T3: Low Fidelity 3G (Geometry, Grade & Gauge) Optimization

- Objective
- LF3G: An integrated Optimization Process
- LF3G Optimization Model
- LF3G Optimization Parameterization
- Material and Gauge Choices
- LF3G Targets
- LF3G Optimization Results
- LF3G Battery Optimization
- Conclusion

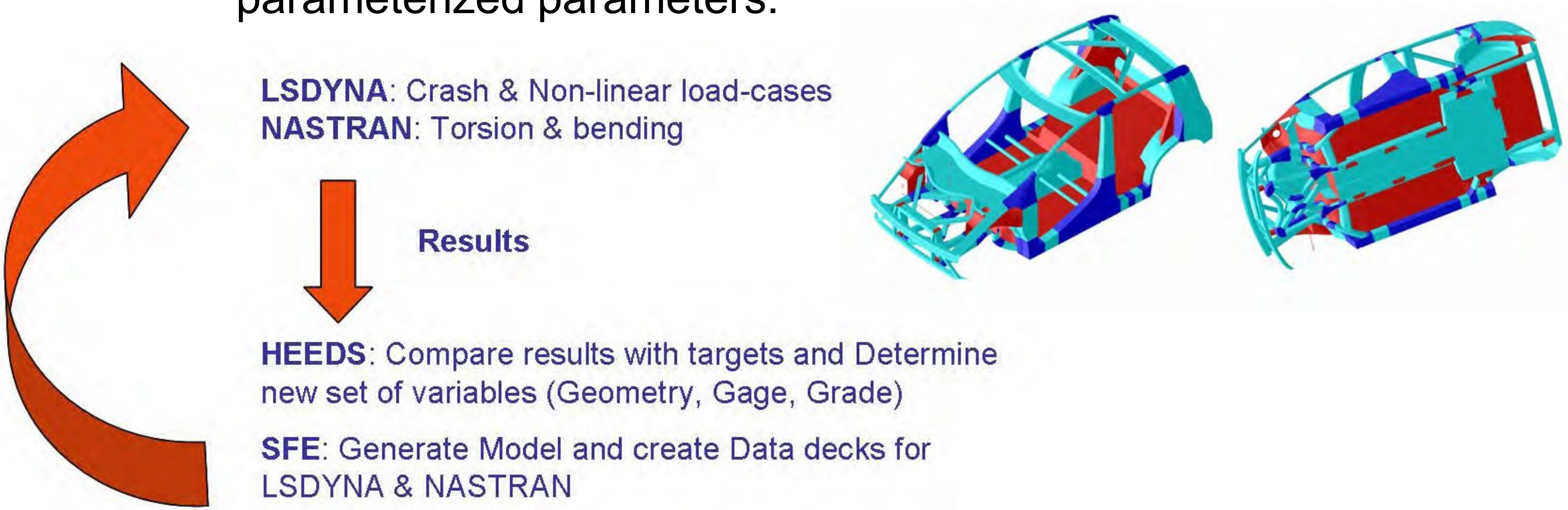
Objective

- Initial topology optimization: linear static analysis
- LF3G optimization: non-linear dynamic model

- Define the optimal position of the structure’s major loadpaths
- Define the approximate size and general cross-section, grade and gauge of the structure along the loadpath
- Create a robust set of boundary conditions for the next phase of sub-system loadpath optimization

LF3G: An integrated Optimization Process

- parameterized CAD model using SFE software
  - based on various design inputs and a comprehension of the styling and packaging constraints
  - size, shape, and/or position of various parts of the dominant load paths, such as the B-pillar and rocker
  - outputting finite element models for any combination of parameterized parameters.



LF3G Optimization Parameterization

- allow position and shape to be modified by the optimization
- all ranges of movement in the parameterization conformed to the allowable structural packaging space
  - B-Pillar
  - Front Bumper Beam
  - Radiator Support to Shock Tower Beam
  - Shotgun
  - Instrument Panel Beam
  - Front Longitudinal above Tunnel
  - Front Cross-Bar
  - Side Roof Rail
  - Roof Bow and Headers
  - Rear Cargo Area Cross Bar
  - Front Seat Crossmember
  - Rocker
  - C-Pillar
  - Rear Longitudinal Rail
  - Bulkheads

Material and Gauge Choices (1)

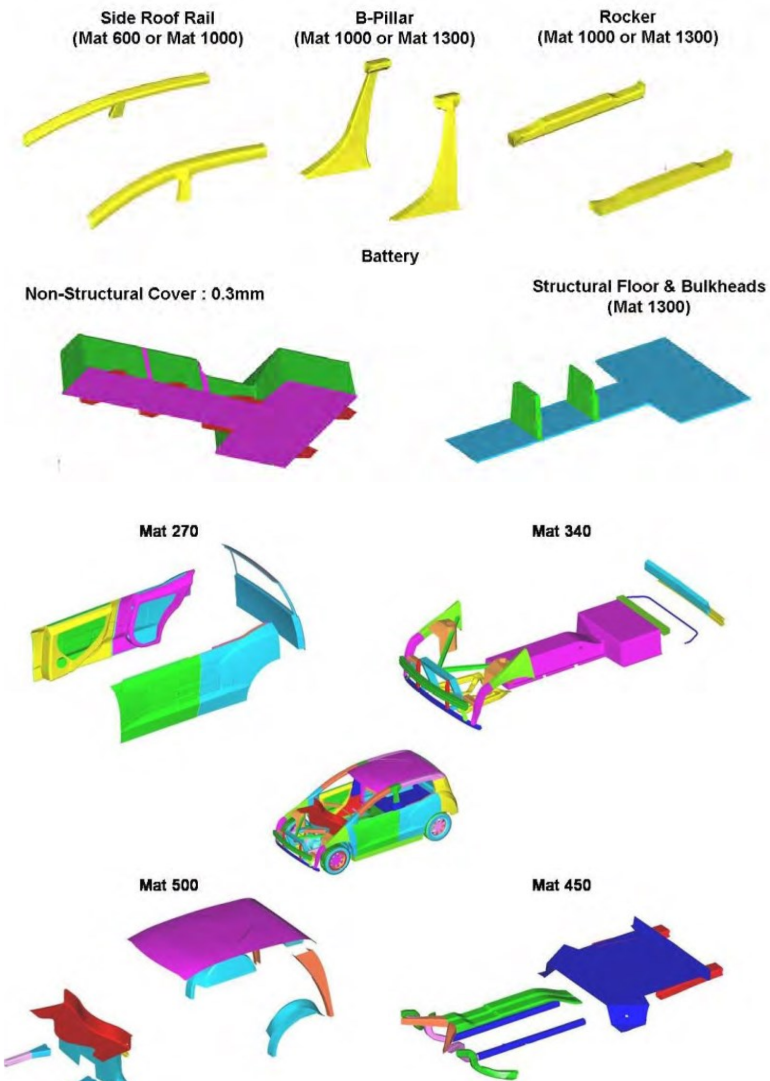
– Grades: intended strength levels only
  - Performance: same with two or more grades with the same tensile strength
  - Manufacturing capability: different between the grades
– minimum and maximum gauges: range of commercially available thicknesses for each steel grade
– Load path study: six critical components with the widest range

MATERIAL	GAUGE MIN (mm)	GAUGE MAX (mm)
Mat 270	0.50	4.60
Mat 340	0.50	3.40
Mat 450	0.50	2.30
Mat 500	0.50	5.00
Mat 600	0.60	2.30
Mat 800	0.60	2.30
Mat 1000	0.60	2.30
Mat 1300	0.60	2.00
Mat 1500	0.42	2.92

