GREAT DESIGNS IN STEEL

LIGHTWEIGHT STEEL ENGINE CRADLE TECHNOLOGIES

Paul McKune

GDIS LIGHTWEIGHT STEEL ENGINE CRADLE CONTENT

GDIS

- Introduction to Martinrea
- A2Mac1 Engine Cradle Benchmarking Study
- Optimized Engine Cradle
  - Baseline Design
  - Ideas Considered
  - CAE Validation
  - Final Optimized Design
  - Mass and Cost Comparison
  - Manufacturing Feasibility
- Summary / Conclusions

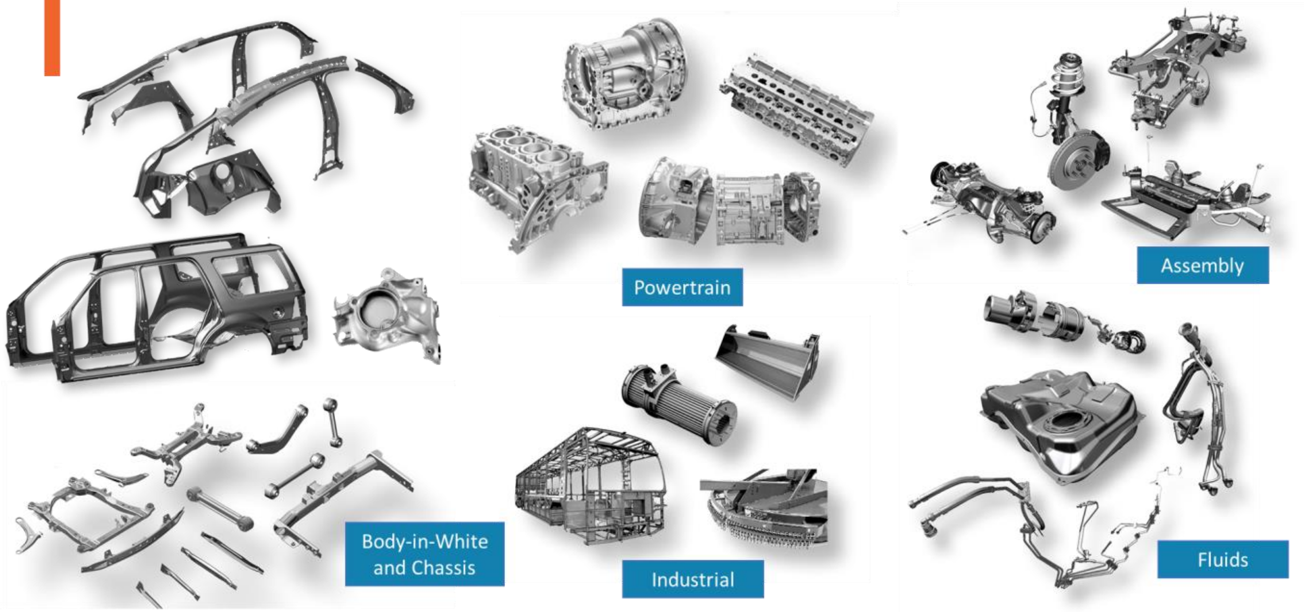
www.martinrea.com

Leading Tier One automotive supplier in metal forming, fluid management systems and aluminum parts

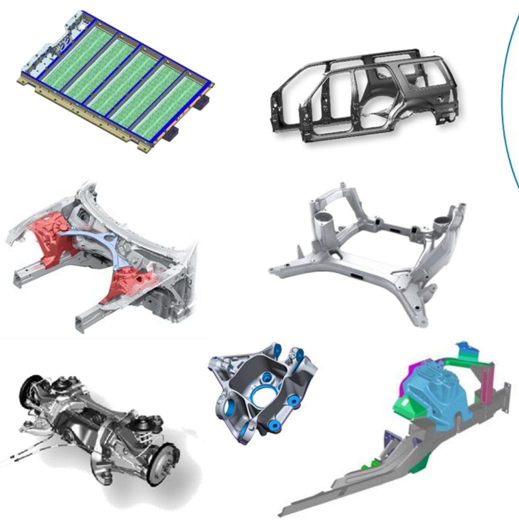
One of the fastest growing automotive parts suppliers in the past 15 years ($0 to ~$4.0 billion in sales)

Headquartered in Canada and operating 44 manufacturing facilities with over 9 million square feet of manufacturing space and 15,000 motivated employees in 9 countries: Canada, United States, Mexico, Brazil, Germany, Slovakia, Spain, China, and Japan.

