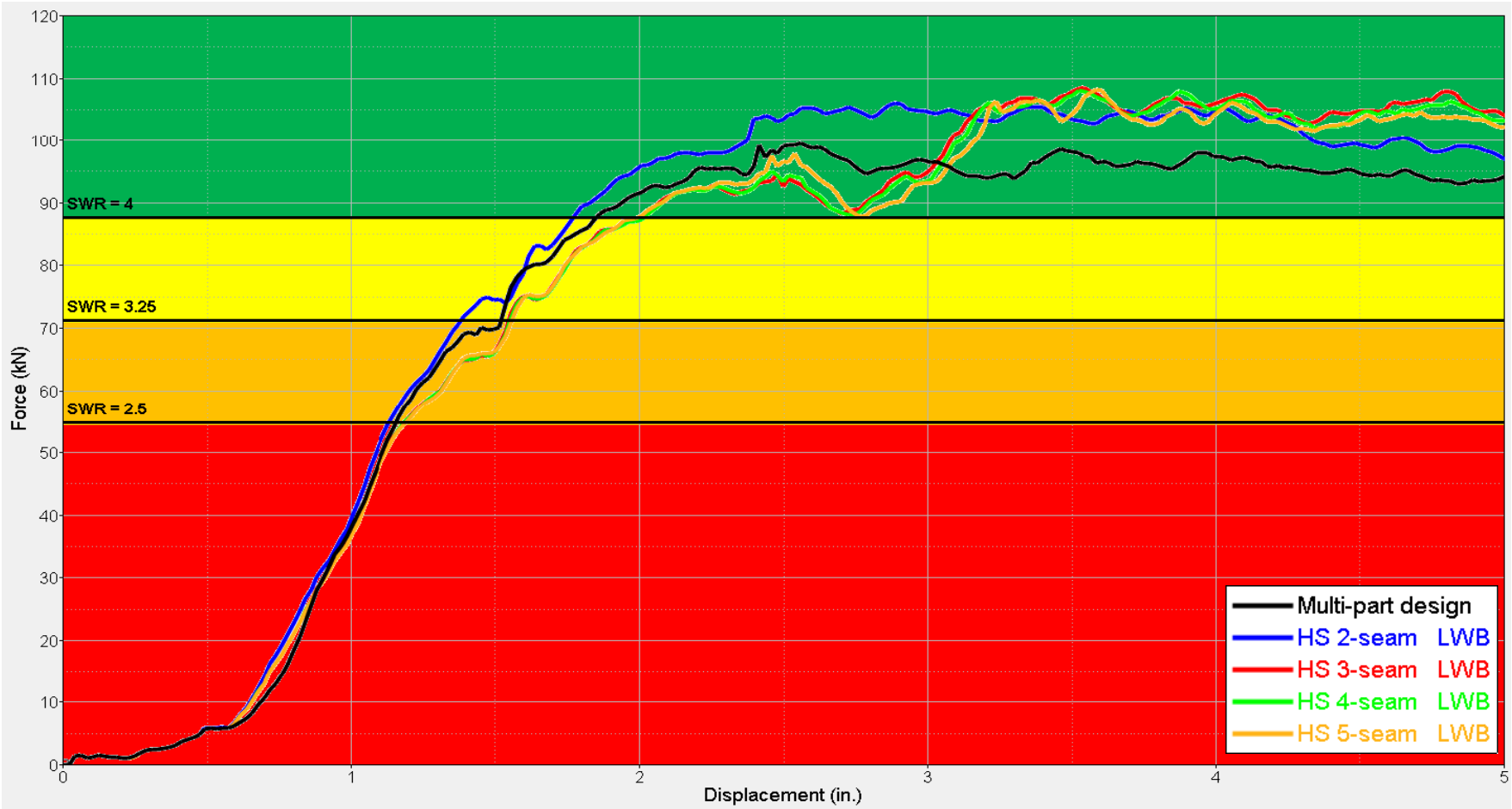




Multi-part design and Usibor®1500 HS LWB solution have similar behavior

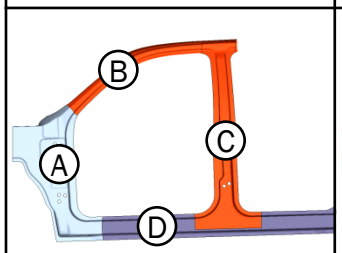
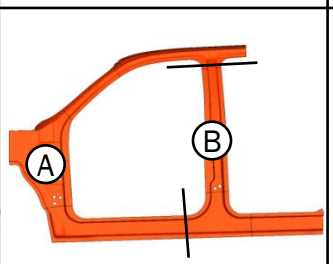
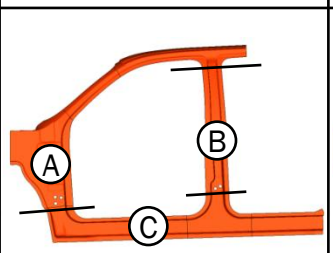
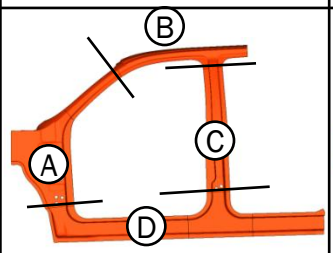