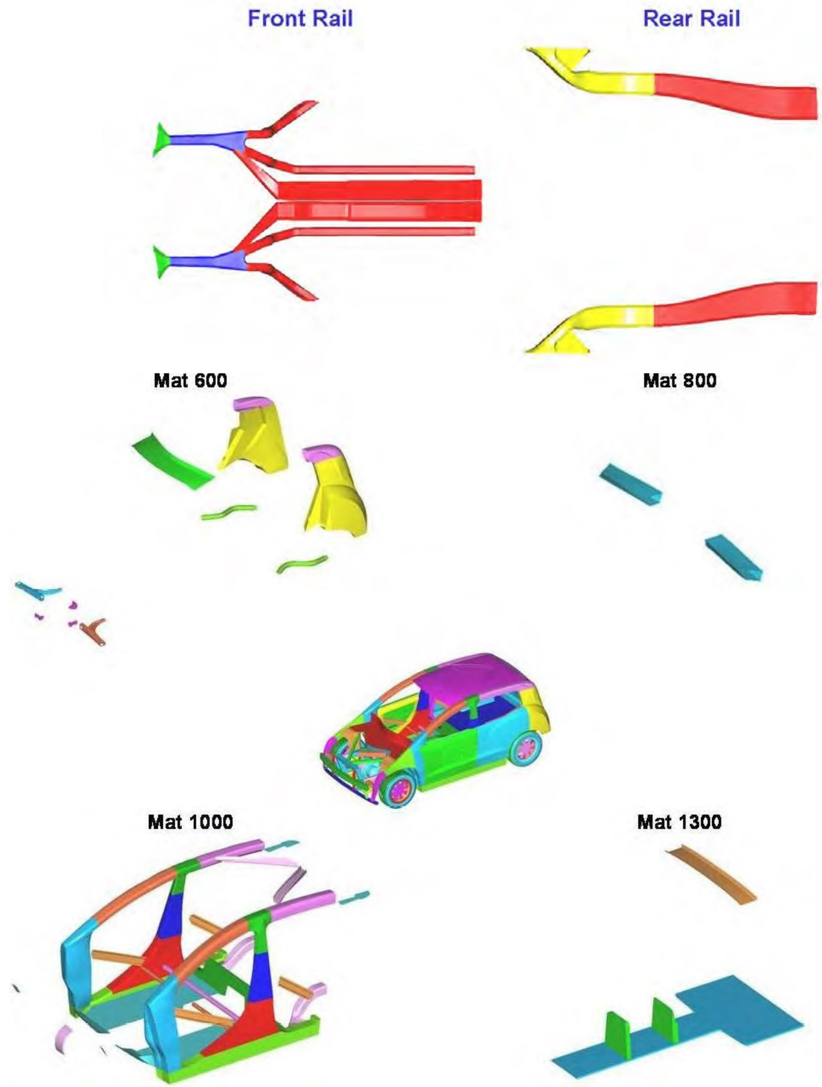
COMPONENT	POSITION	MATERIAL	GAUGE RANGE
Front Rail	Outboard	Mat 340 or Mat 500	1.5 to 2.5mm
	Mid	Mat 450 or Mat 500	
	Inboard	Mat 450 or Mat 600	
Rear Rail	Outboard	Mat 450 or Mat 600	1.5 to 3.0mm
	Inboard	Mat 1000	
Side Roof Rail	N/A	Mat 600 or Mat 1000	0.8 to 1.2mm
B-Pillar	N/A	Mat 1000 or Mat 1300	0.8 to 1.2mm
Rocker	N/A	Mat 1000 or Mat 1300	0.8 to 1.6mm
Battery	N/A	Mat 1300	2.0 to 3.0mm

Material and Gauge Choices (2)

Only one material/thickness combination each model



multiple zones for material and gauge variation



materials based on the results of the calibration study

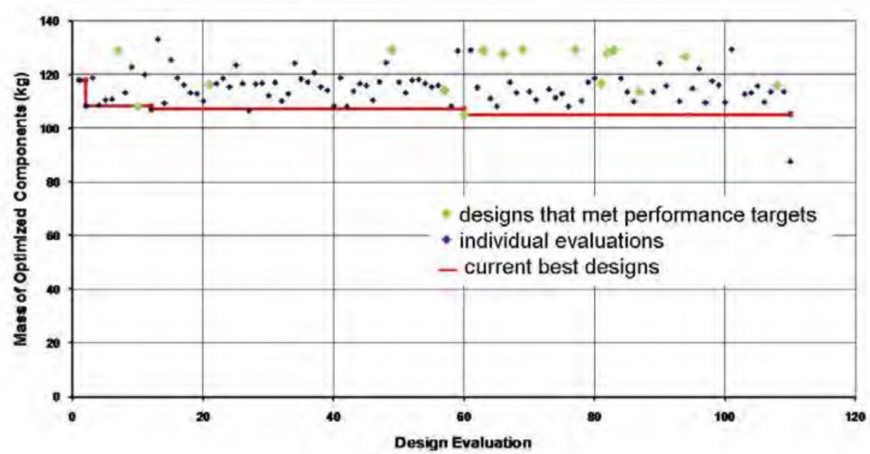
LF3G Targets & Optimization Results (1)

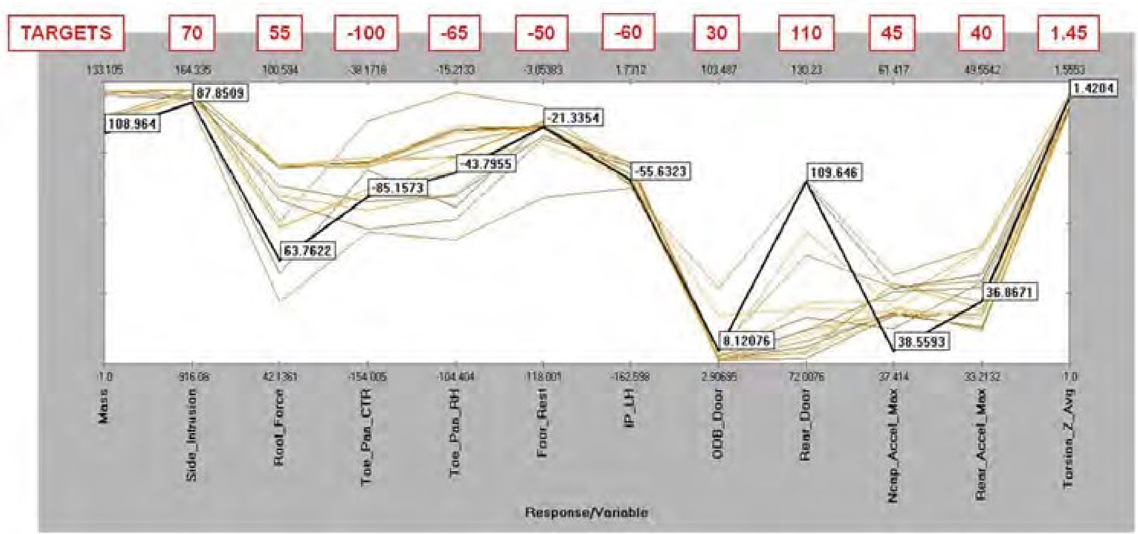
- 6 load cases
- static bending and pole impact
  - 80~90% satisfied if met, easily achieved by adding local reinforcements without the need of adding much mass

LOADCASE	TARGET	PERFORMANCE
NCAP Frontal Impact	45g Peak Acceleration	38.6g Peak Acceleration
IIHS Front Crash 40% ODB	GOOD Rating	GOOD Rating
FMVSS 301 Rear 70% ODB	40g Peak B-Pillar Good Rear Door Openability	36.9g Peak B-Pillar Acceleration
IIHS Side Impact	GOOD Rating	GOOD Rating
FMVSS 216 Roof Crush (with IIHS 4*strength to weight ratio)	55 kN (4.0 x Curb Weight)	58.2 kN
Torsional Static Stiffness	18,082 Nm/deg	18,459 Nm/deg

LF3G Targets & Optimization Results (2)

– Parametrized model + variable range + performance targets
  - Total 110 designs, 17 feasible designs

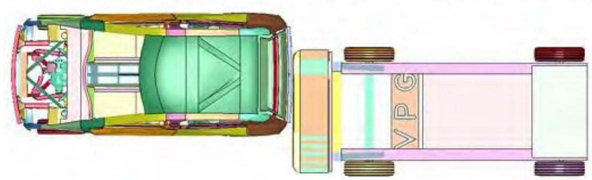




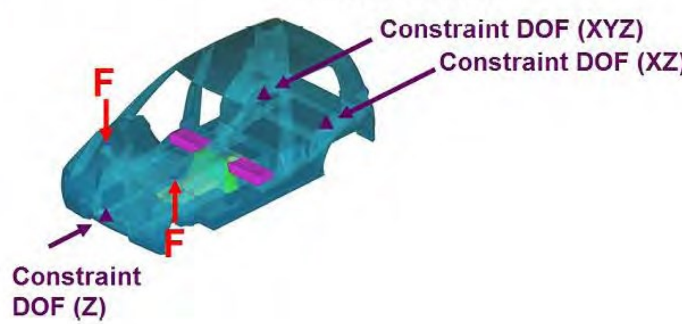
LF3G Battery Optimization

– All previous optimization was based on use of a T-Shaped battery
– Identify the most mass efficient shape for the FSV vehicle battery, as well as the most robust rear load path
– Two configuration: original T-Shaped and newly revised I-Shaped
– gauge only optimization
– two load cases most affected by rear longitudinal design