PRODUCTS /CAPABILITIES



Lightweight Structures

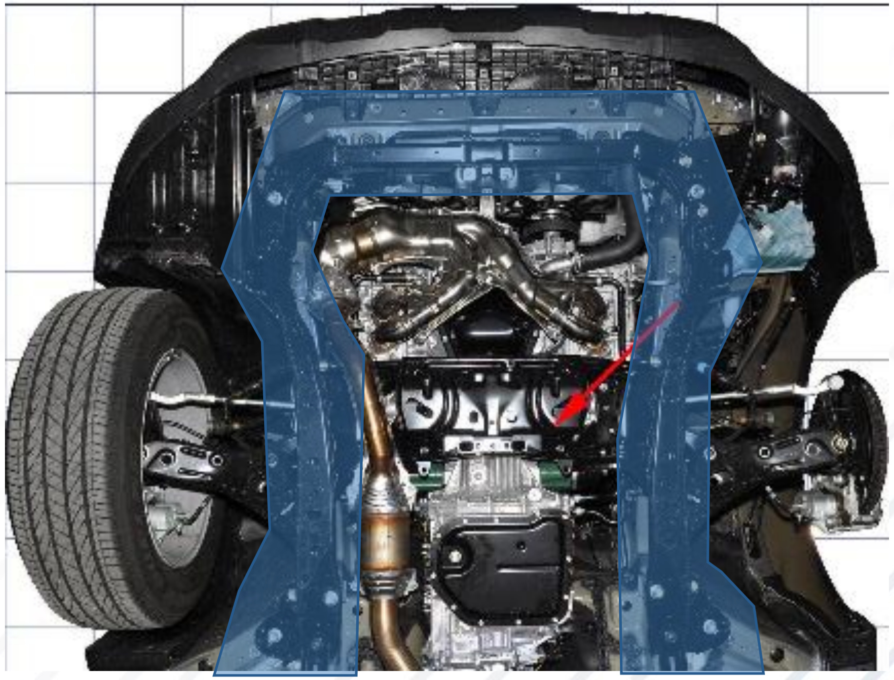


Propulsion Systems

ENGINE CRADLE BENCHMARKING – SIZES

Hyundai Elantra
Mass = 14.6 kg
SMALL

Subaru Outback
Mass = 27.0 kg
LARGE

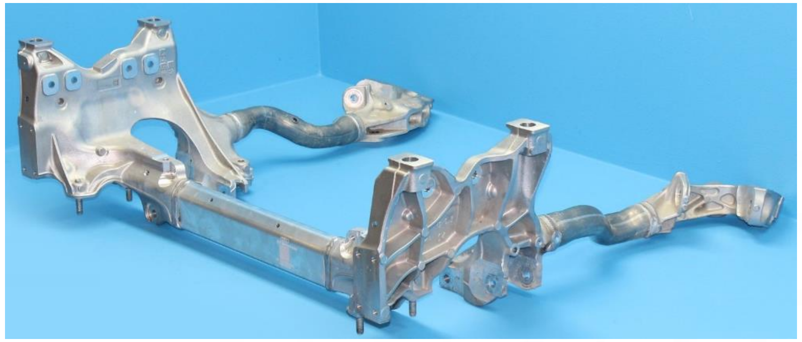


ENGINE CRADLE BENCHMARKING - MATERIALS

Aluminum

BMW 5 Series
Mass = 16.8 kg

Hybrid

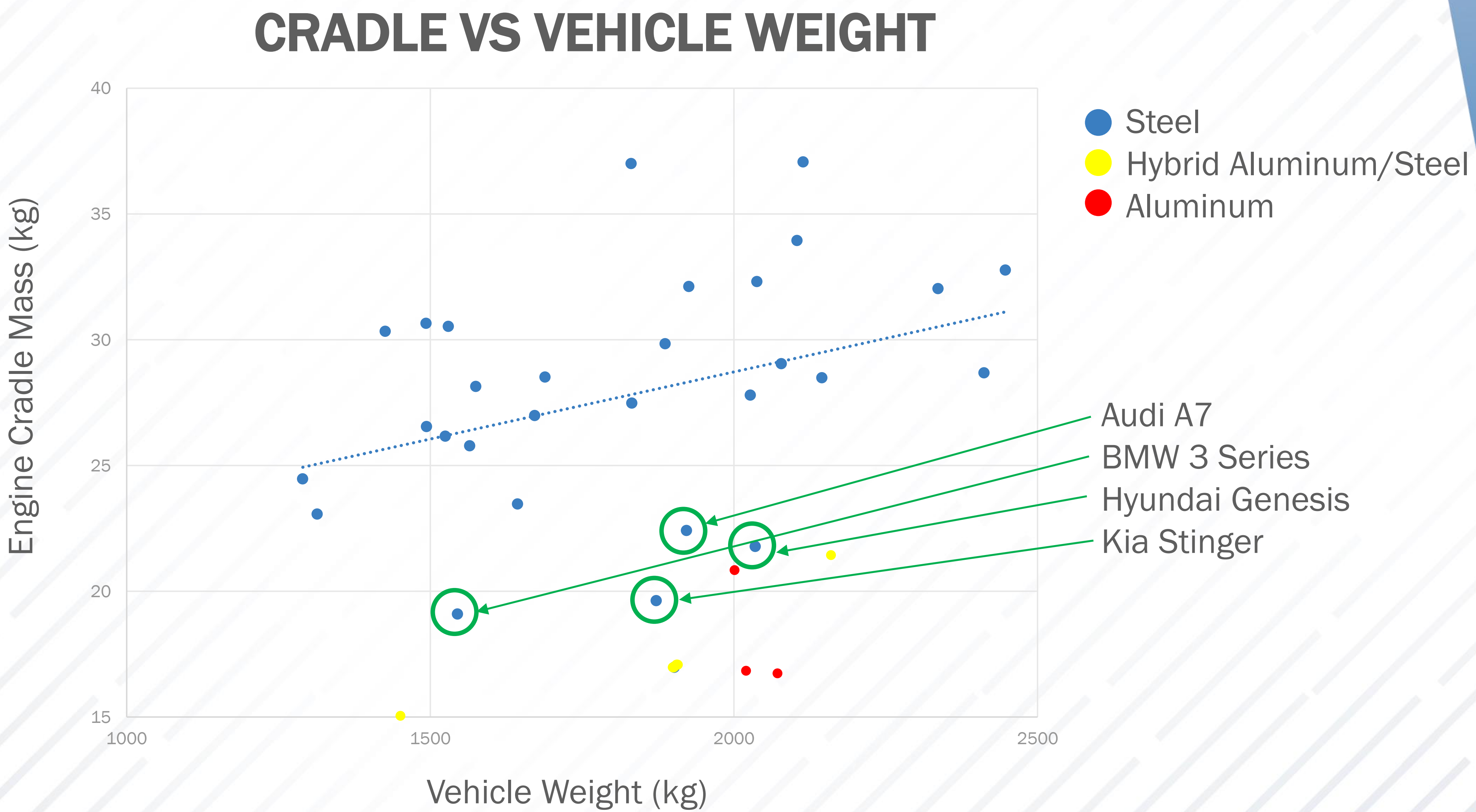


Audi Q7
Mass = 21.4 kg

Steel

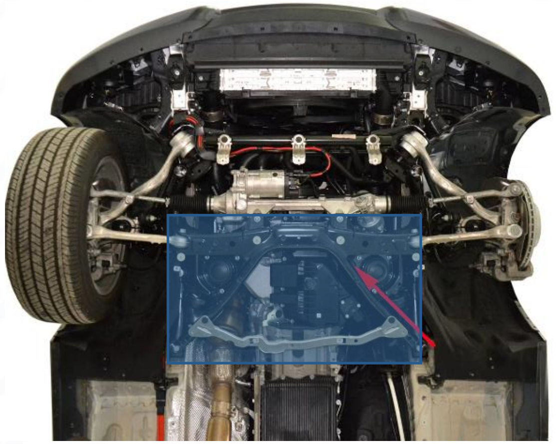
Chrysler Pacifica
Mass = 27.8 kg