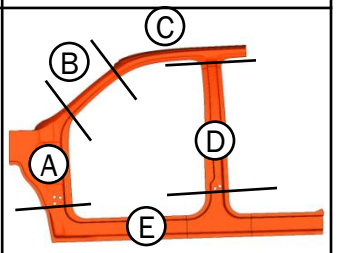
ArcelorMittal
TAILORED BLANKS

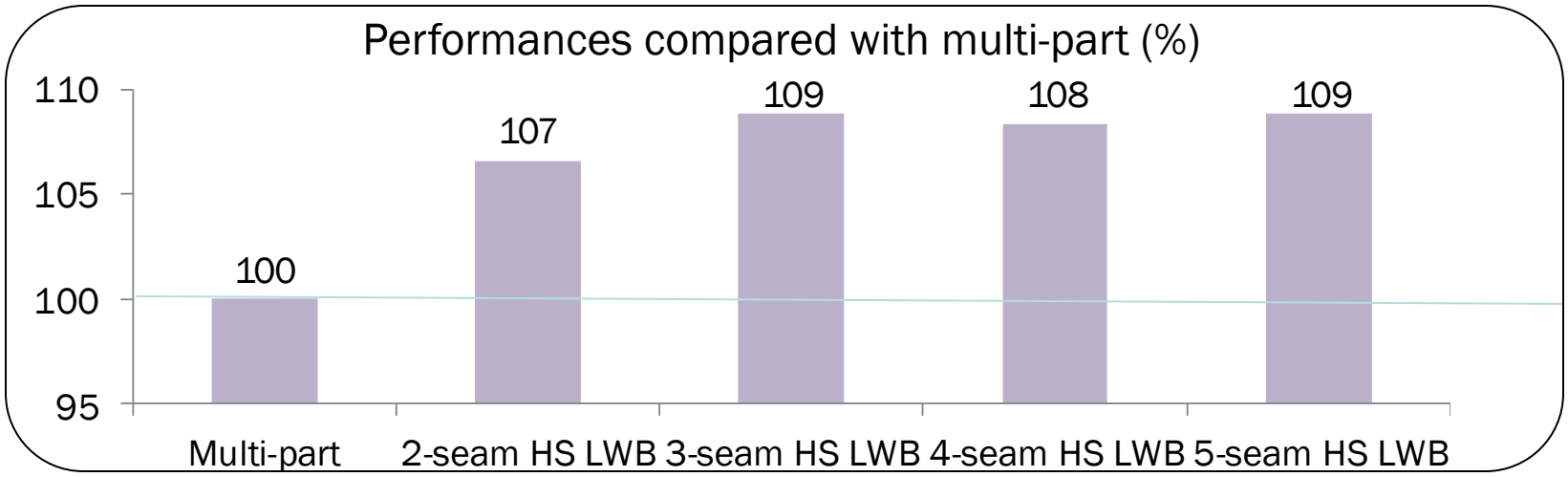
IIHS – Roof crush force curves



Multi-part and Usibor®1500 HS LWB solutions reach good IIHS level
Usibor®1500 HS LWB solutions have better performances than the multi-part design

