

GREAT DESIGNS IN STEEL

HOT FORMED STEEL BUMPER BEAM TO REPLACE ALUMINUM

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Multimatic



BUMPER EVOLUTION

The last 50 years has witnessed an extraordinary evolution of automotive bumpers.

Chrome structural faceplates gave way to molded covers over steel stampings or roll forms.

Advancing safety regulations required use of AHSS and/or PHS steel.

Energy savings paved the way for efficient 2-cell aluminum extrusions.

Most recently, further advances in steel solutions have been claiming back some of that market.

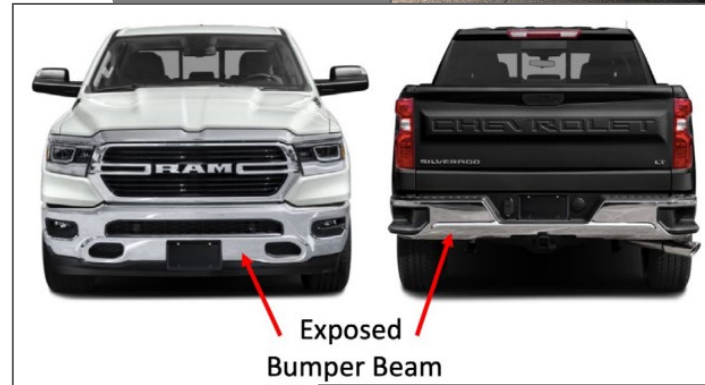


FIGURE 3.5 BENCHMARK STEEL BUMPER BEAMS

A: Facebar: 2017 Ford F150 front bumper



B: Facebar: 2017 Chevrolet 1500 front bumper



C: Facebar: 2017 Ford F250 rear bumper



D: Hot Formed 2015 Chevy Colorado front bumper



E: Hot Stamped 2016 Mazda front bumper



F: Hot Stamped 2016 Lincoln MKC front bumper



G: Roll Formed 2016 Nissan Altima rear bumper



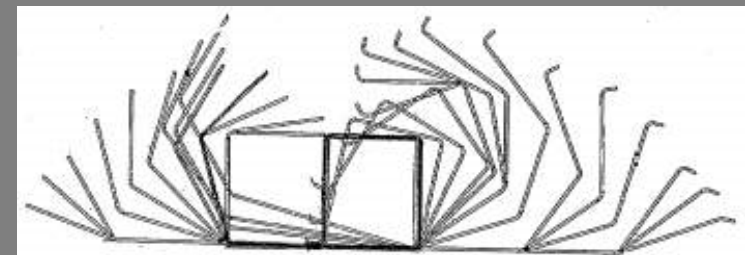
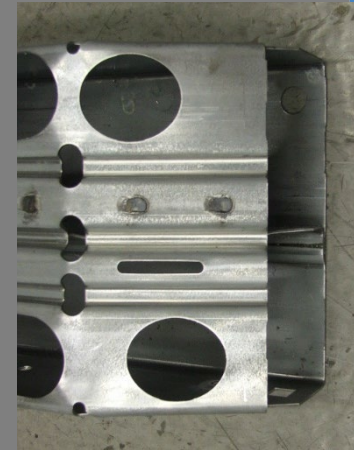
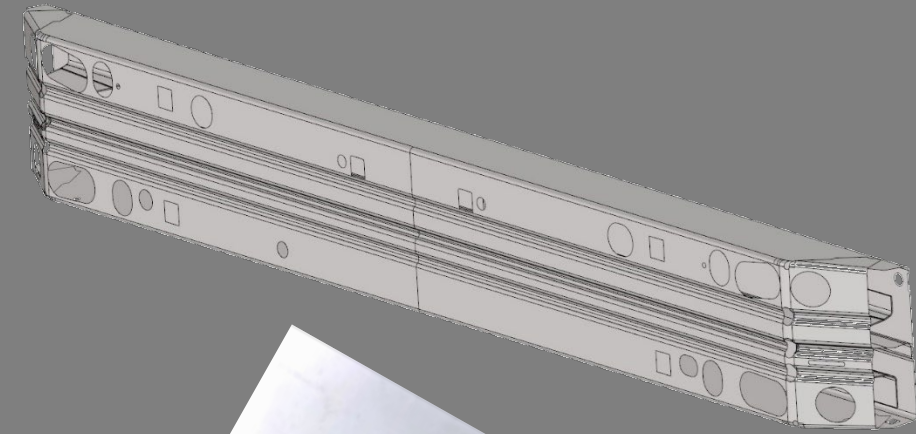
ROLL FORM BUMPERS

As structural requirements increased, bumper (impact) beams went from stampings to PHS and AHSS roll forms.

An interesting example of an AHSS roll formed bumper is the “Hinoji” bumper featured on the 2004 Ford Focus.

This bumper used an early version of the 2-cell design which has proven to be very efficient at managing impact loads.

Made from M190 steel this was a straight roll form with 3T rads and folded end sections.



ACCRA® BUMPERS

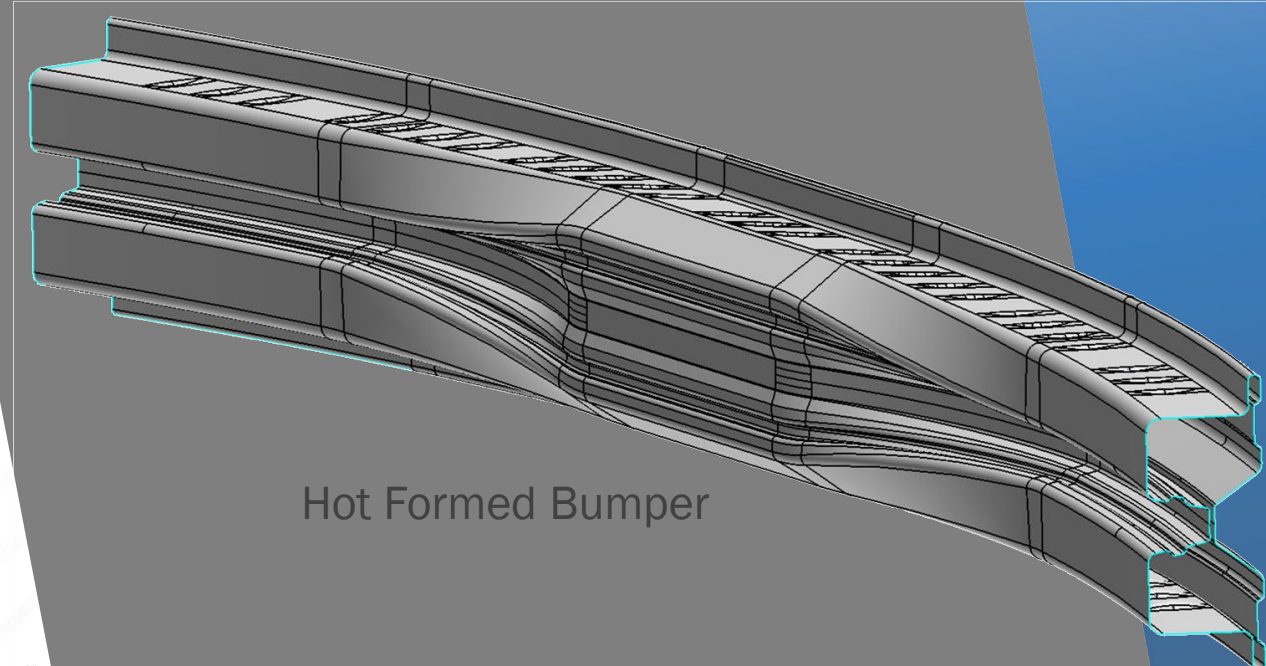
ACCRA® bumpers were introduced to North America on the Ford Mustang and Focus (rear) in 2004.