Rear 70% Impact ODB (Offset Deformable Barrier)

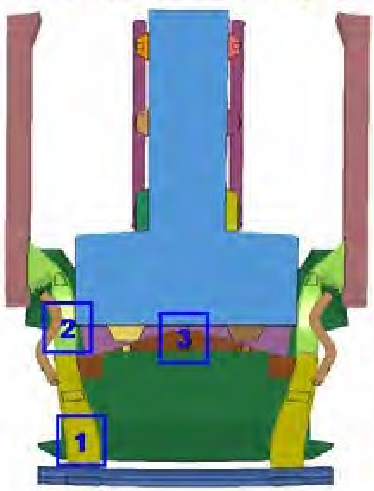


Static Torsion



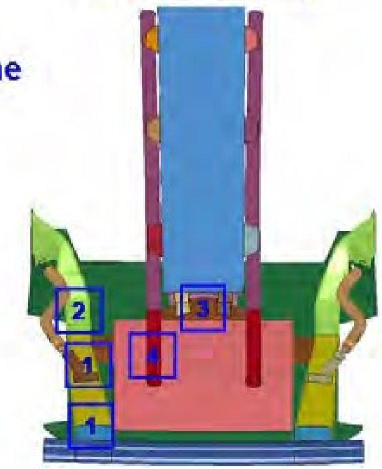
Optimization Results

T-Shaped Battery



Door Open ability Crush Distance
Measured at Top & Middle of Door Frame

I-Shaped Battery

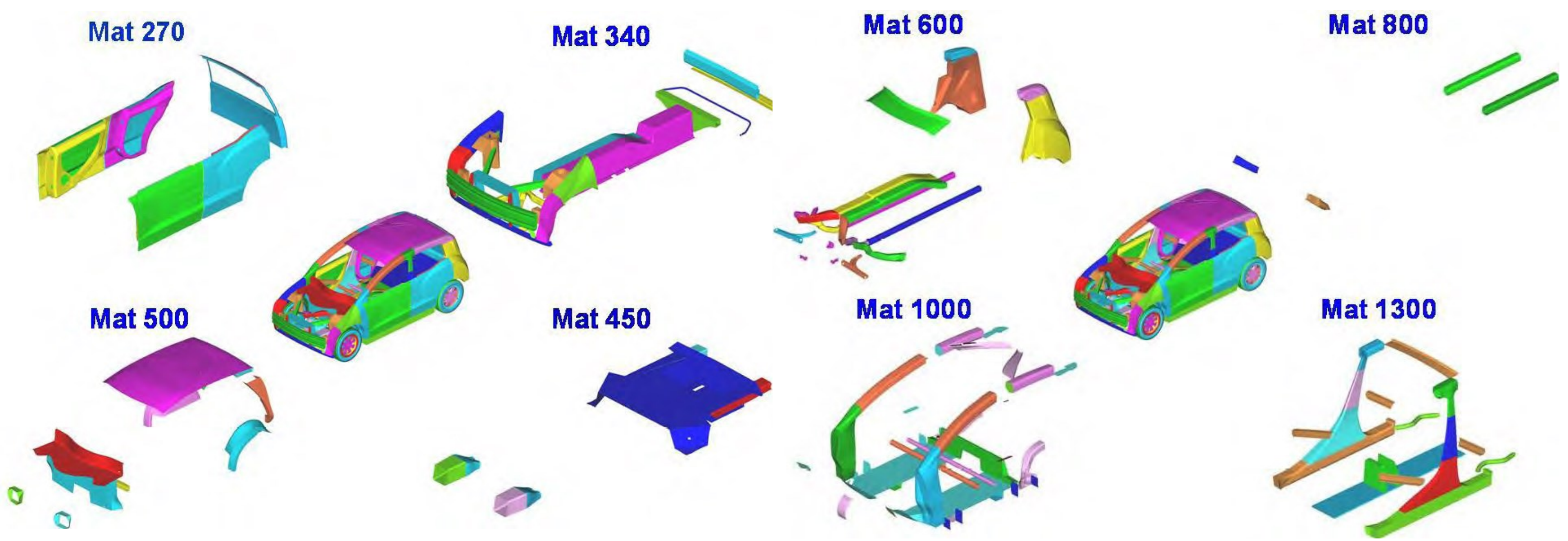


ITEM	GAUGES		MATERIAL	MASS OF OPTIMIZED PARTS		REAR IMPACT PEAK ACCELERATION		DOOR OPENABILITY		TORSIONAL STIFFNESS	
	T-SHAPED	I-SHAPED		T	I	T	I	T	I	T	I
1	1.7mm	2.2mm	Mat 450	89kg	96kg	34G	34G	108mm	99mm	1.44mm	1.44mm
2	1.6mm	2.1mm	Mat 1000								
3	1.2mm	1.2mm	Mat 450								
4		1.1mm	Mat 800								

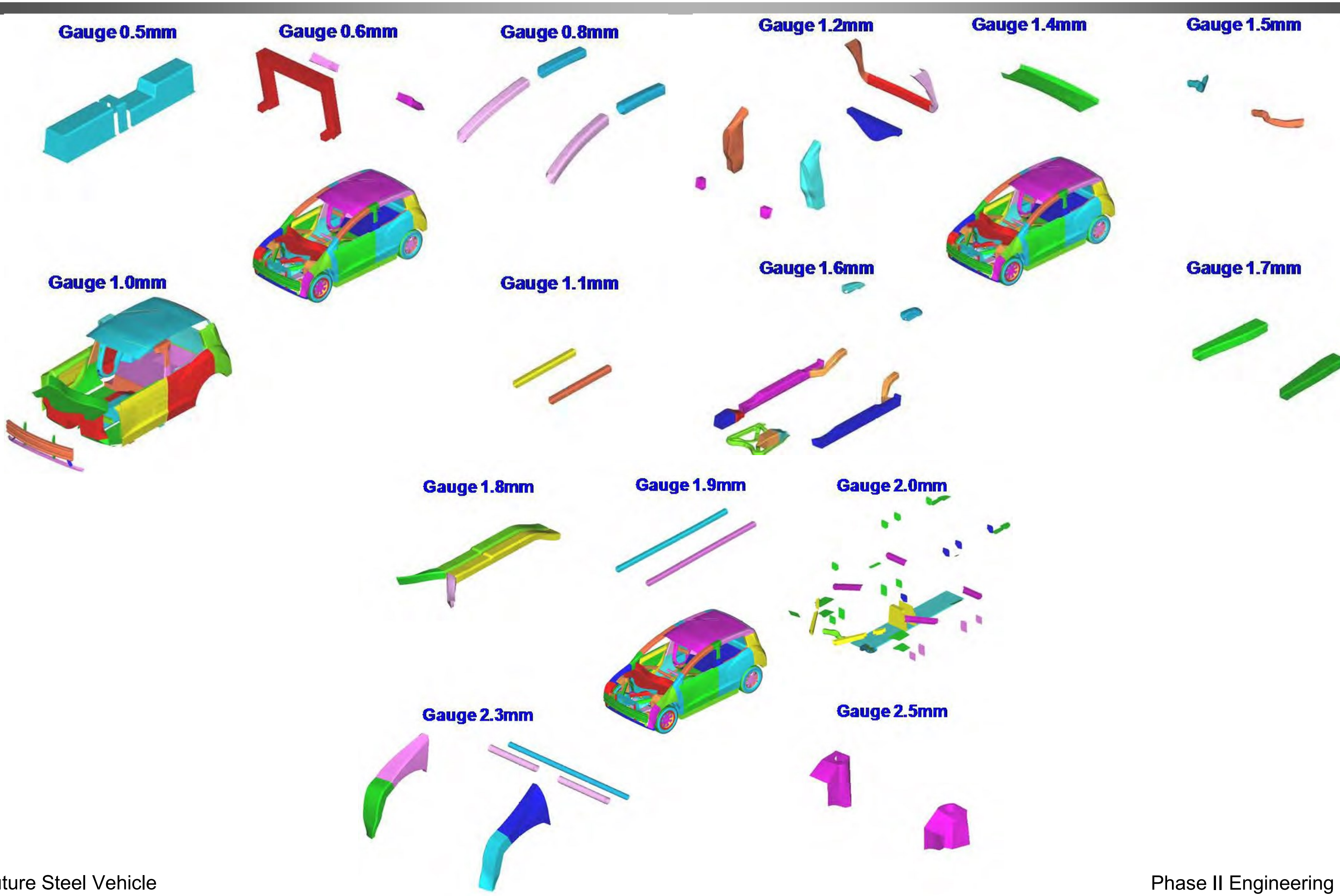
COMPONENT	T-SHAPE	I-SHAPE
Optimized BIW Components	89 kg	96 kg (+8%)
Battery* (Structural Floor Only)	34 kg	22 kg (-35%)
TOTAL FUNCTIONAL MASS	**123 kg**	**118 kg (-4%)**