IIHS – Roof crush performance summary

	Multi-part design	2-seam HS LWB	3-seam HS LWB	4-seam HS LWB	5-seam HS LWB
Proposal					
IIHS criteria	GOOD	GOOD	GOOD	GOOD	GOOD
Max SWR	4.55	4.85	4.96	4.93	4.95



Multi-part and Usibor®1500 HS LWB solutions reach good IIHS level ratings
Usibor®1500 HS LWB solutions have better performances than the multi-part design

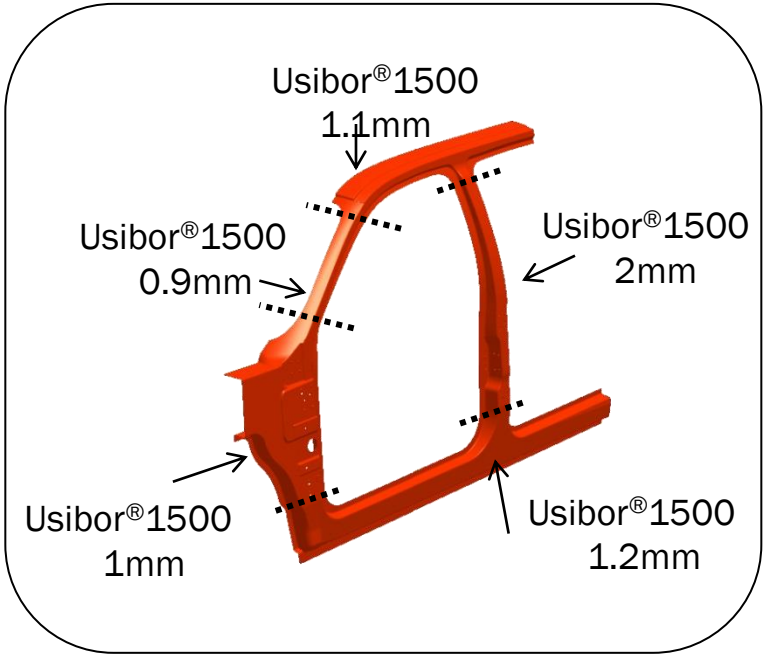
ArcelorMittal
TAILORED BLANKS

3. Process validation

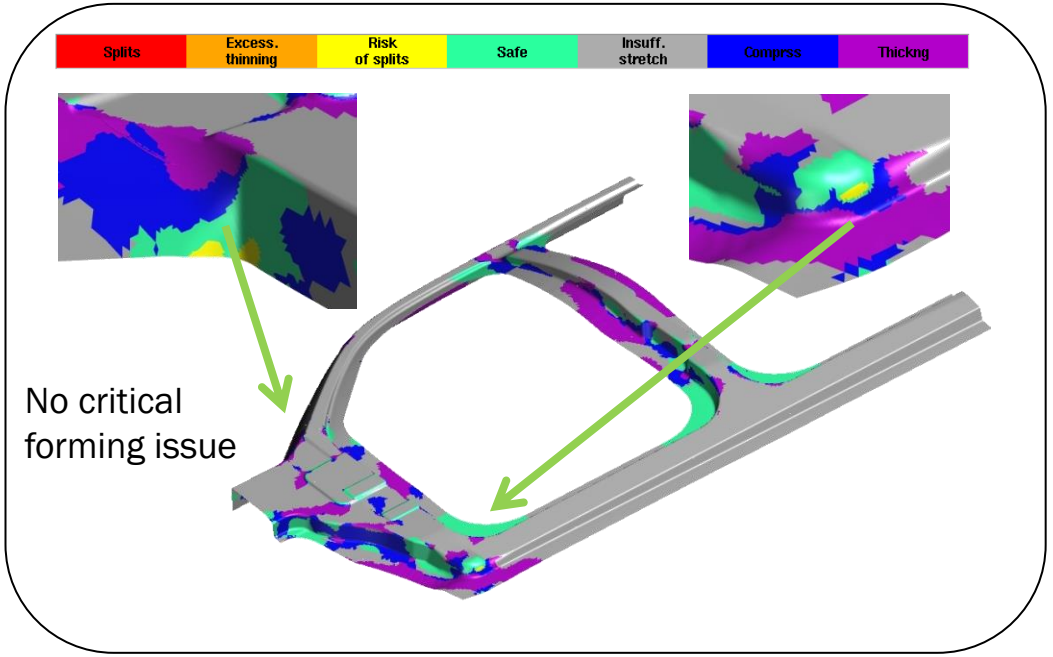
- Forming Validation
- Hot Stamping Validation
- Analytical to Experimental Validation