ENGINE CRADLE BENCHMARKING – WEIGHTS

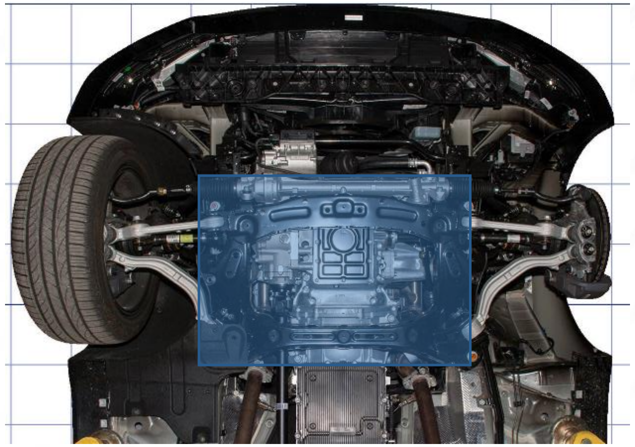


ENGINE CRADLE BENCHMARKING – NEW ‘MEDIUM’ SIZE

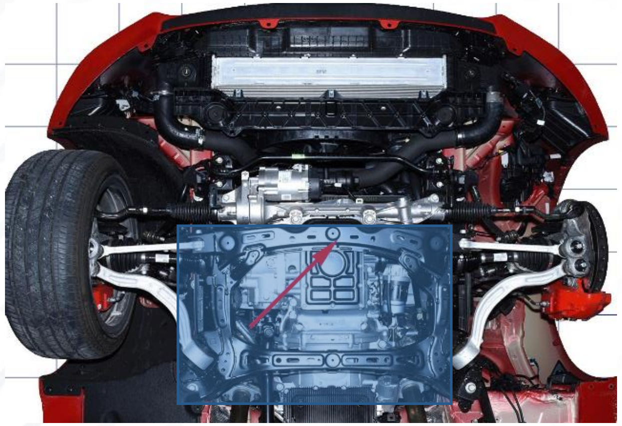
2013 BMW 3 Series



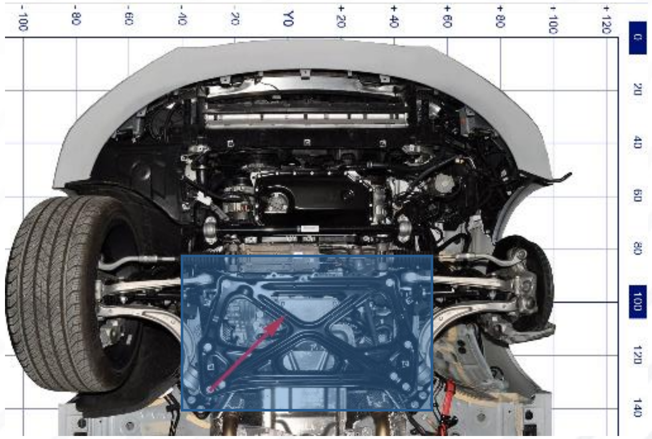
2015 Hyundai Genesis



2018 Kia Stinger



2018 Audi A7



MEDIUM SIZE ENGINE CRADLE OBSERVATIONS

Audi A7
- Large steel X-brace
- 2 hydroformed tubes

BMW 3-Series
- 6 tubes configuration
- 3 hydroformed

Hyundai/Kia
- Heavy use of lightening holes