Those designs featured a complex variable cross-section with tight radii that were subsequently swept and shaped in the hot forming process to achieve ultra high strength with a complex geometry.

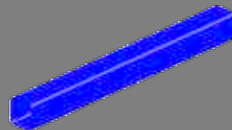
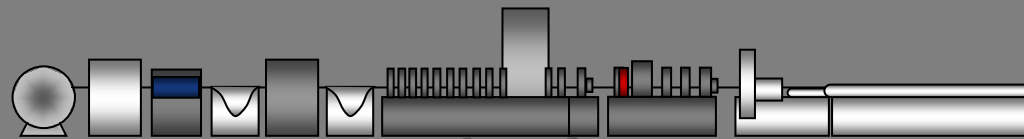
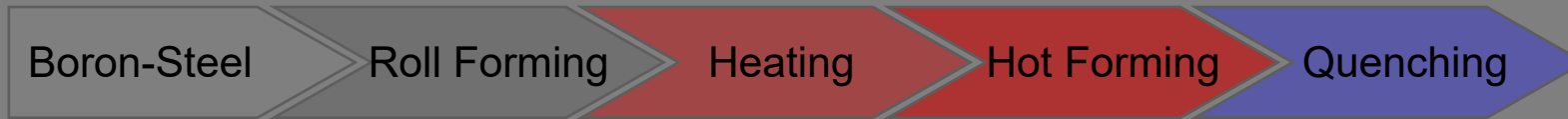
Since then, millions of ACCRA® bumpers have been produced for over a dozen applications in Europe and North America.



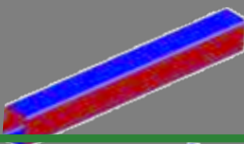
Roll Formed Blank Section



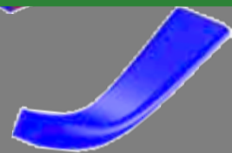
Hot Formed Bumper



1 In-line Hardening
Cross members, etc.



2 Tailored In-line Hardening
Rockers, crash parts



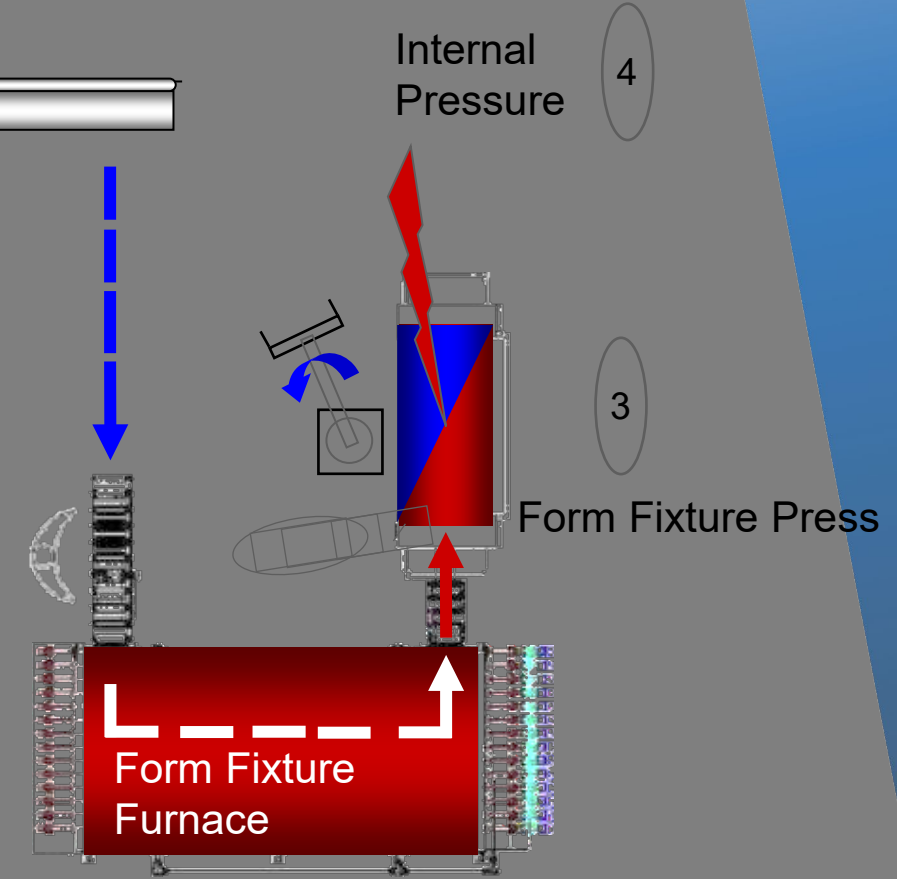
3 **Form Fixture Hardening**
Bumpers, Rockers, Reinforcements



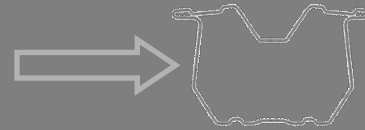
4 Form Blowing Hardening
A / B / C pillars