Door ring forming overview

5-seam design optimized for hot-stamping process



Forming assessment overview



Basic hot stamping process feasibility study does not show any critical areas

In depth part hot stamping assessment

Detailed stamping analysis

Deeper feasibility analysis in simulation

Tool manufacturing

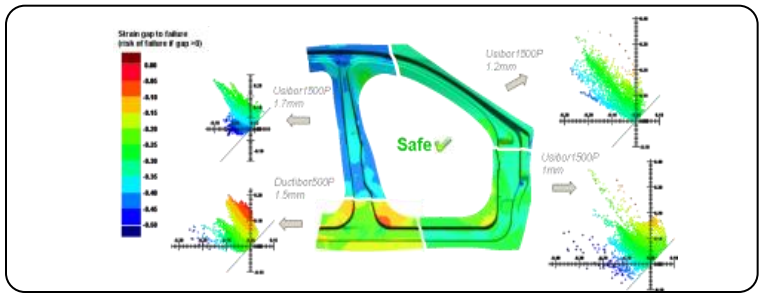
Hot stamping trials and tool set-up

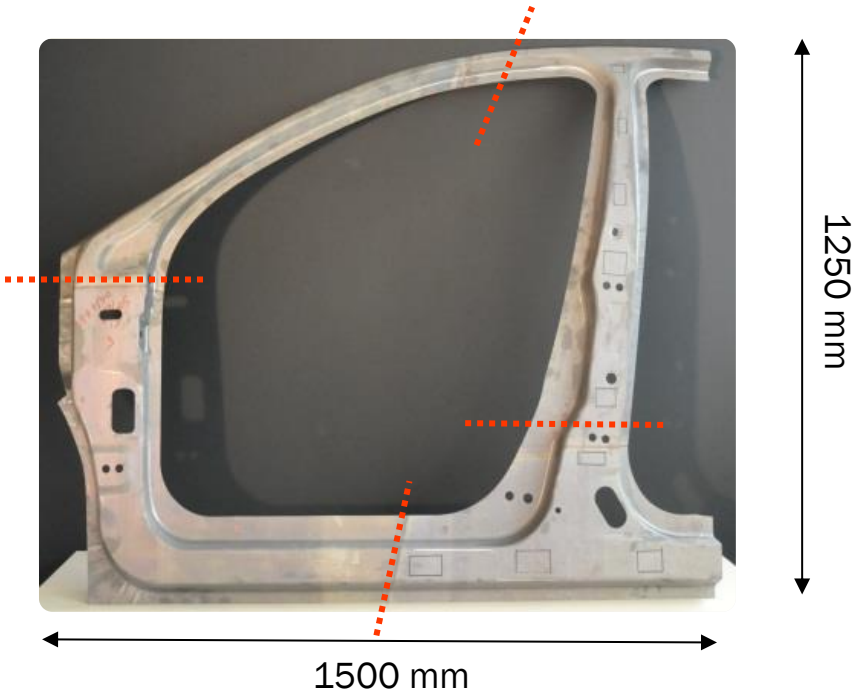
Successful scale 1 prototyping

Geometry accuracy

Quenching in base metal

Quenching in weld areas





Door ring prototypes have been already produced by ArcelorMittal S-in motion C-segment study