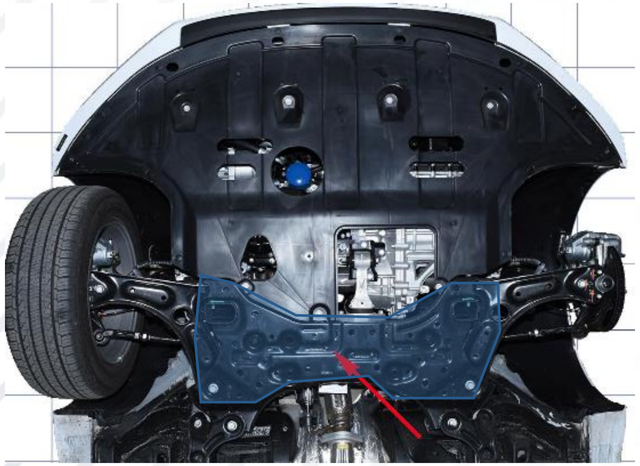
Genesis

Stinger

ENGINE CRADLE BENCHMARKING - SIZES

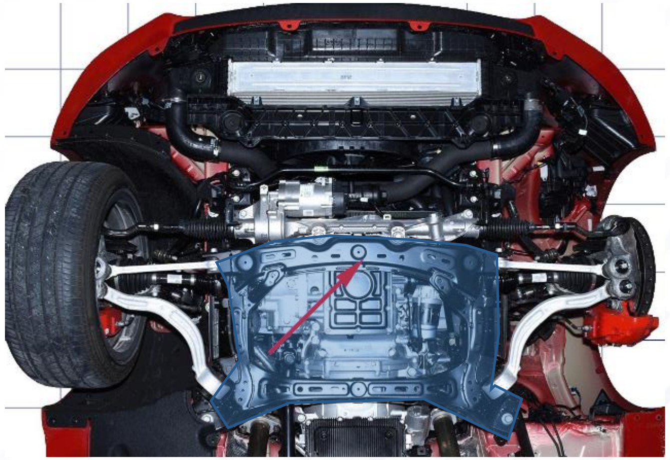
Small

Hyundai Elantra
Mass = 14.6 kg



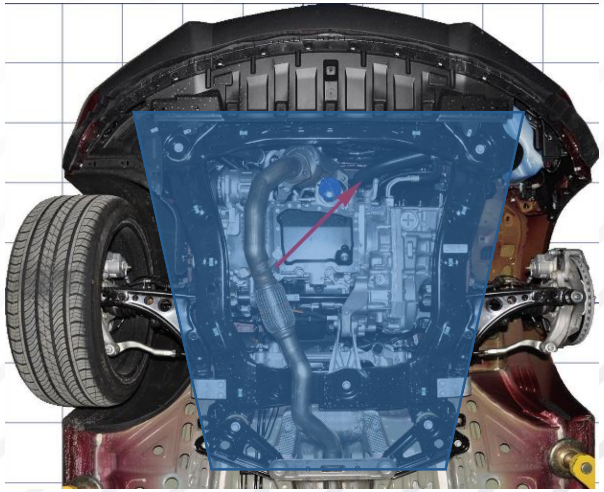
Medium

Kia Stinger
Mass = 19.6 kg

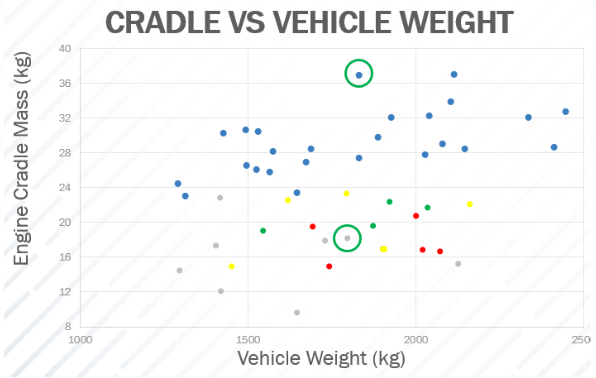


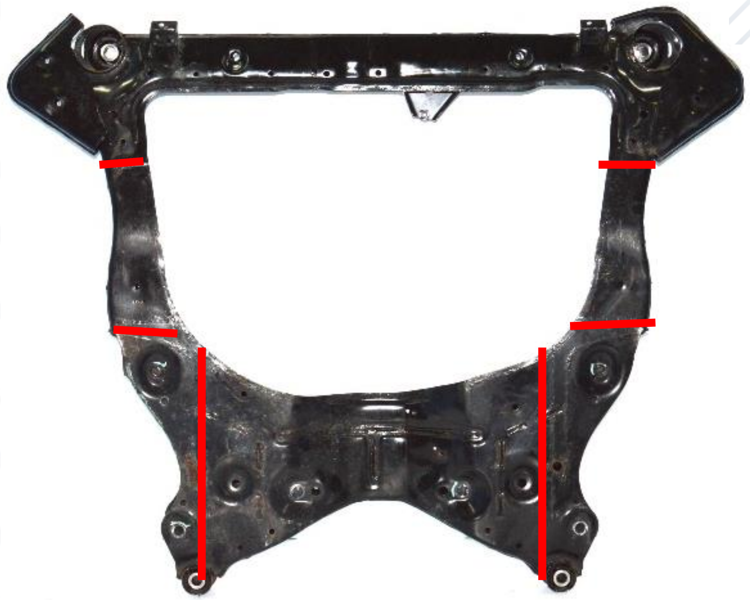
Large

Chevy Malibu
Mass = 28.5 kg



MURANO & SORENTO CRADLE COMPARISON





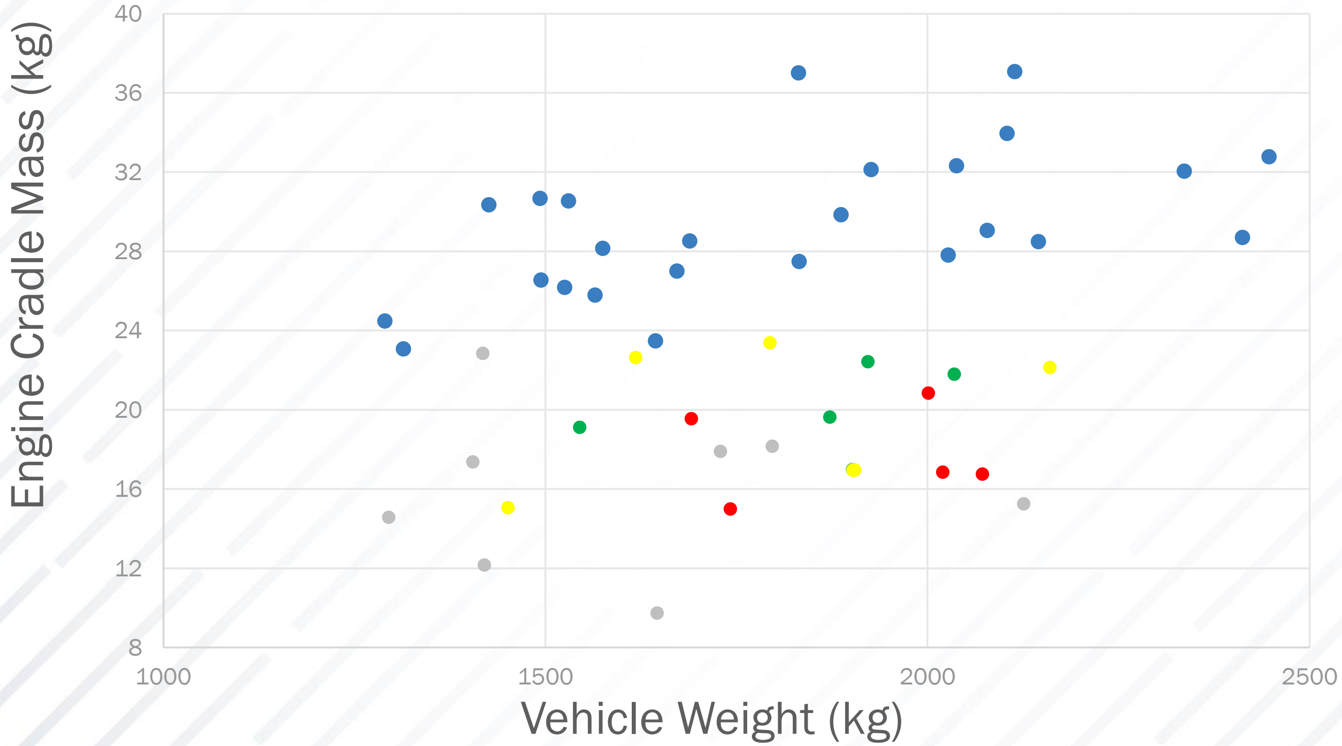
2015 Nissan Murano Large Engine Cradle
Weight: 37 kg