** Does not include mass of battery cells or cover*

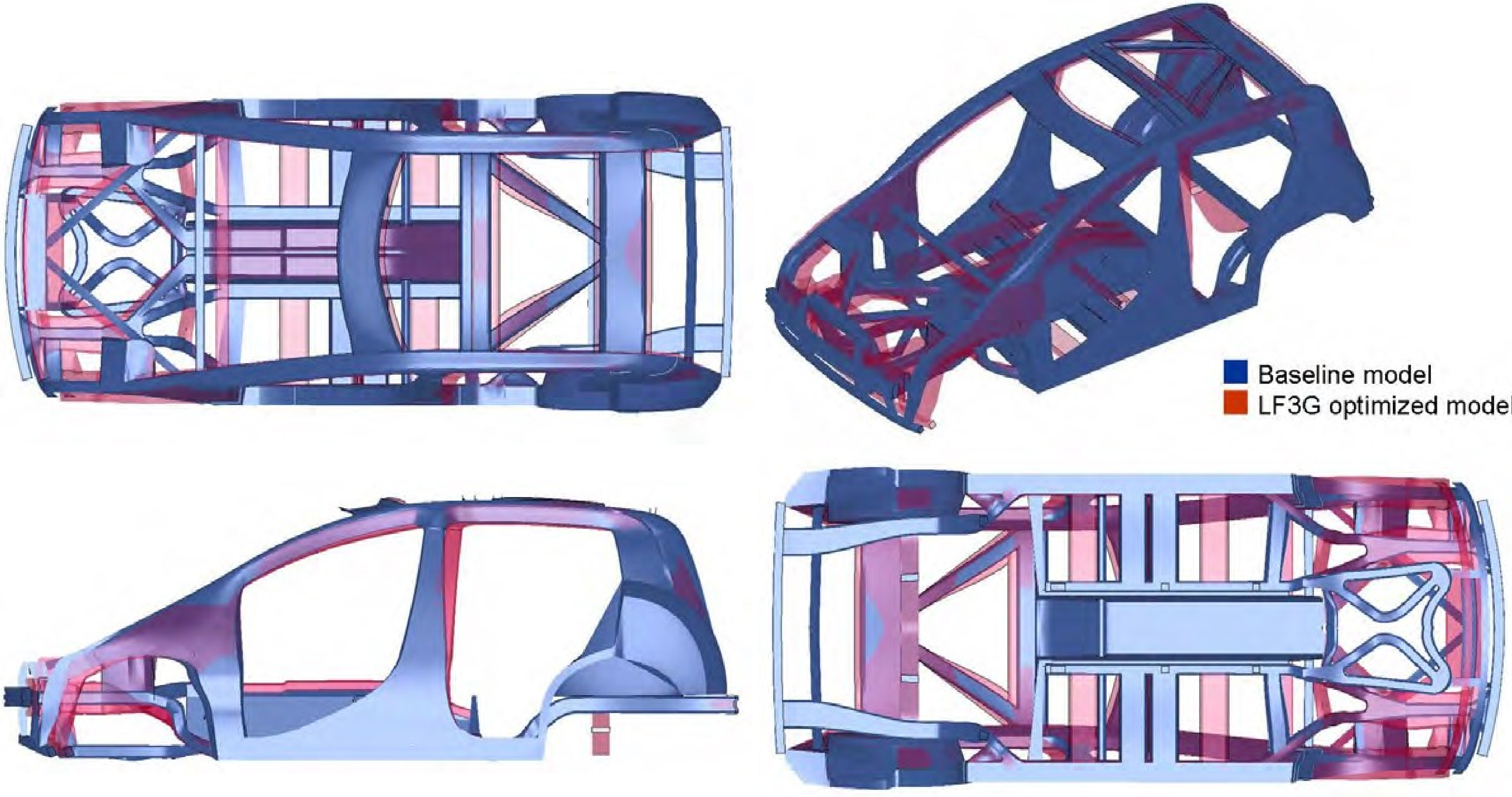
Conclusion: Grade



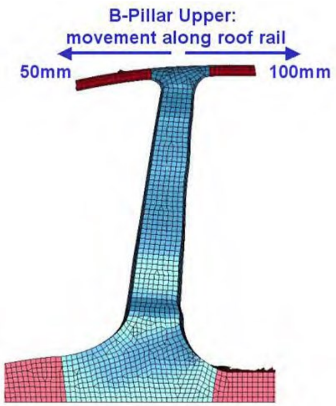
Conclusion: Gauge

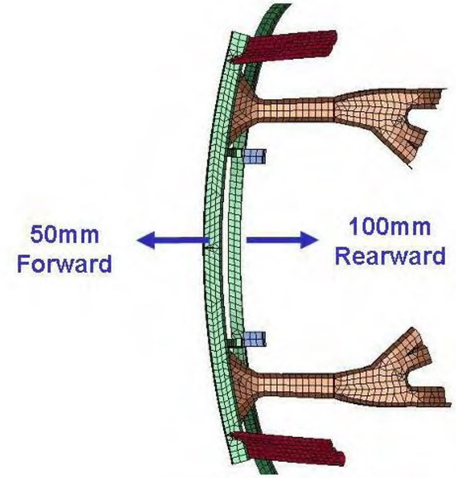


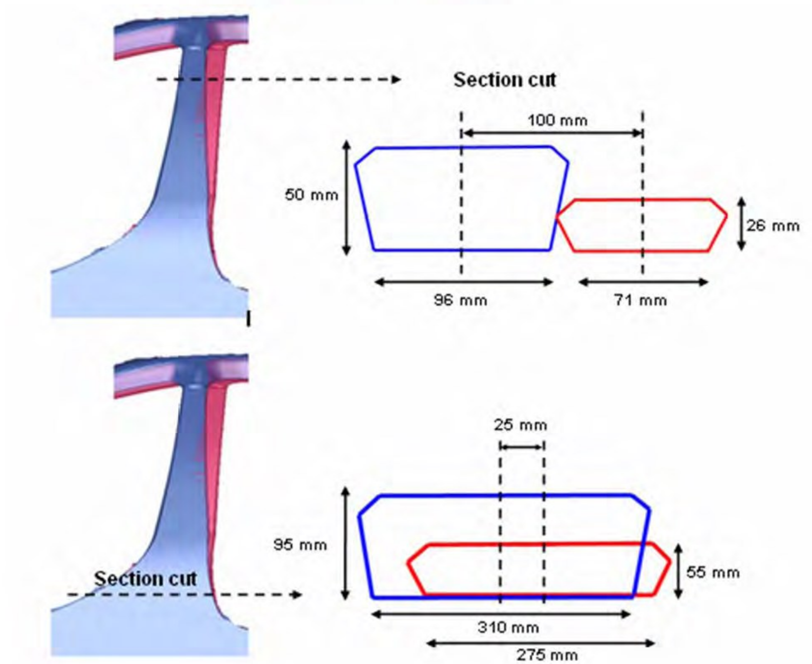
Conclusion: Geometry (shape)