Tool forming only →

Pressurized during hot forming →



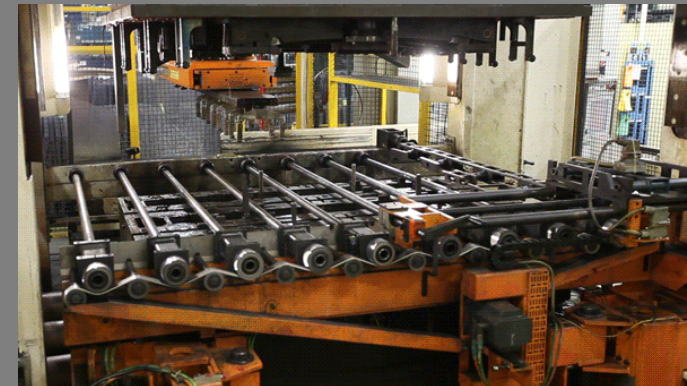
ACCRA[®] BUMPER PROCESS EXAMPLE



Boron steel
35% Elongation
450 MPa



Formed in tool and
Direct Water Quenched



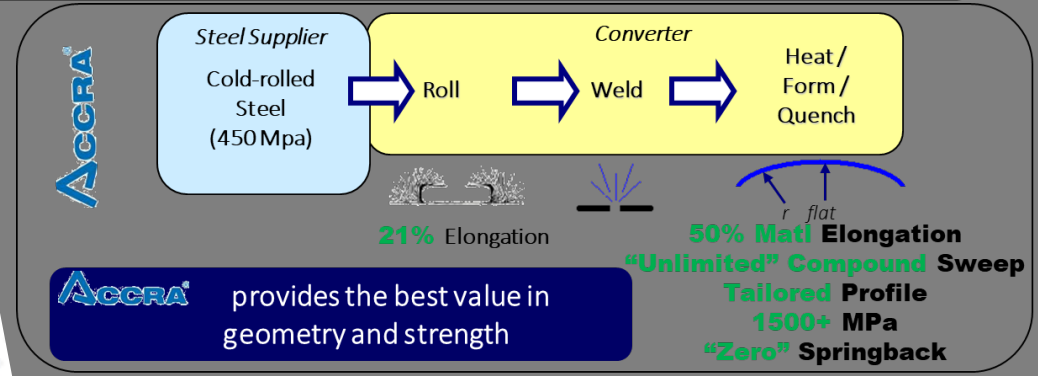
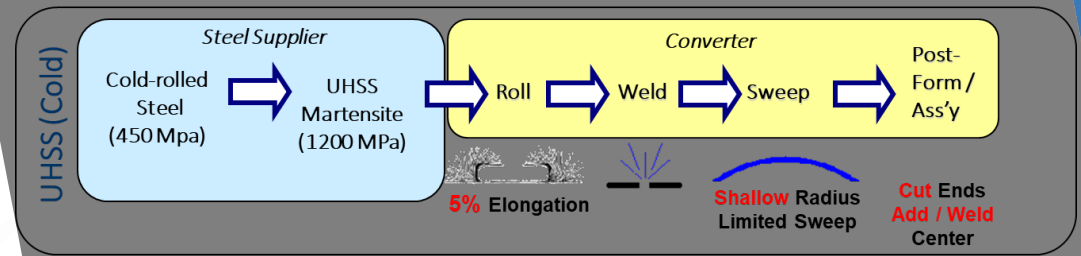
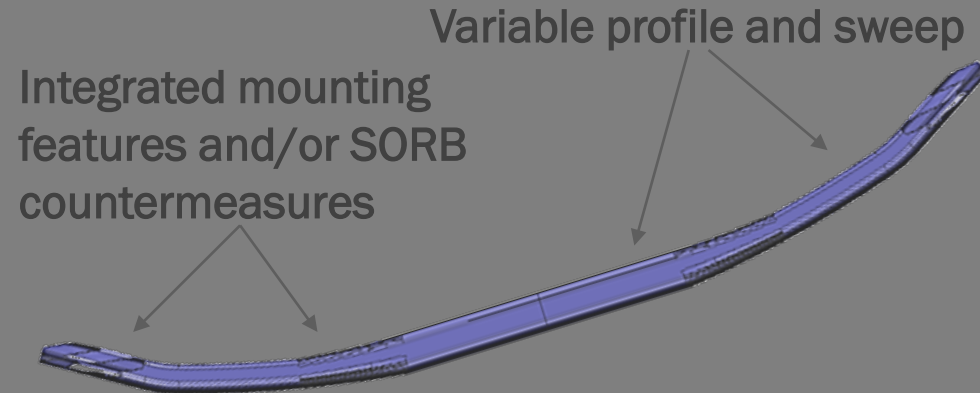
At Temperature
70% Elongation
200 MPa

Final form created by ACCRA[®] die prior to direct water quench

ACCRA® ADVANTAGES

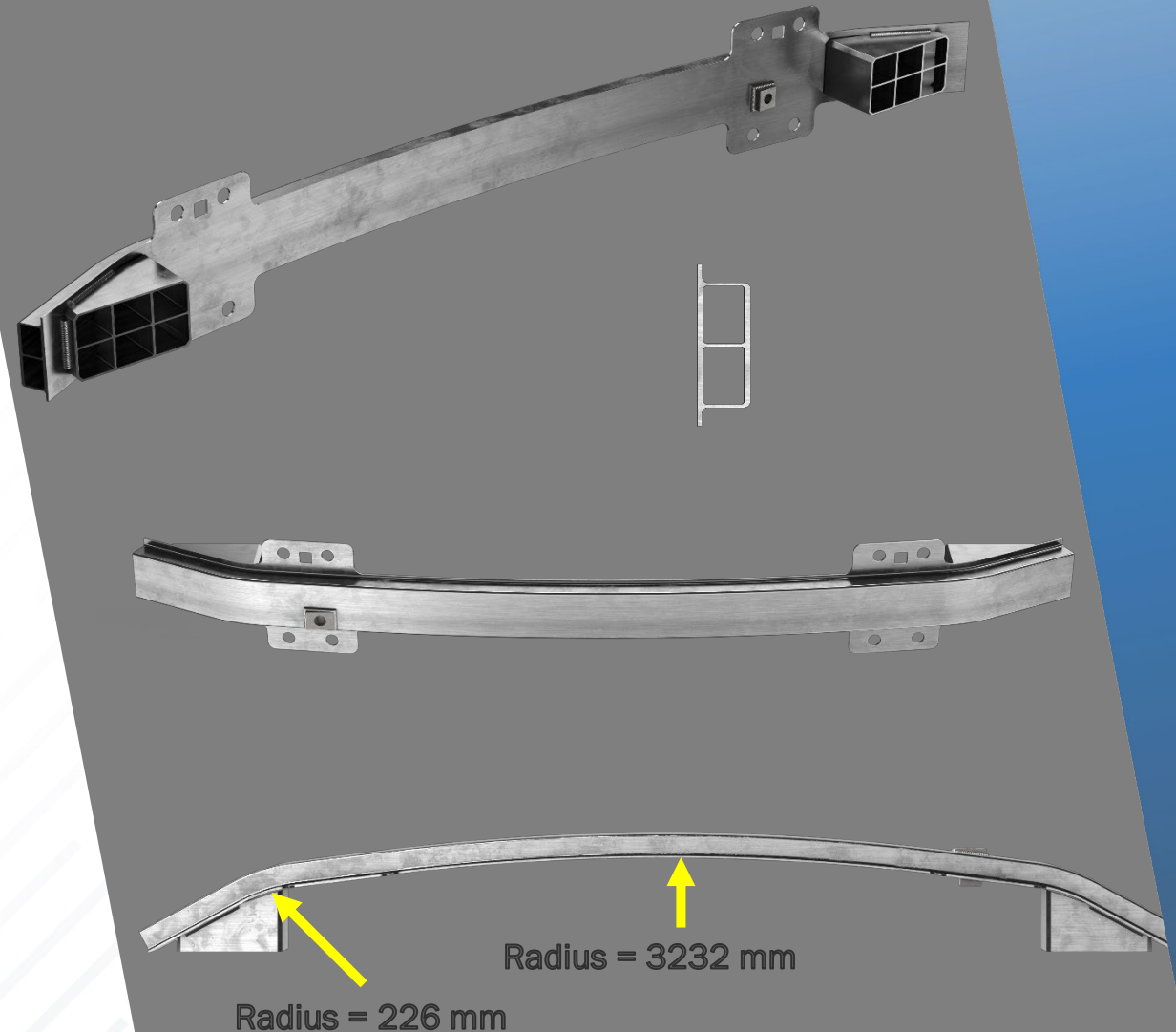
By roll forming a custom geometry and subsequently hot forming it, ACCRA® can achieve:

- Tighter corner radii
- Tighter and compound sweeps
- Section shape changes (within process limits)
- No springback
- Material transformation included in the forming process
- Pre-pierced holes and features
- Ultra high strengths (UHSS) without Heat Affected Zones (HAZ)



SUBJECT ALUMINUM APPLICATION

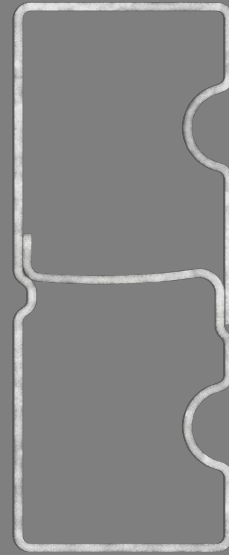
- SUV front bumper
- High volume North American application
- Variable thickness 6000-series extrusion
- Integrated mounting features and welded on “blocker” brackets
- Approximately 4.4kg (NA version)
- Low volume variant includes tow eye receiver



NEW INNOVATION

The innovation presented here is a combination of the earlier roll form and **ACCRA**® examples.

Starting with the roll formed 2-cell section, a complex profile is formed in the **ACCRA**® process to replace the stretch bent aluminum extrusion.



KEY DESIGN FEATURE – TIGHT RADII

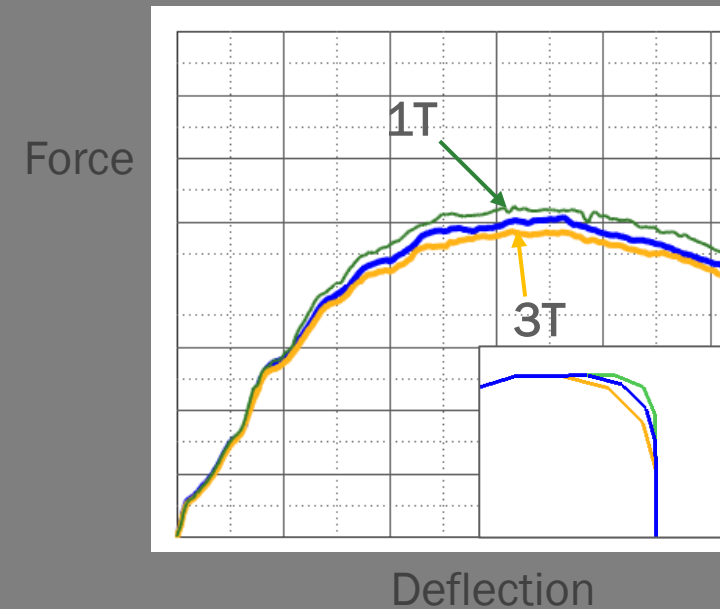
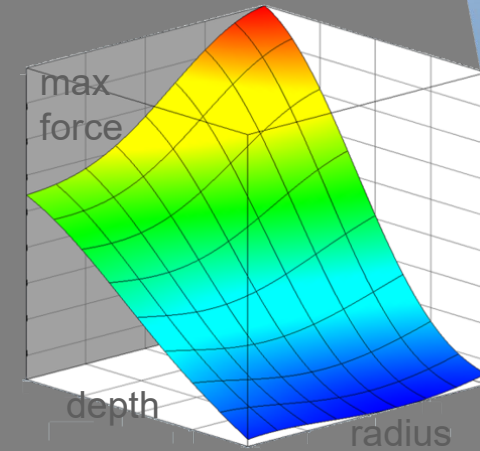
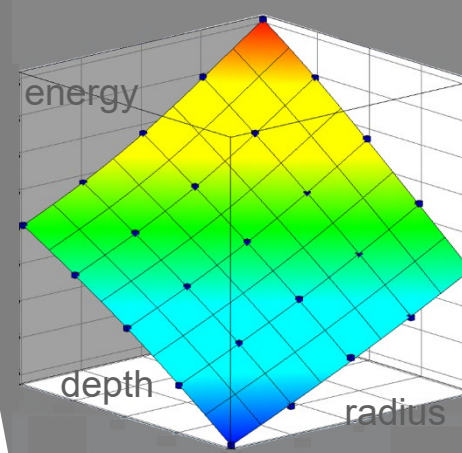
Design optimization included analyses of the beam depth, height (both constrained) and corner radii.

Corner radii were determined to be critical in achieving high performance.

By roll forming boron steel in the soft condition, very tight radii (1T) can be achieved (vs 4T for cold formed M1500).