2017 Kia Sorento Small Engine Cradle
Weight: 18 kg

ENGINE CRADLE BENCHMARKING CONCLUSIONS

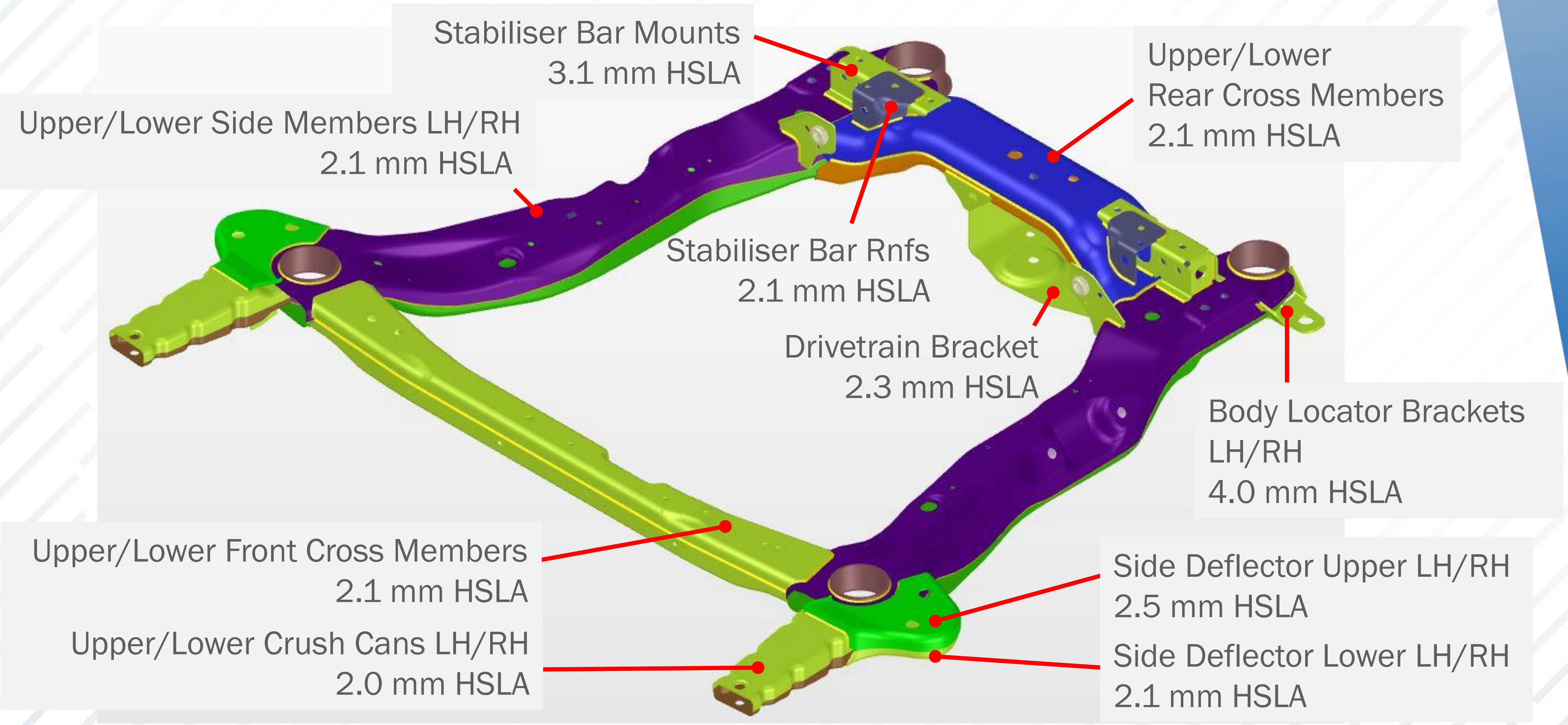
- 3 Sizes: Small, Medium and Large
- 3 Material Configurations: Steel, Aluminum and Hybrid
- Potential mass reduction enablers: Tubes, X-braces, and Lightening Holes
- Aluminum mainly used for large engine cradles

CRADLE VS VEHICLE WEIGHT



	Average Mass (kg)
Large Steel Cradles	29.4
Medium Steel Cradles	20.7
Small Steel Cradles	16.9
Hybrid Al/Steel Cradles	20.0
Large Aluminum Cradles	16.8