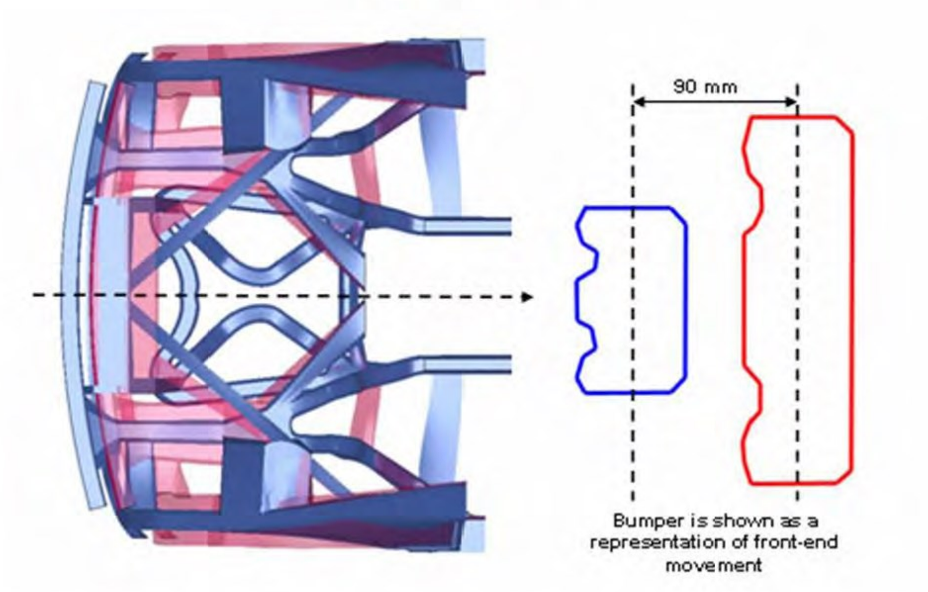


B-pillar / Front end

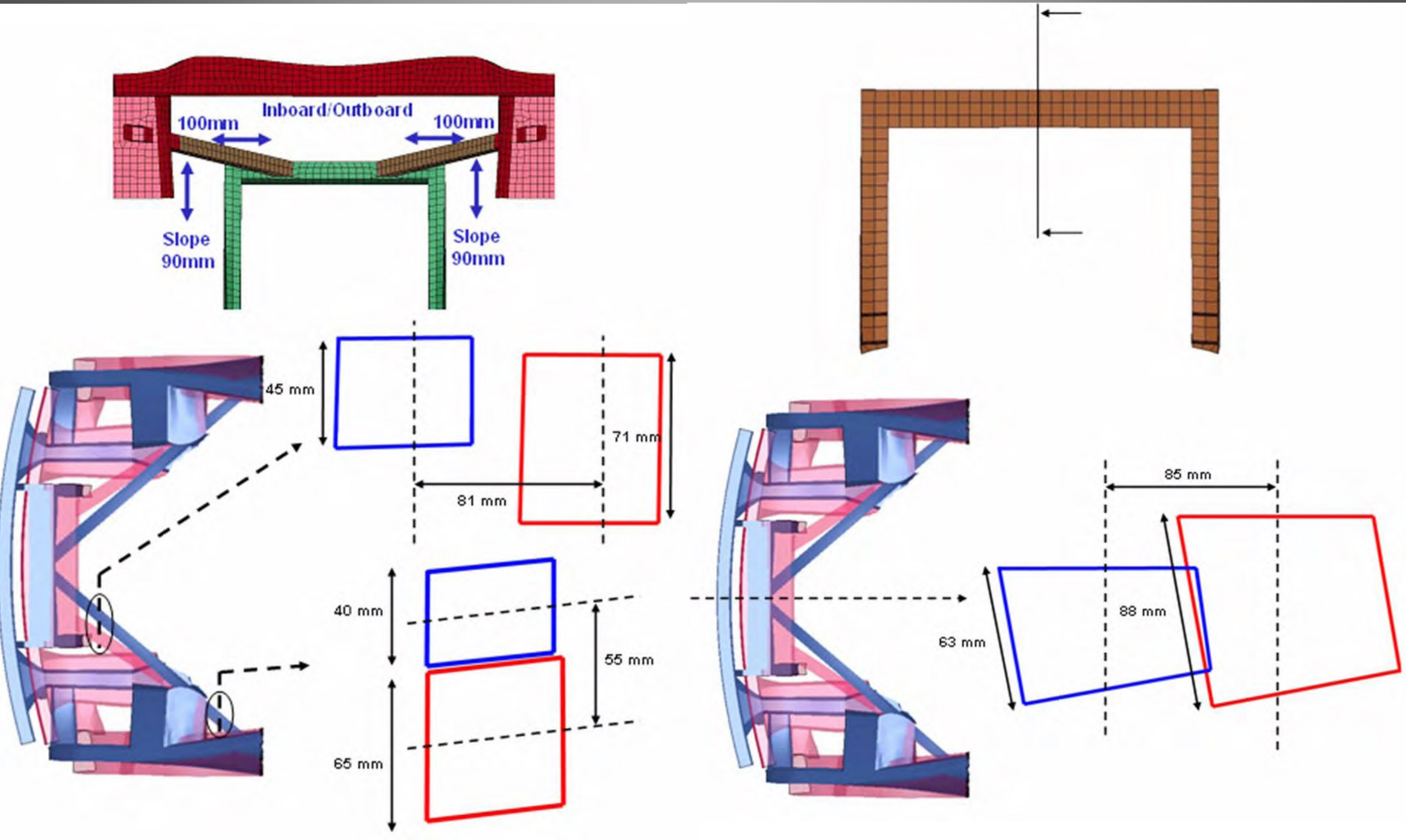




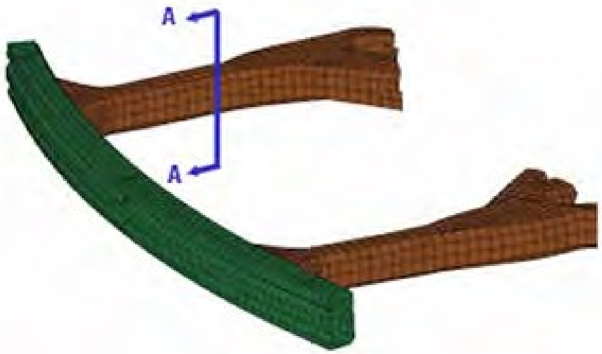


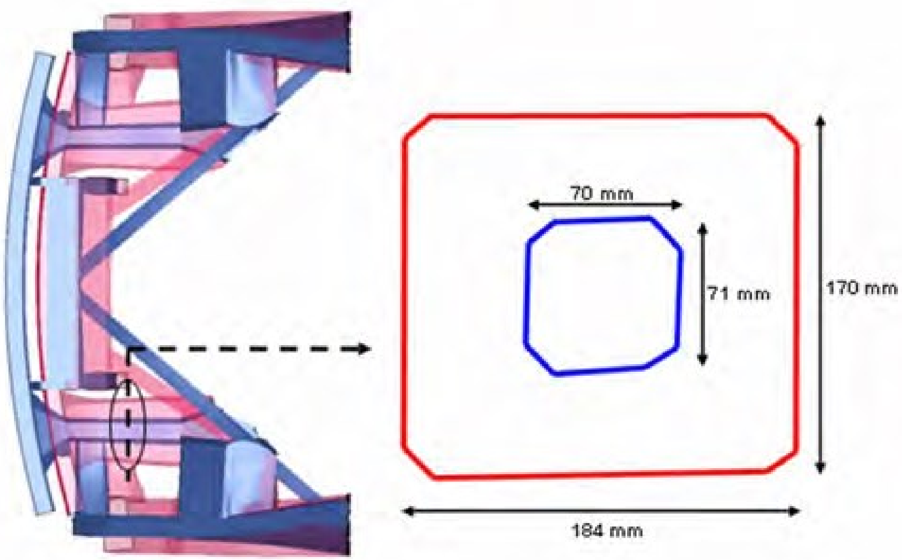


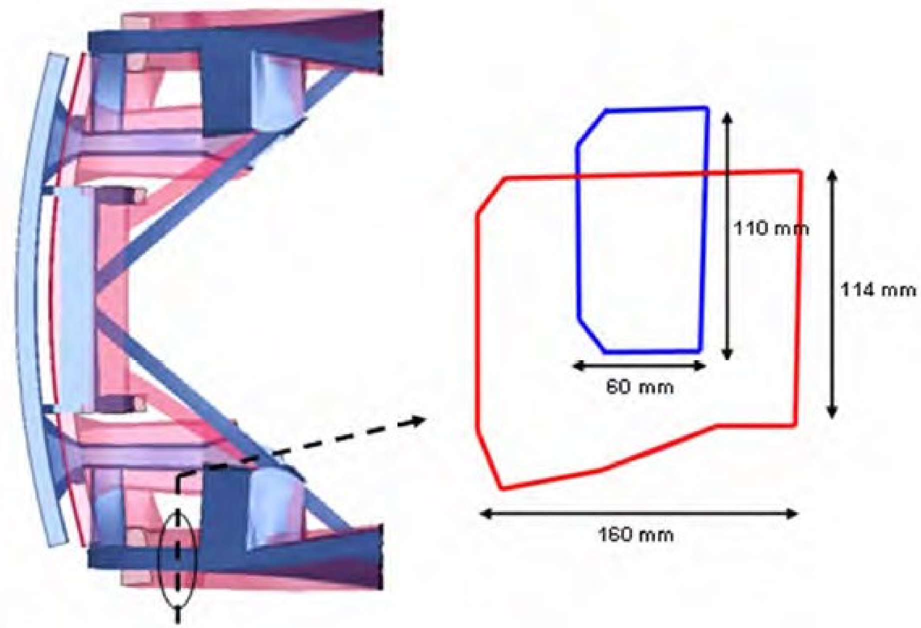
Radiator support



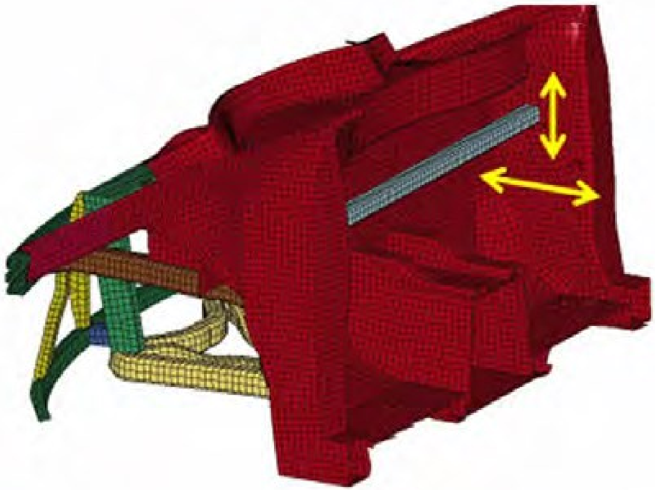
Front rail / Shotgun

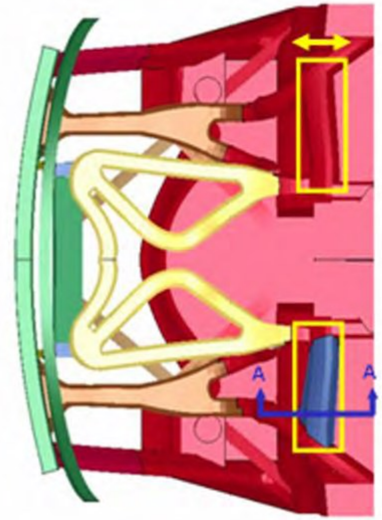