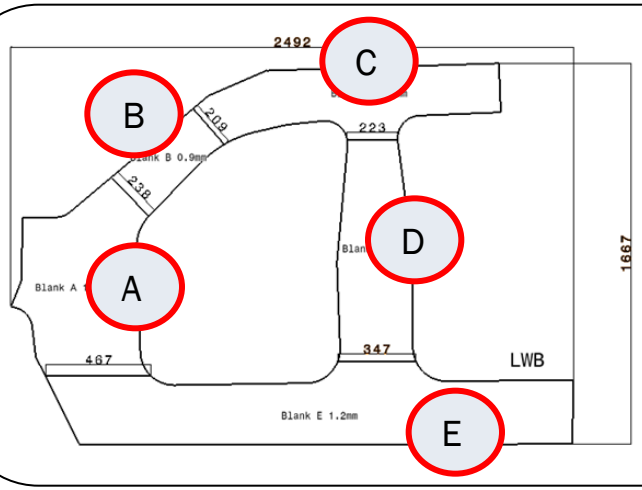
Usibor®1500 and Ductibor®500 4-seam HS LWB door ring

ArcelorMittal
TAILORED BLANKS

4. Design efficiency

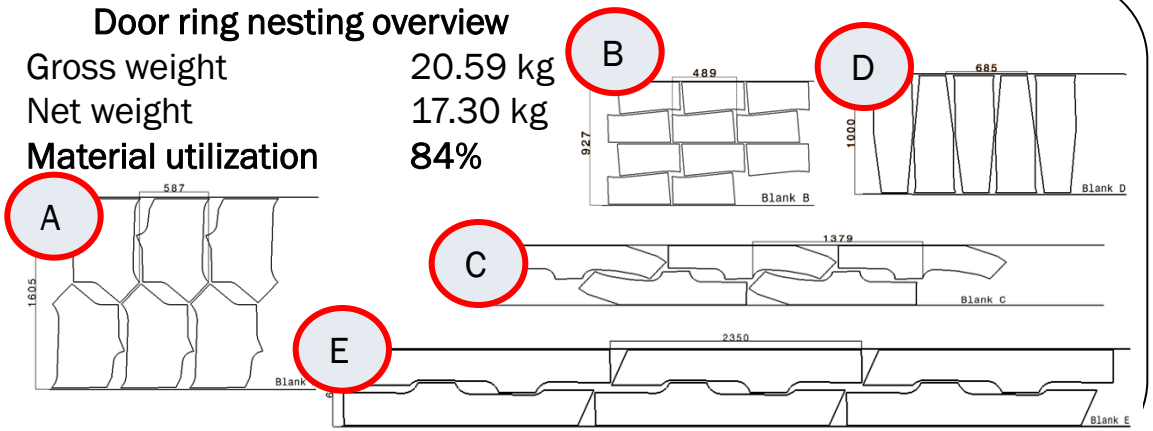
- Material Utilization
- Design Efficiency – North America Data
  - Normalized Cost Impact (base=100%)
  - Material Utilization (%)
  - Opportunity Cost ($/kg)
  - Weight Savings (kg)

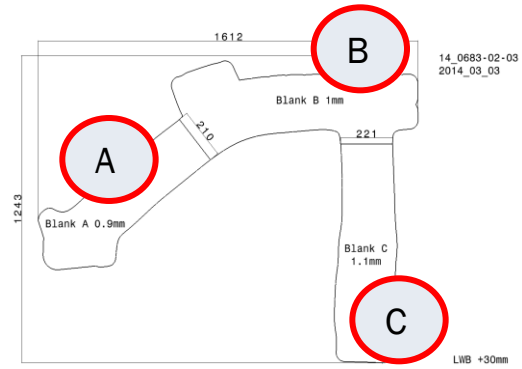
Material utilization: 5-seam door ring example