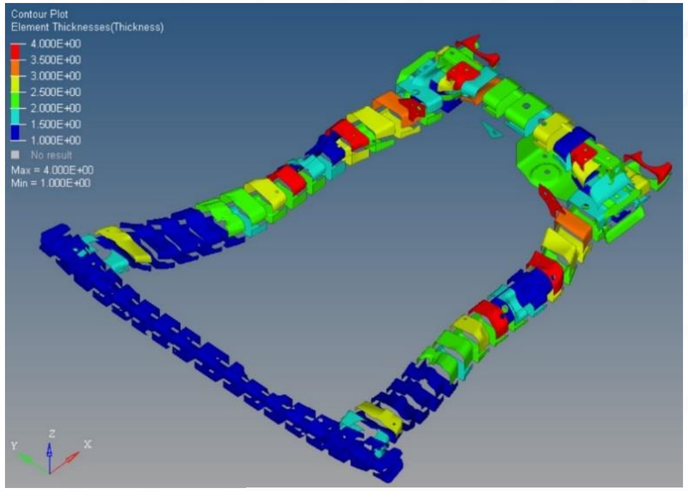
OPTIMIZED ENGINE CRADLE – BASELINE DESIGN



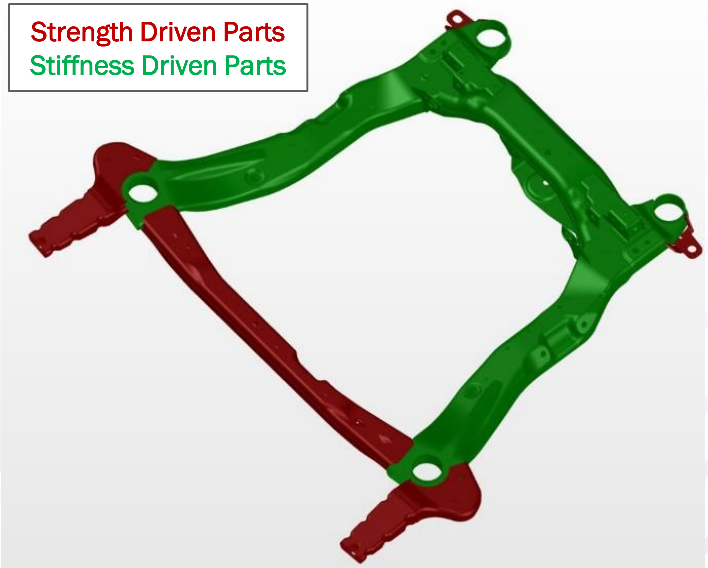
OPTIMIZED ENGINE CRADLE – IDEAS CONSIDERED

1. Lap Weld to Butt Weld

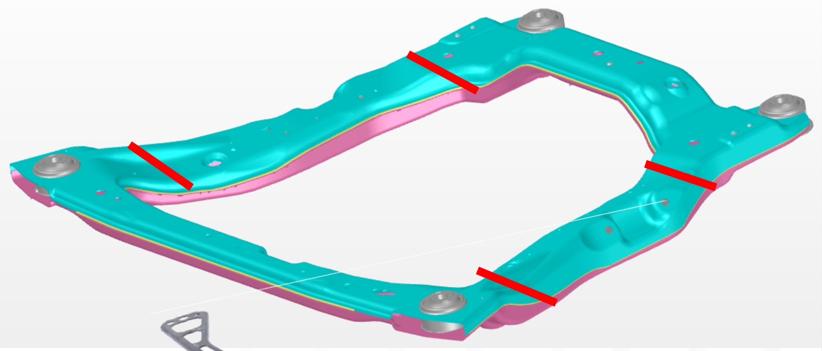
2. Gauge Optimization



3. 1180 3rd Gen for Strength Driven Parts



4. Tailored Blank Rings



5. Light Front Cross Member

OPTIMIZED ENGINE CRADLE – IDEAS NOT CONSIDERED

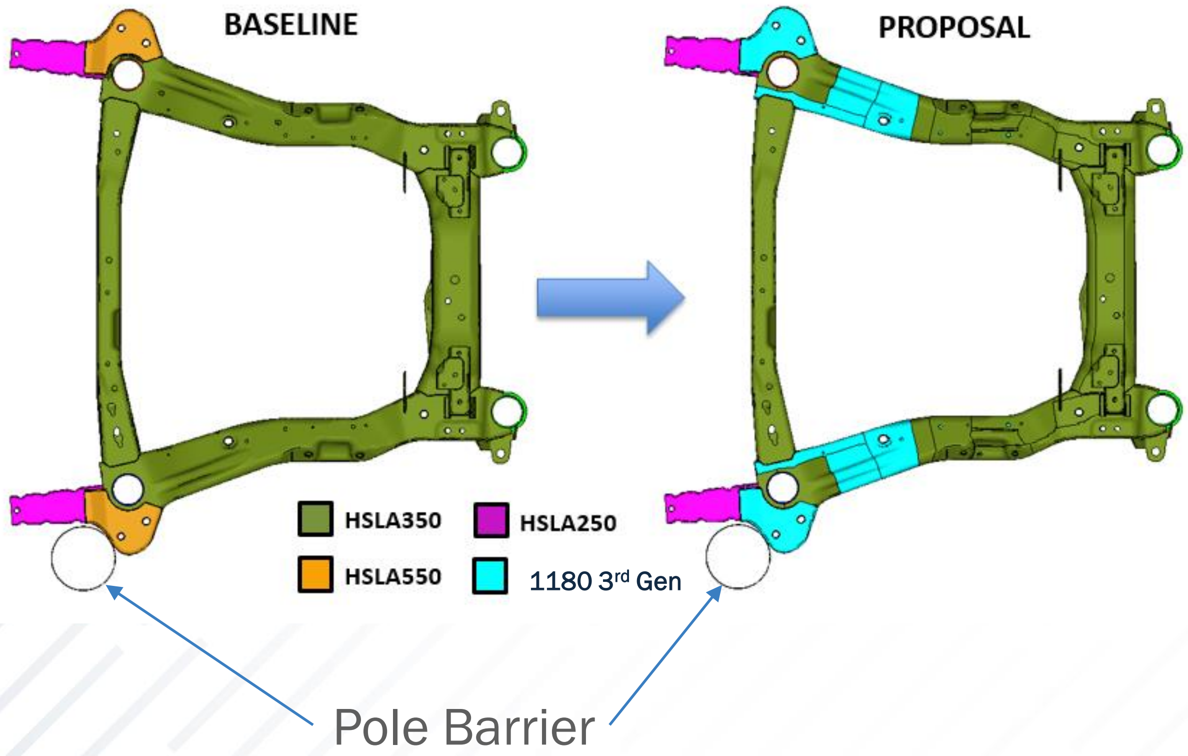
1. Lightening Holes

2. Hydroformed Tubes

3. ‘X’ Braces

OPTIMIZED ENGINE CRADLE – CAE VALIDATION

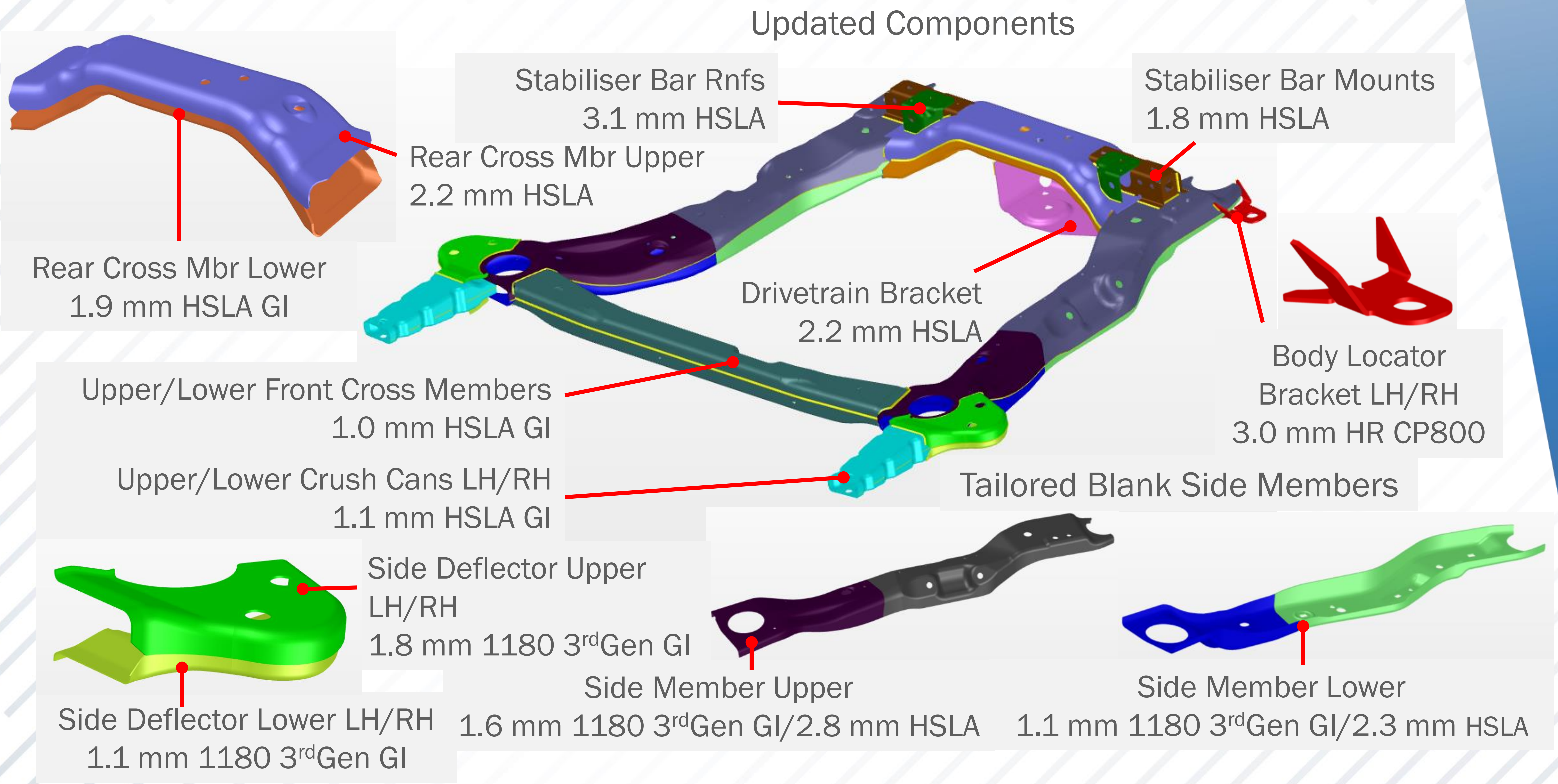
Strength



Stiffness

Load Location/Direction	Baseline Design (%)	Optimized Design Percent Improvement (%)
HandleBushLHSX	100	4.74
HandleBushLHSY	100	2.53
HandleBushLHSZ	100	1.77
HandleBushRHSX	100	4.83
HandleBushRHSY	100	2.26
HandleBushRHSZ	100	2.01
RideBushLHSX	100	9.04
RideBushLHSY	100	12.65
RideBushLHSZ	100	16.87
RideBushRHSX	100	9.22
RideBushRHSY	100	11.63
RideBushRHSZ	100	15.91
TieRodLHSX	100	43.87
TieRodLHSY	100	10.39
TieRodLHSZ	100	11.76
TieRodRHSX	100	42.95
TieRodRHSY	100	10.39
TieRodRHSZ	100	10.79
StabBarLHSX	100	9.20
StabBarLHSY	100	2.36
StabBarLHSZ	100	15.85
StabBarRHSX	100	9.41
StabBarRHSY	100	2.67
StabBarRHSZ	100	15.61
RrPendulumX	100	3.58
RrPendulumY	100	7.22