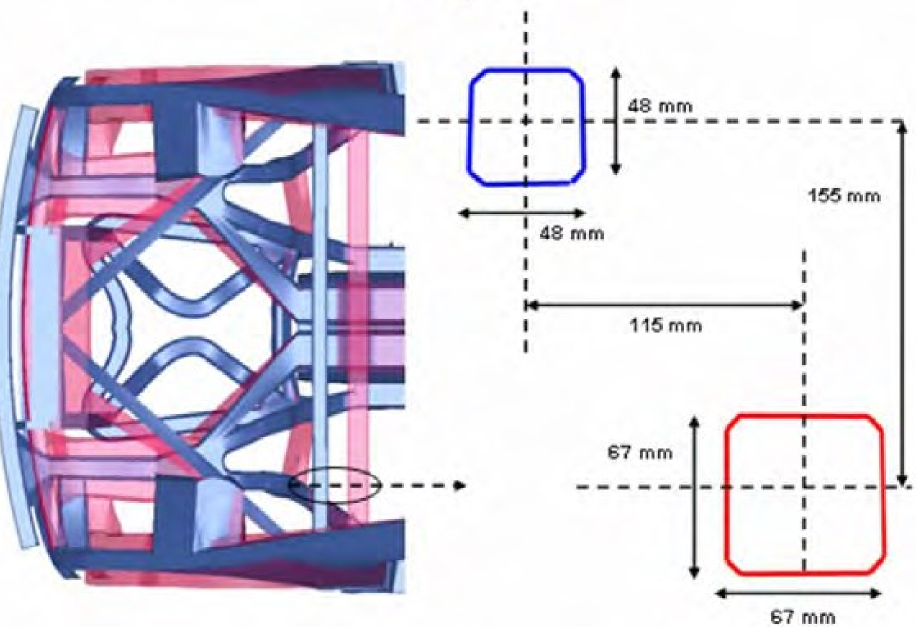


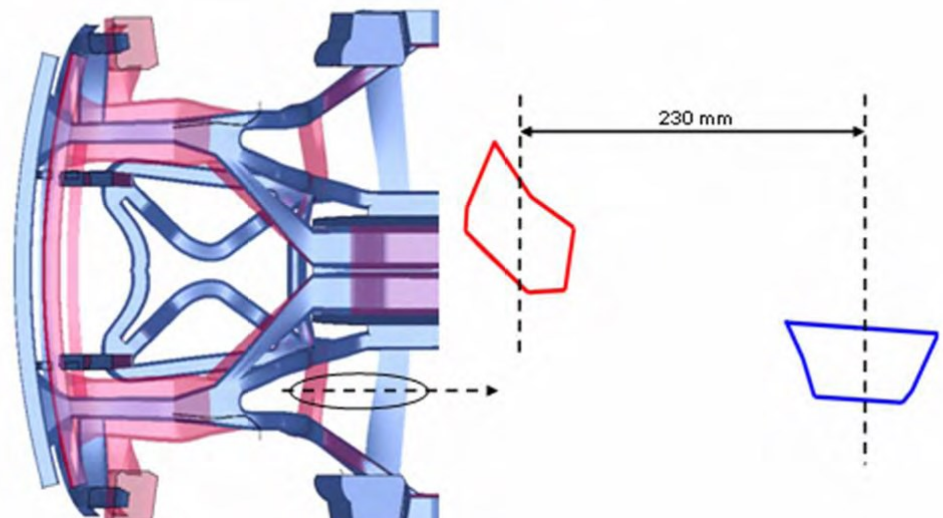


Lower IP / Torque box member

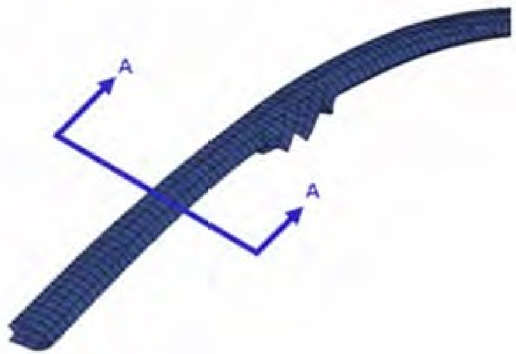


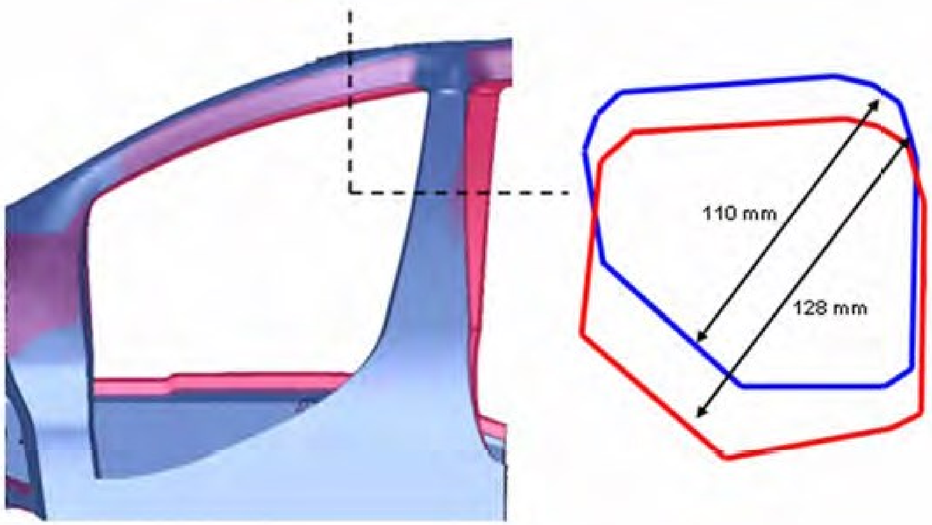


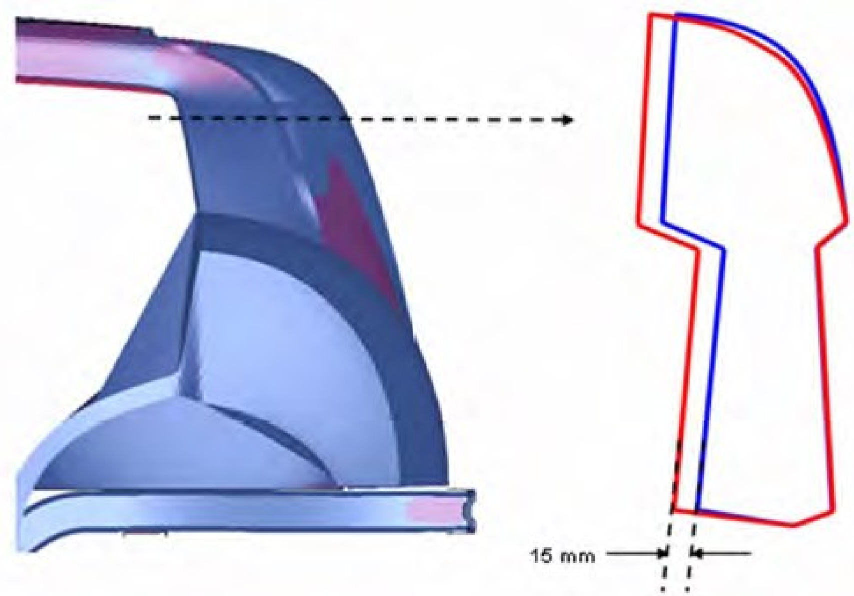




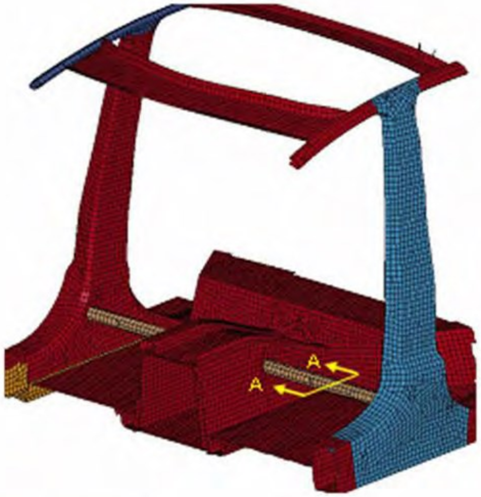
Roof rail member / Joint rear upper

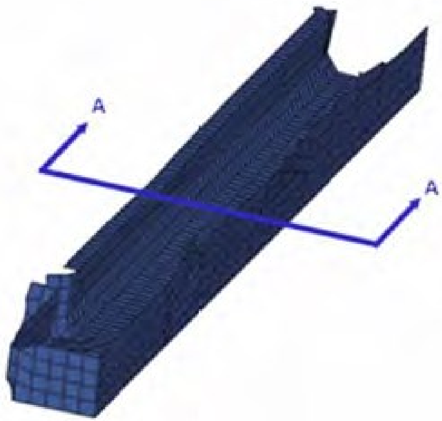