Door ring nesting overview

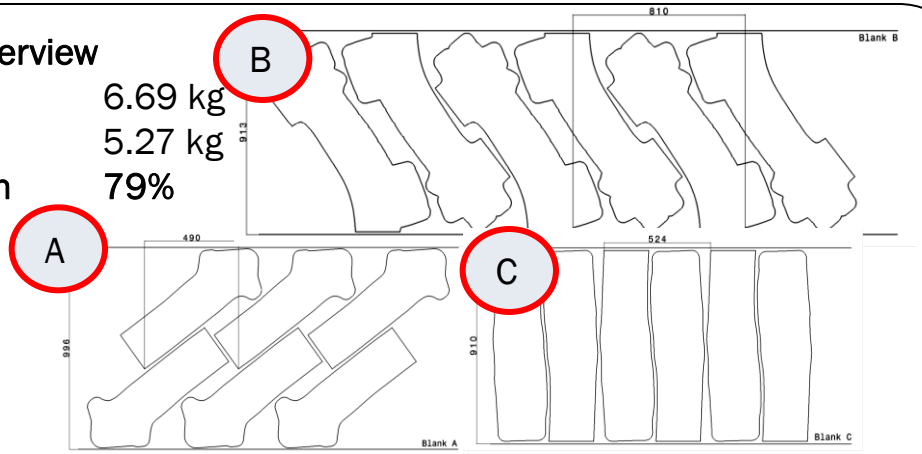
Gross weight	20.59 kg
Net weight	17.30 kg
Material utilization	**84%**