RrPendulumZ	100	4.25

OPTIMIZED ENGINE CRADLE – FINAL DESIGN



OPTIMIZED ENGINE CRADLE – EBOM MASS COMPARISON

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Component	Mass (kg)	Opt Mass (kg)	Mass Save (kg)	Part Count
Engine Cradle Assembly	25.33	21.52	3.81	43
Side Rail Upper (lh/rh)	5.50	6.04	-0.54	2
Side Rail Lower (lh/rh)	4.94	4.25	0.69	2
Rear Cross Member Upper	1.52	1.58	-0.06	1
Rear Cross Member Lower	1.44	1.30	0.14	1
Front Cross Member Upper	1.70	0.81	0.89	1
Front Cross Member Lower	1.52	0.72	0.80	1
Stab Bar Mounts (lh/rh)	0.86	0.50	0.36	2
Stab Bar Reinforcements (lh/rh)	0.22	0.31	-0.09	2
Drive Train Bracket	1.02	0.98	0.05	1
Triangle Bracket	0.03	0.03	0.00	1
Side Deflector Upper (lh/rh)	0.82	0.57	0.25	2
Side Deflector Lower (lh/rh)	0.60	0.32	0.28	2
Upper Crush Can (lh/rh)	0.84	0.46	0.38	2
Lower Crush Can (lh/rh)	0.80	0.44	0.36	2
Steering Brackets (lh/rh)	0.16	0.21	-0.05	2
Body Mount Sleeves (4)	1.04	1.04	0.00	4
Side Rail Inside Bracket (lh/rh)	0.52	0.25	0.27	2
Rear Body Locator Brackets (lh/rh)	0.30	0.22	0.08	2
LCA Front Threaded Spacers	0.32	0.32	0.00	4
LCA Rear Sleeves (lh/rh)	0.40	0.40	0.00	2
Front Cross Member Sleeve	0.07	0.07	0.00	1
Stabilizer Bar Sleeves	0.16	0.16	0.00	2
Welded Steering Bracket Nuts	0.04	0.04	0.00	2
Weld Material	0.51	0.51	0.00	