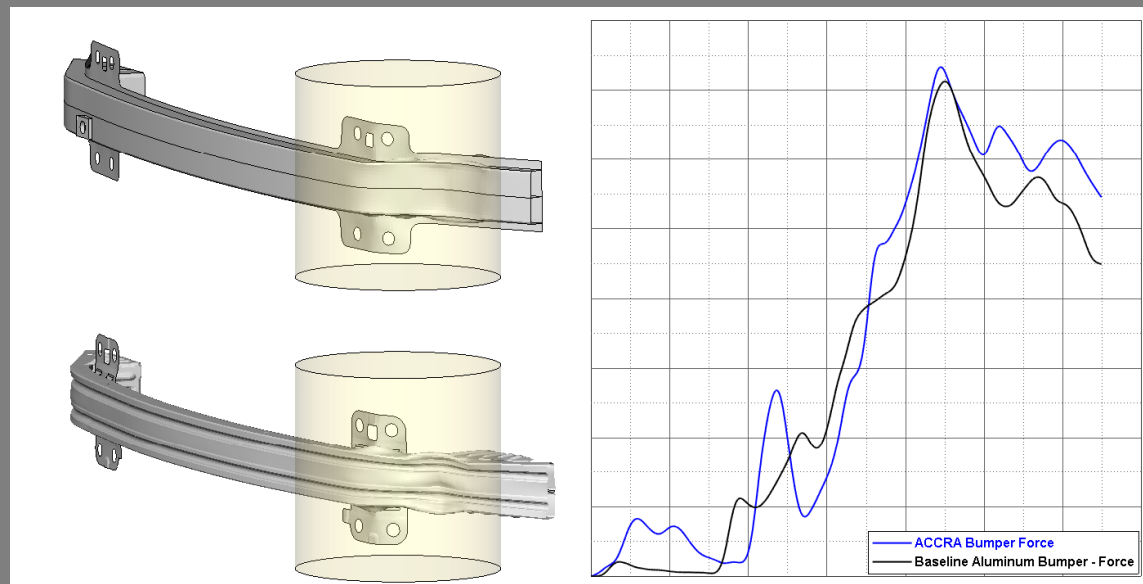
Load carrying capability at 1T increased 9% from 3T and 13% from 4T.

This enabled a reduction in thickness to 1.2 mm, with a corresponding mass reduction.