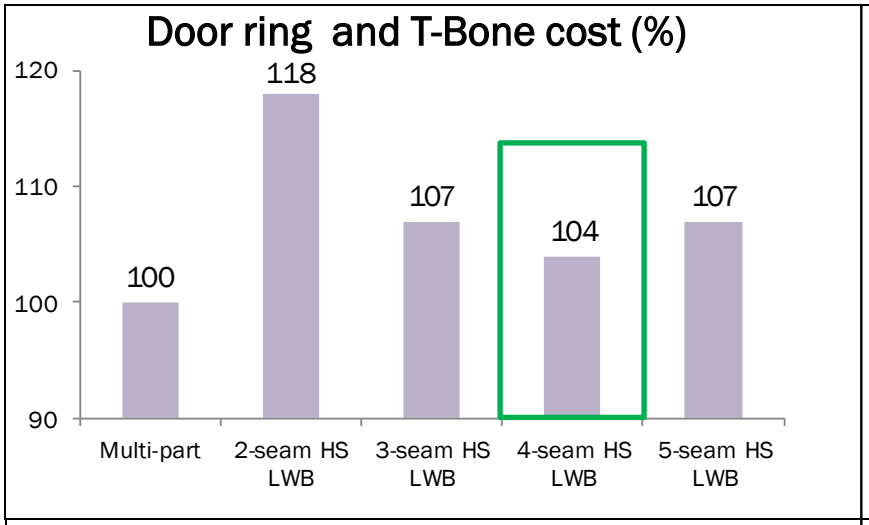
T-Bone nesting overview

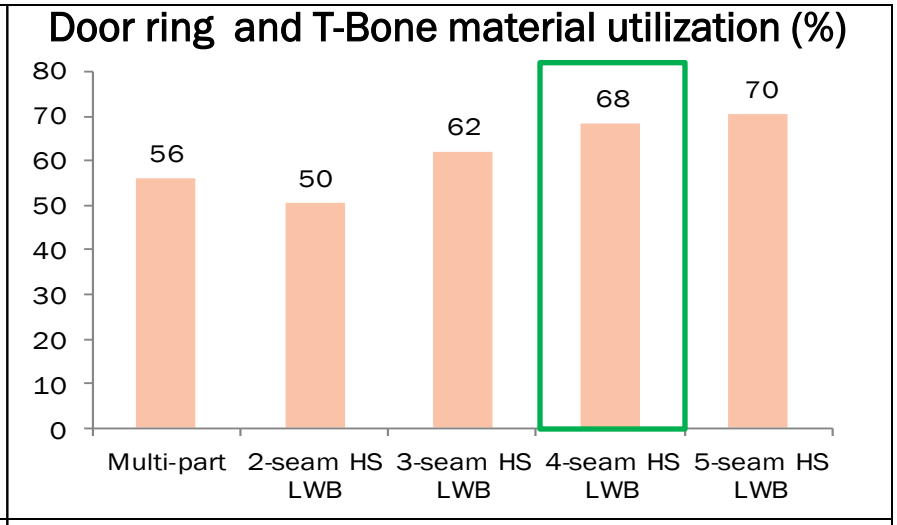
Gross weight	6.69 kg
Net weight	5.27 kg
Material utilization	**79%**

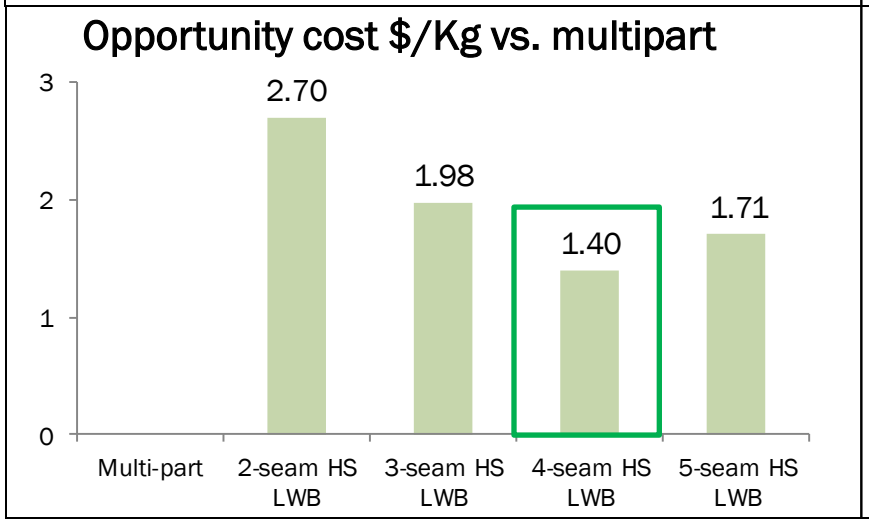


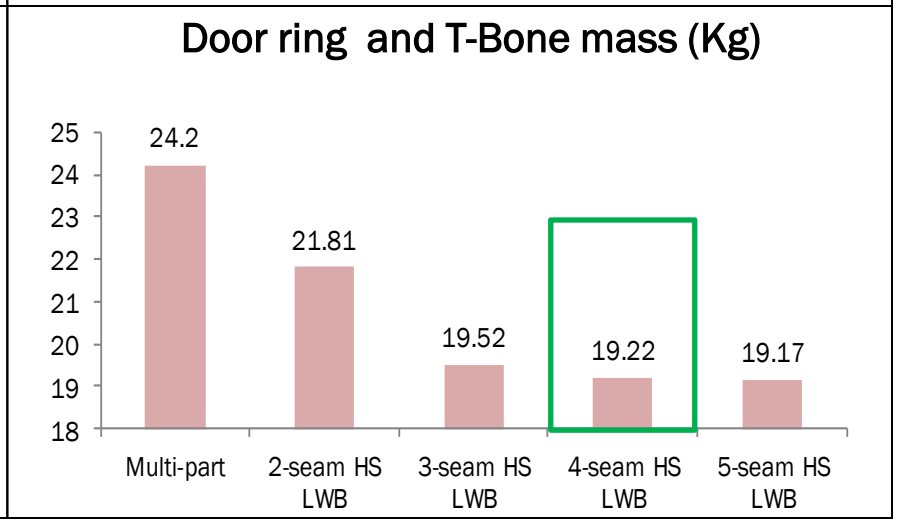
Usibor®1500 HS LWB door ring solutions allow very high material utilization rate