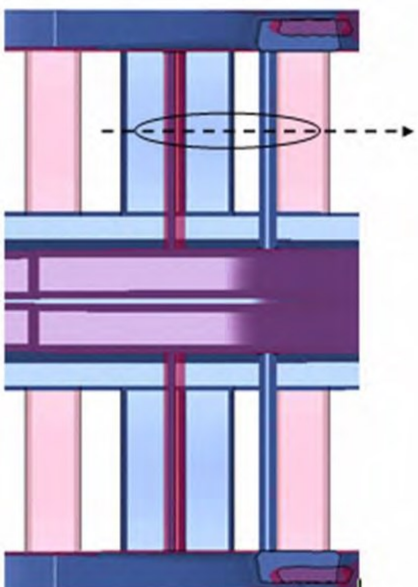


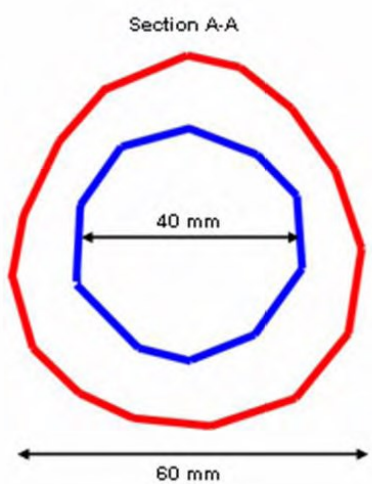


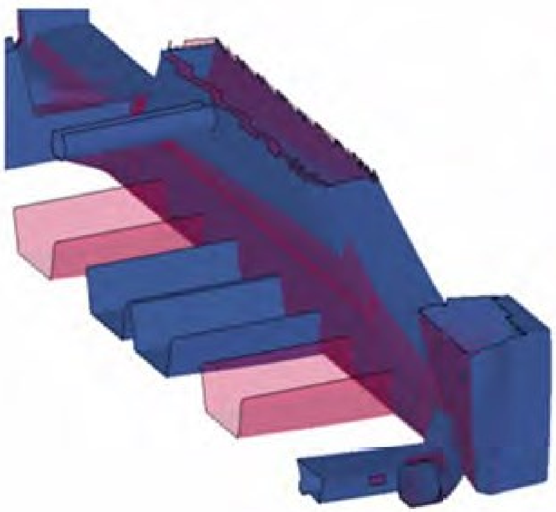
Seat crossmember / Rocker

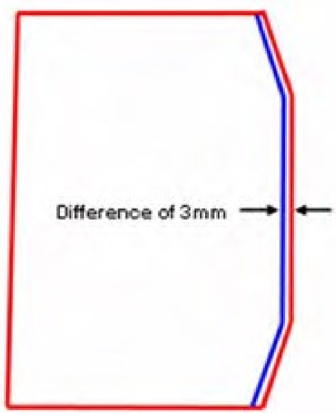




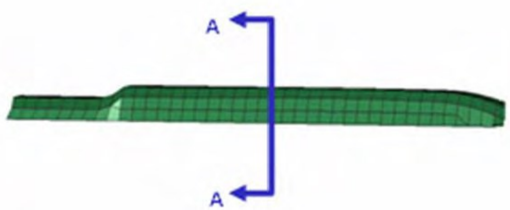


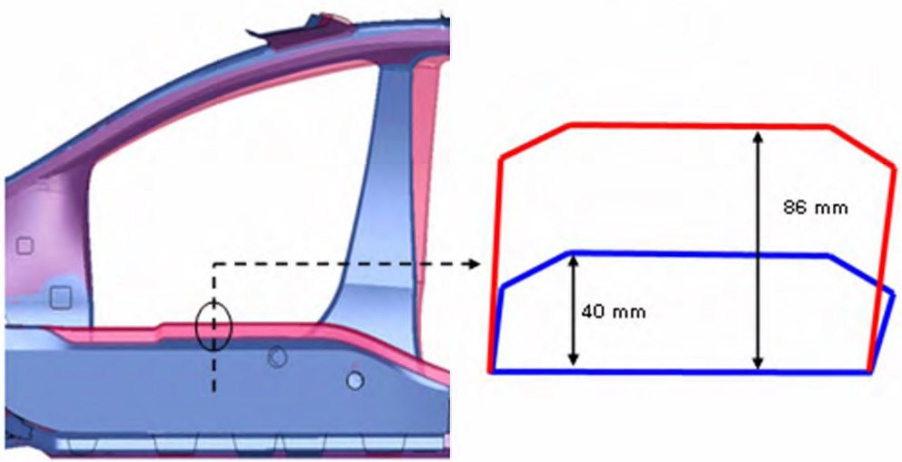


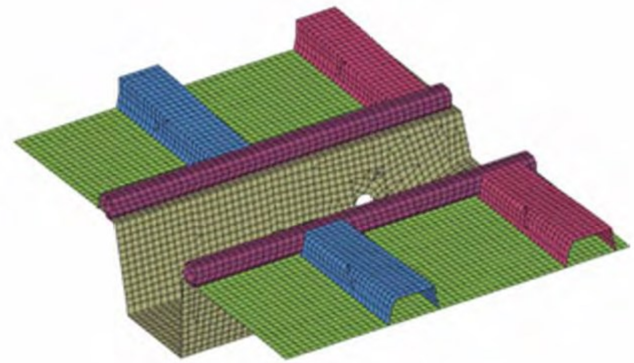


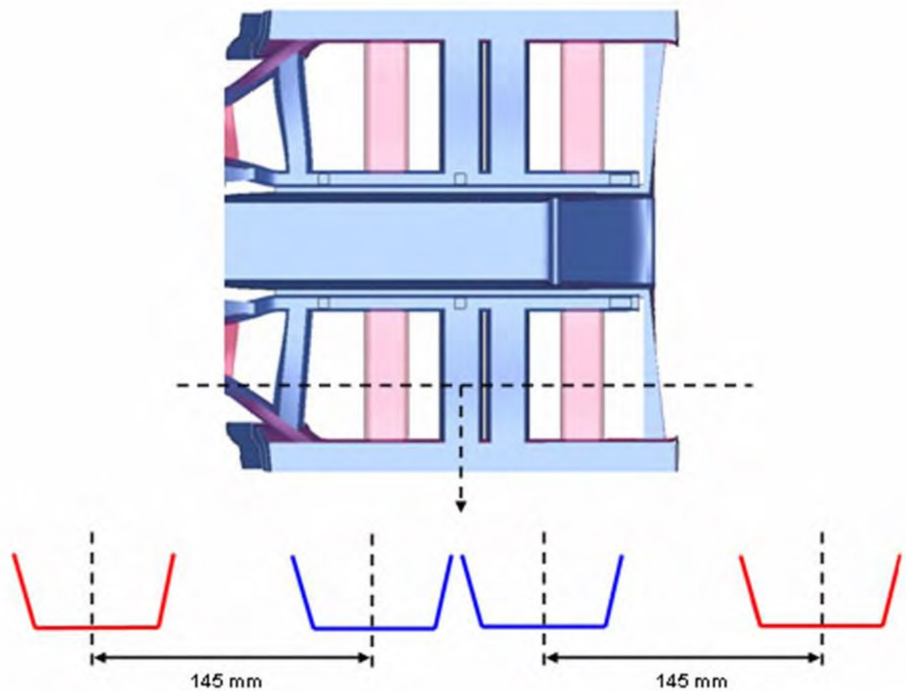