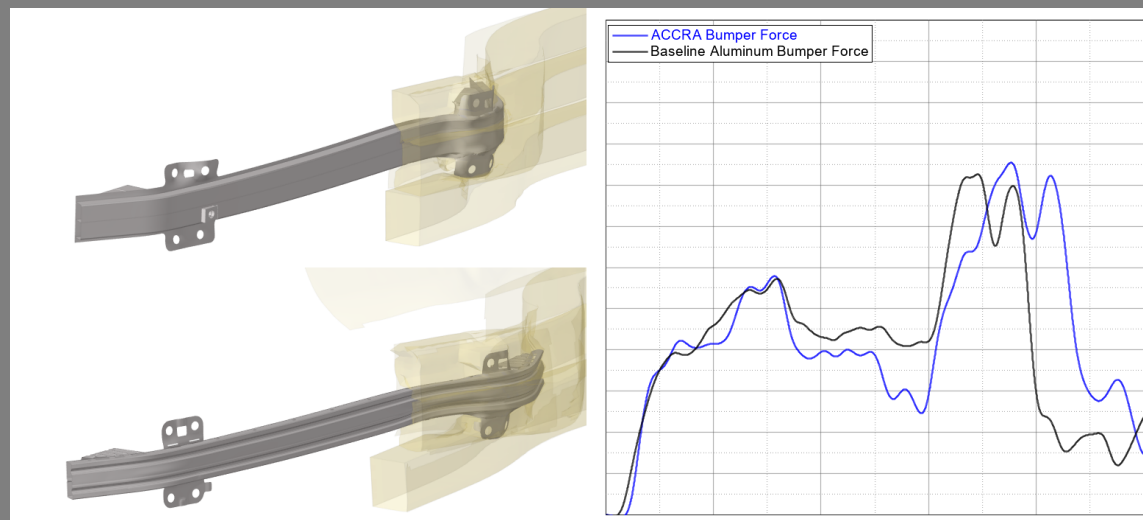


MATCHING OEM ALUMINUM PERFORMANCE

SORB Example



ODB Example

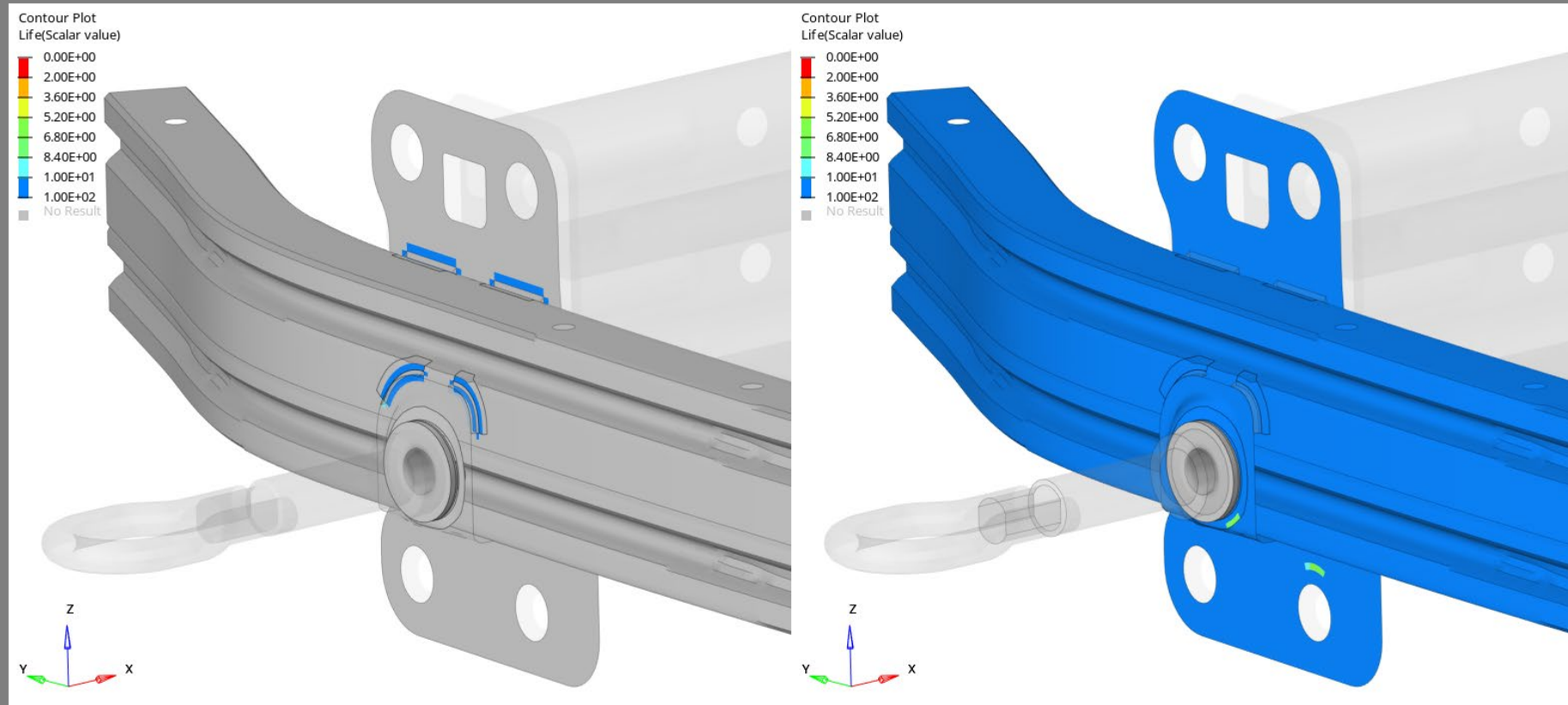


MATCHING OEM ALUMINUM PERFORMANCE

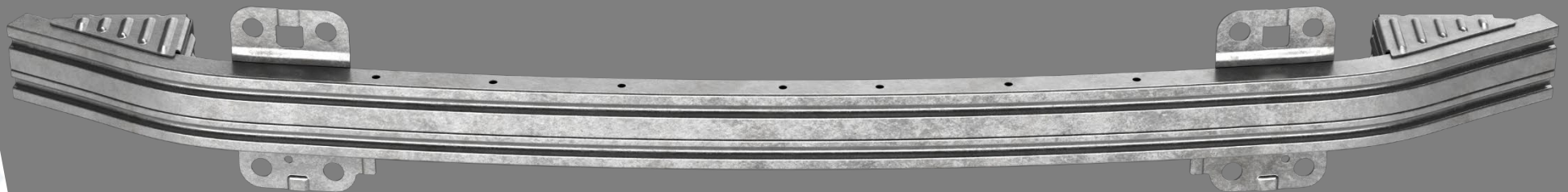
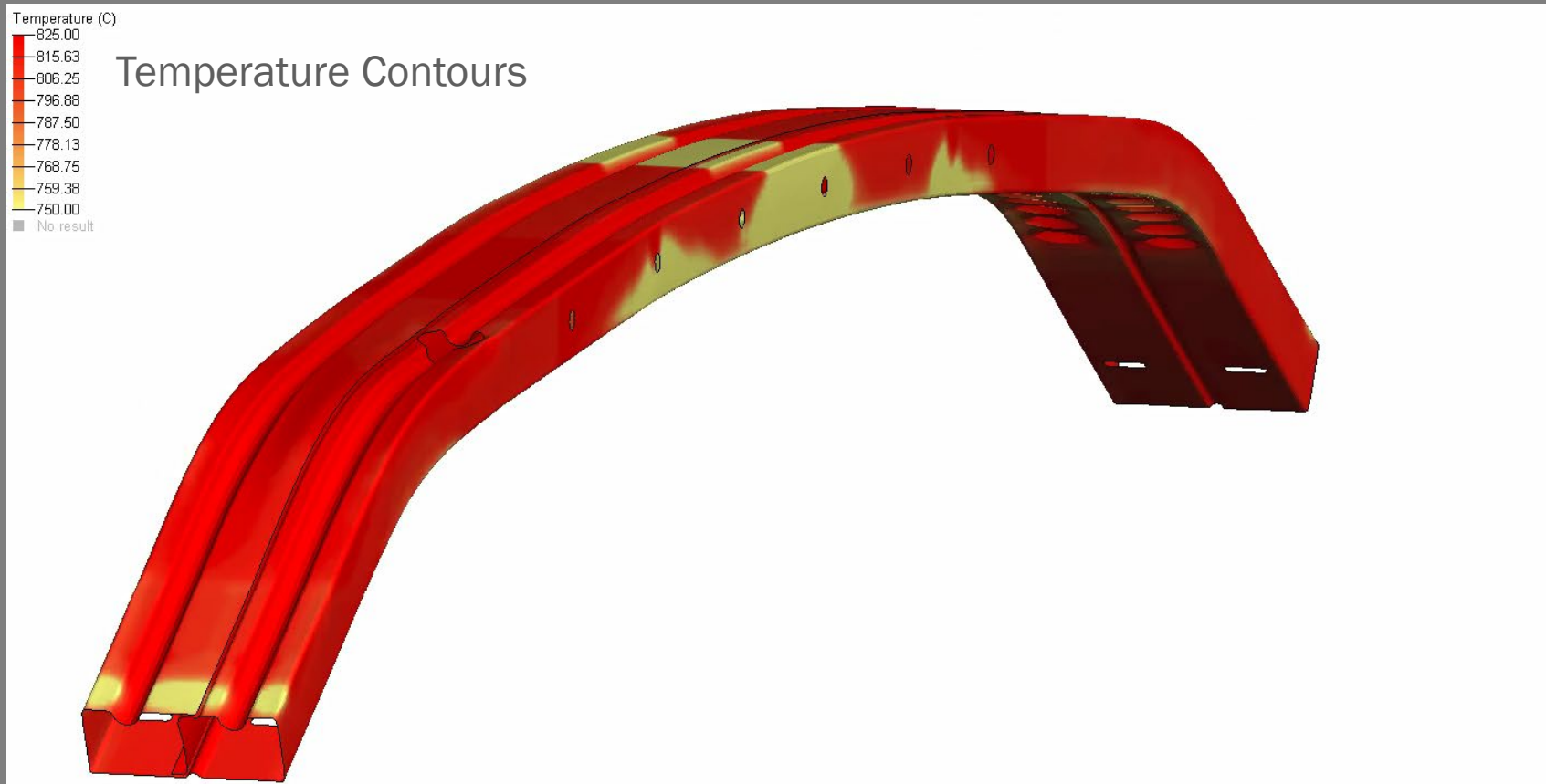
Tow Eye Receiver Fatigue