OPTIMIZED ENGINE CRADLE – MASS/COST COMPARISON

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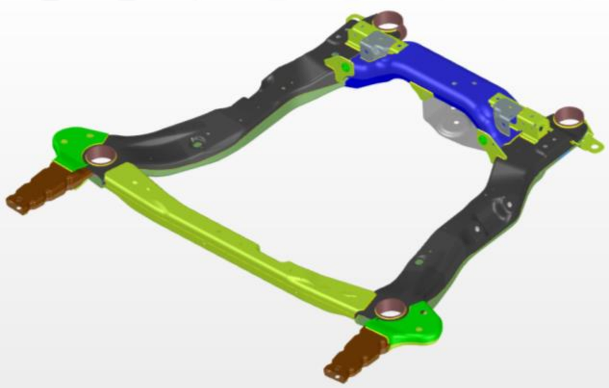
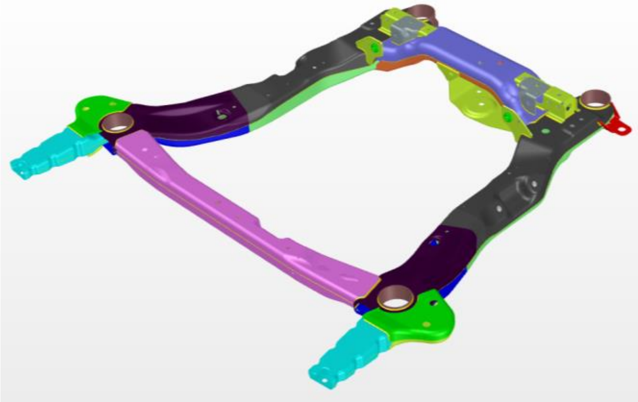
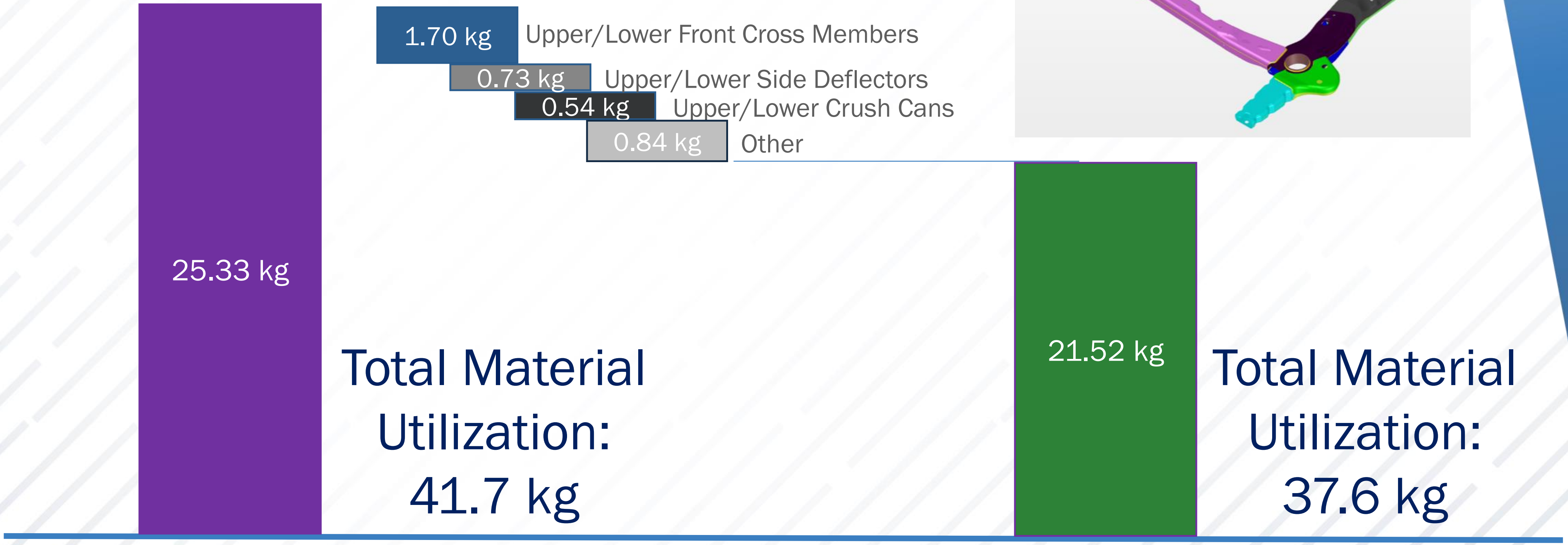
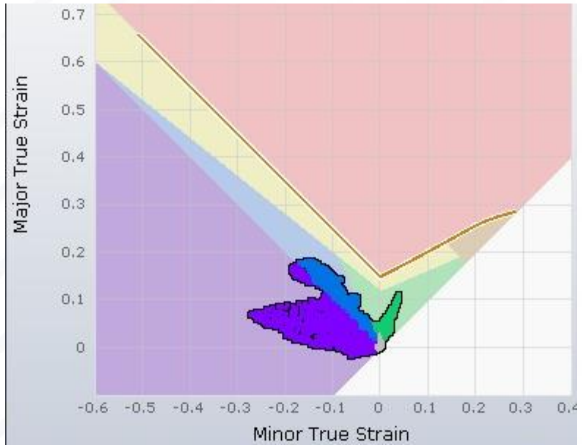


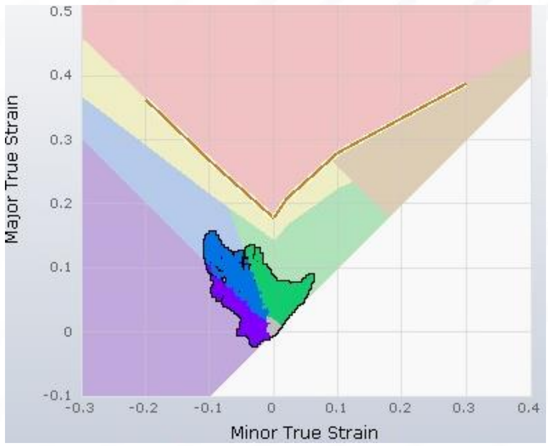
Mass Savings: 15%
Estimated Cost Increase: 11.3%
Cost/kg Saved: $3.36

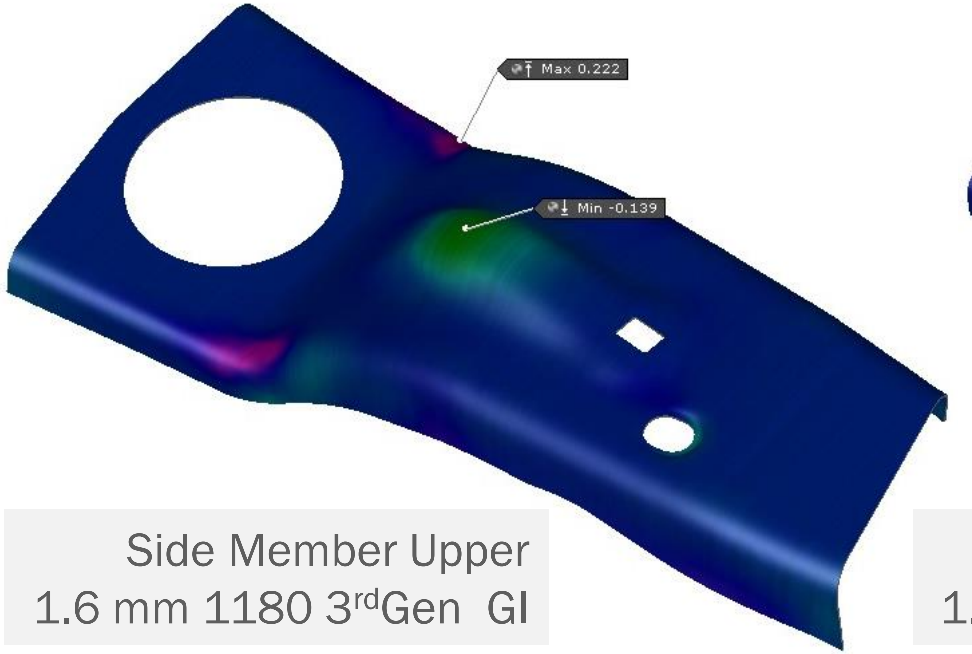




1180 3RDGEN SIDE MEMBERS MANUFACTURING







Side Member Upper
1.6 mm 1180 3rdGen GI

Side Member Lower
1.1 mm 1180 3rdGen GI

SUMMARY / CONCLUSIONS

1) Benchmarking Study Recap
2) An optimized Engine Cradle was developed with a 15% mass savings versus the baseline design meeting the same packaging requirements
3) Most of this mass savings was achieved with gauge optimization and 1180 3rd Gen application for Side Deflectors and tailored blank Side Members
4) The optimized steel cradle in this study was estimated to have an 11.3% cost premium over the baseline design due to additional material cost and the addition of 4 tailored blanks. This translates to $3.36 / kg saved.
5) Next Steps: Prototype Cradle Assemblies & Corrosion Testing
6) Come to Martinrea for 'Great Designs in Steel'!!!

FOR MORE INFORMATION

Thank You!

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