Design efficiency – North American Data









Usibor®1500 HS LWB door ring solutions allow high weight reduction with low cost increase

ArcelorMittal
TAILORED BLANKS

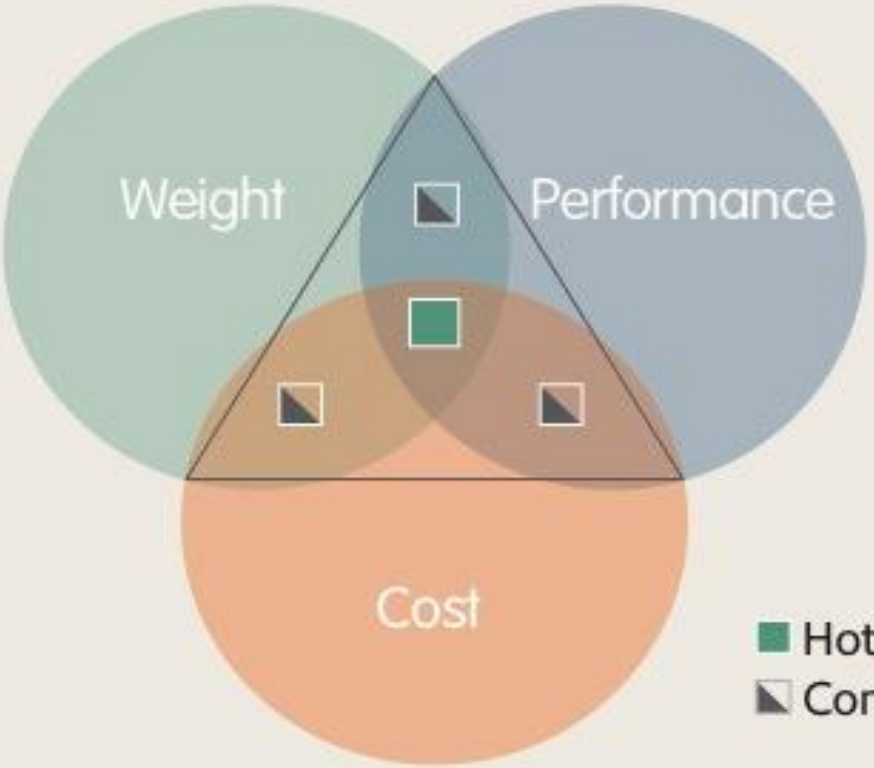
5. Conclusions

- Game-changer solution for body design
- Solution summary

ArcelorMittal
TAILORED BLANKS

Usibor®1500 HS LWB door ring concepts

Game-changer Solution for body design



Hot stamped laser welded blank technology benefits

- Weight reduction
- Part consolidation
- Material cost reduction
- Improved part performance
- Simplifies manufacturing process

■ Hot stamped laser welded blank technology
◣ Competing technologies

ArcelorMittal Tailored Blanks hot stamped laser welded blank technology balances all three competing needs.

Usibor®1500 HS LWB Door Ring concept

- Usibor®1500 Hot stamped LWB door ring solution is a flexible design concept that enables:
  - Big mass savings (up to 21% - 10kg per vehicle)
  - Part integration
  - Better material utilization
  - Better crash performances as multi-part structures
  - Low cost increase compared with multi-part design

Thank You

Steel
Market Development
Institute

PRESENTATIONS WILL BE AVAILABLE MAY 16

Use your web-enabled device to download the presentations from today's event

Great Designs in Steel is Sponsored by:

AK Steel
ArcelorMittal DOFASCO | HAMILTON
ArcelorMittal
NUCOR
Severstal
U. S. Steel