Weld Life

Parent Life



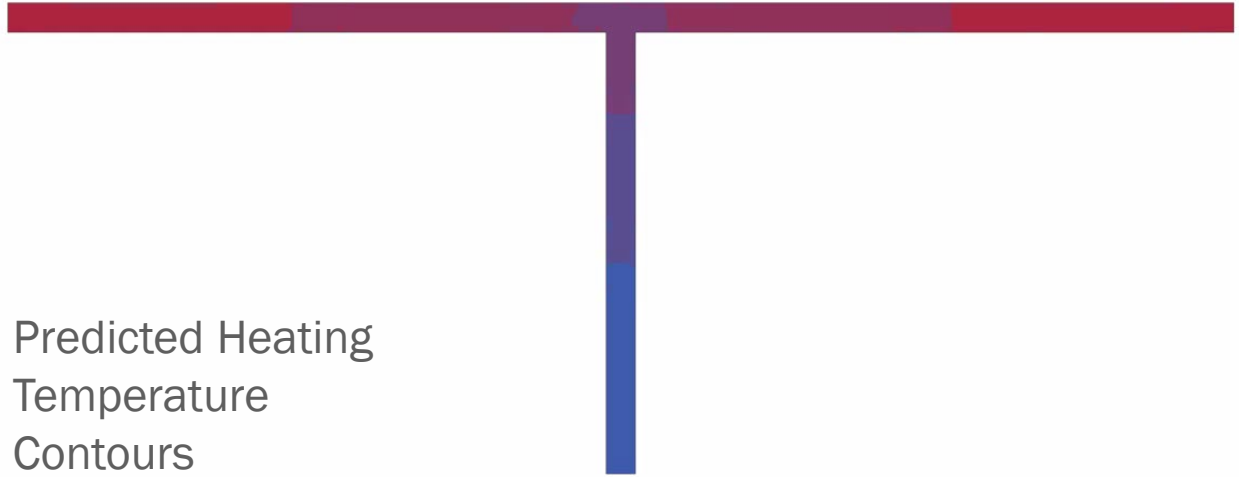
HOT FORMING ANALYSIS



ENSURING AUSTENITIZATION

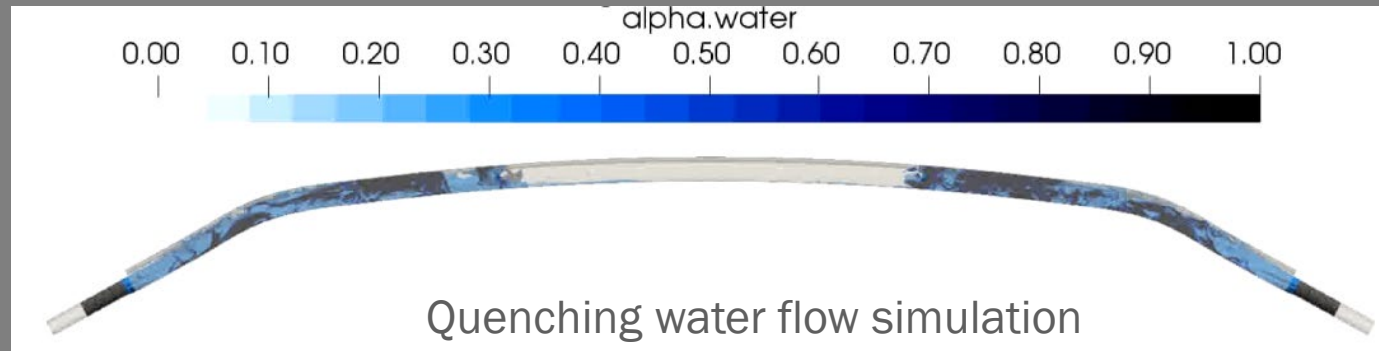
New challenge: center web is not exposed to radiation heating, unlike PHS or previous designs

Predicted Heating
Temperature
Contours



Simulation was used to determine minimum heating time to ensure austenitization of the center web. These results were confirmed during initial builds at minimum cycle time.

ENSURING QUENCHING AND PROPERTIES



Final Part Mechanical Properties

- >1100 MPa Yield Strength
- >1400 MPa Tensile Strength
- 5% Elongation

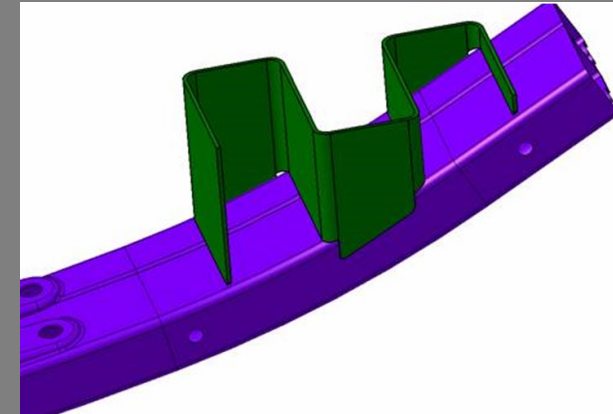
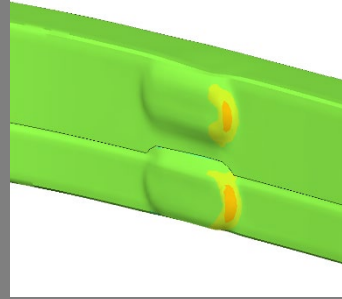
DROP-IN CONSIDERATIONS

Due to the “drop-in” requirement of this design, we had to forego other mass savings opportunities.

ACCRA is able to hot form mounting embosses which could have eliminated the add-on brackets had there been flexibility in the attachment scheme

SORB “blocker” brackets were dictated by their interaction with mating components

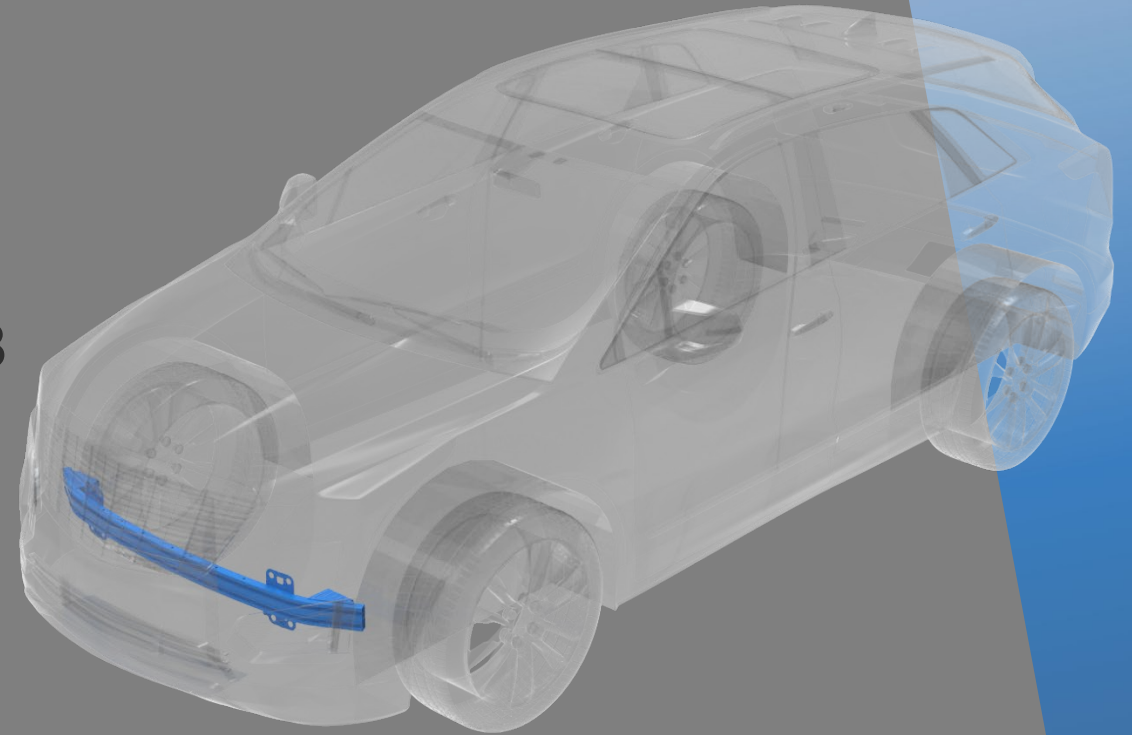
Greater design flexibility, as might be available on a clean sheet design, may have allowed for a mass neutral ACCRA solution.



Mass Comparison (kg)			
Design:	AL	Potential Accra	Final Drop-In
Beam	3.637	3.825	3.847
Blockers (ea)	0.308	0.176	0.450
Mounting Plates (ea)	w/ beam	0	0.168
Total	4.370	4.177	5.083

STATUS

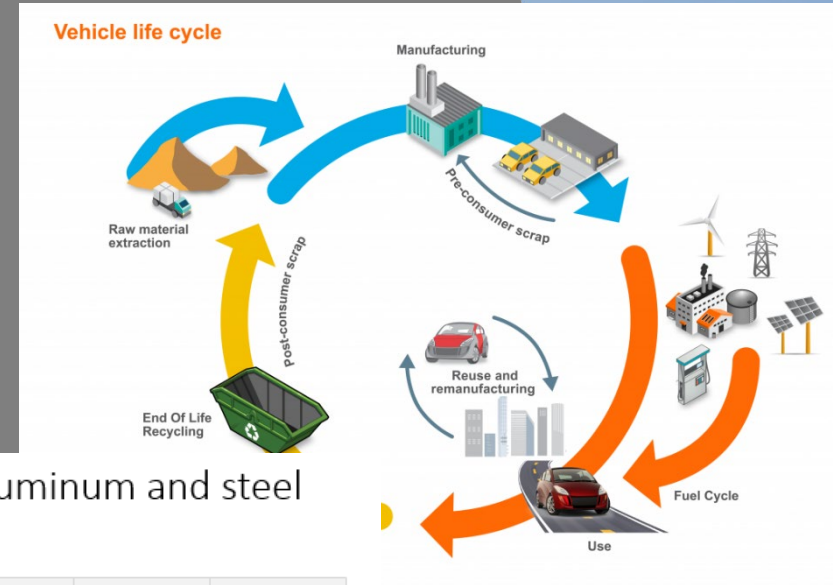
- All program targets achieved
- Tools homelined and PPAP'd
- High volume SUV mid-cycle action (MCA) implementation later in 2023
- Weight “buy” (estimated) at more than \$20 per kg



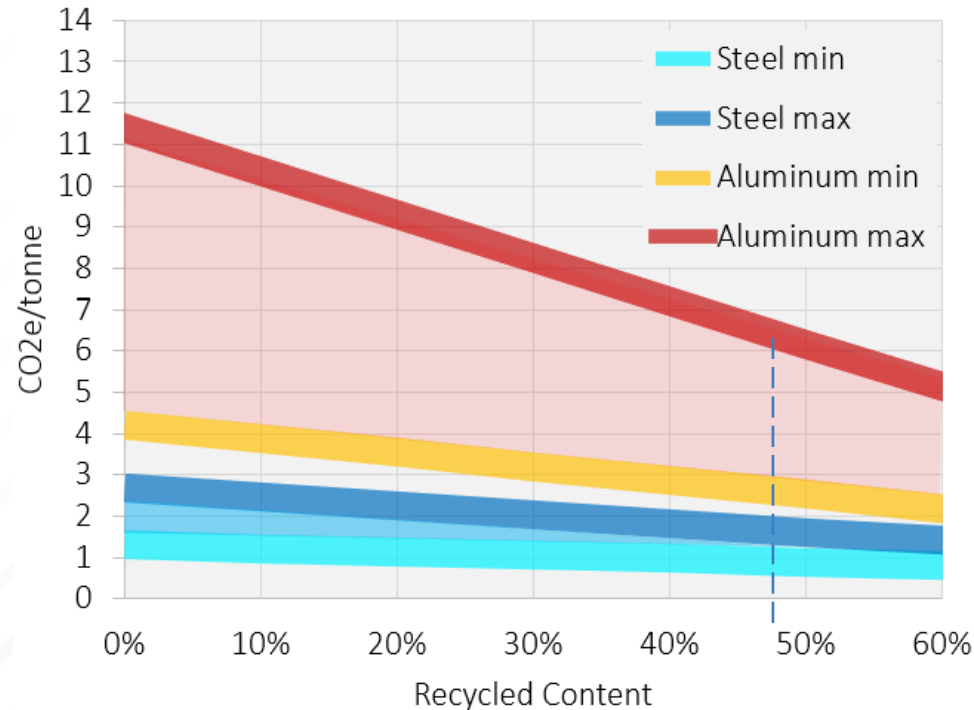
A WORD ABOUT SUSTAINABILITY

Raw material production CO₂e is a major factor:

- Advanced bumper materials (both AL and Steel) use only prime scrap (50% maximum)
- CO₂e from raw aluminum production is >4x that of steel in this case
- Extrusions, hot forming and other processes are a small contributor
- The manufacturing CO₂e impact exceeds the use impact in this case
- This difference will grow with advances in performance, BEV, etc

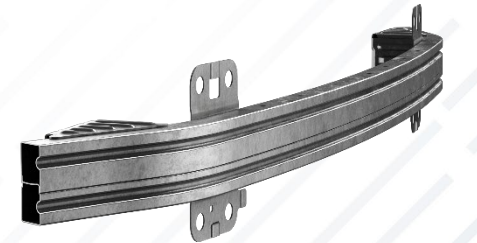


CO₂e/tonne estimate for aluminum and steel



SUMMARY AND CONCLUSIONS

- By hot forming optimized closed roll-form sections it is possible to create a very **cost-effective, high performance** impact beam that is **mass-neutral** compared to current Aluminum beams
- **Complex** sweeps and **variable geometry** are achievable which can enhance vehicle styling and packaging
- Tight corner radii enable designs that **exceed** cold formed steel capabilities
- Flanges, holes, ribs and other **features** can be included in the roll forming operation
- All of this, together with transformation to UHSS material properties, can be achieved **efficiently** using the **ACCRA** process
- **Proven technology** with two decades of high-volume serial production



STEEL - CAPABILITY AND VALUE

FOR MORE INFORMATION

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