Tunnel top member / Underbody crossmember





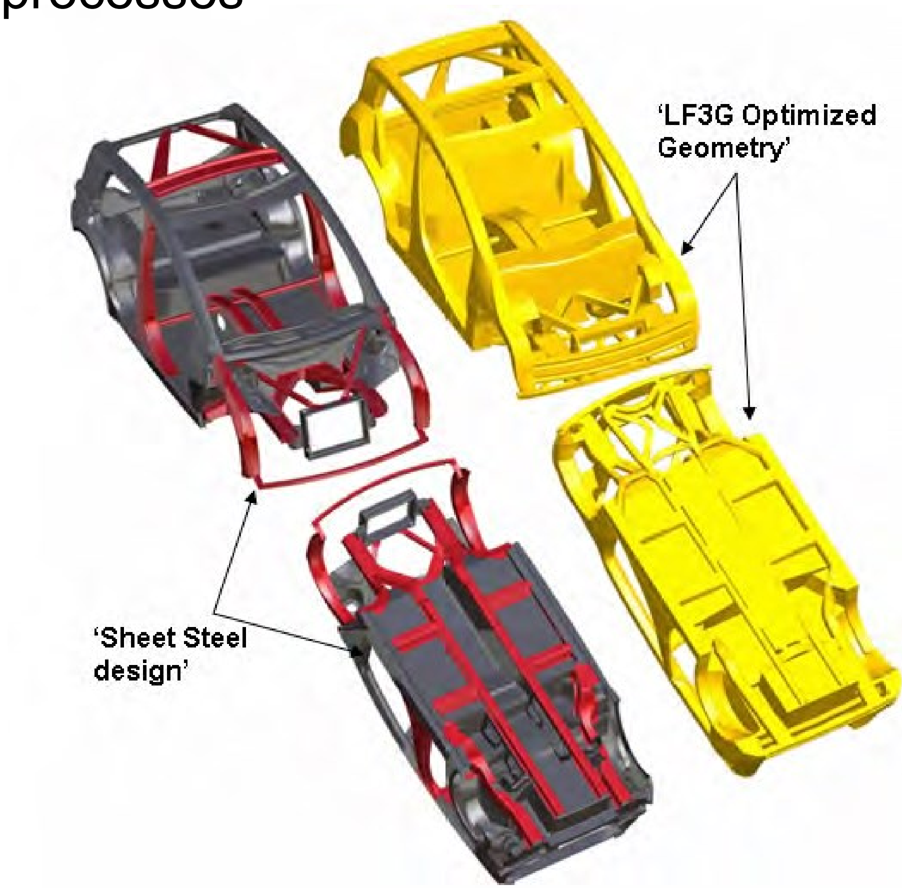




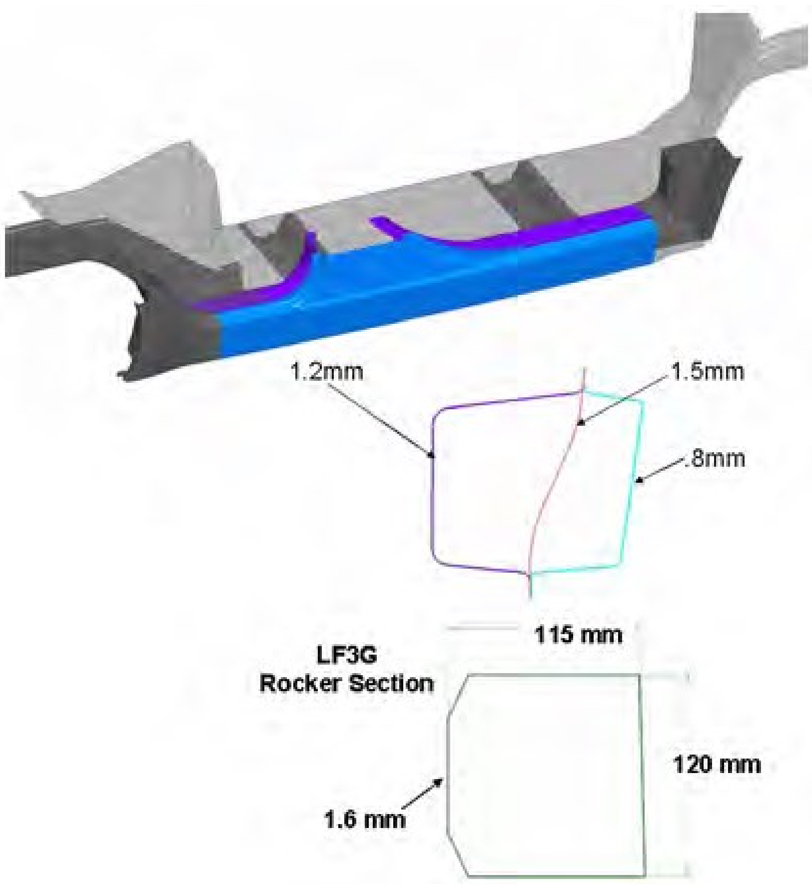
LF3G Geometry Interpretation

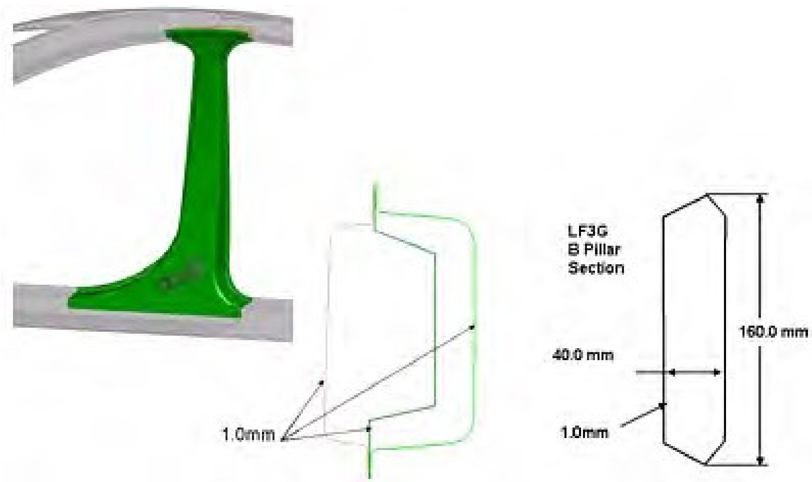
- Geometry from LF3G model → sheet metal design
  - assess and optimize various body structure sub-systems and related manufacturing processes

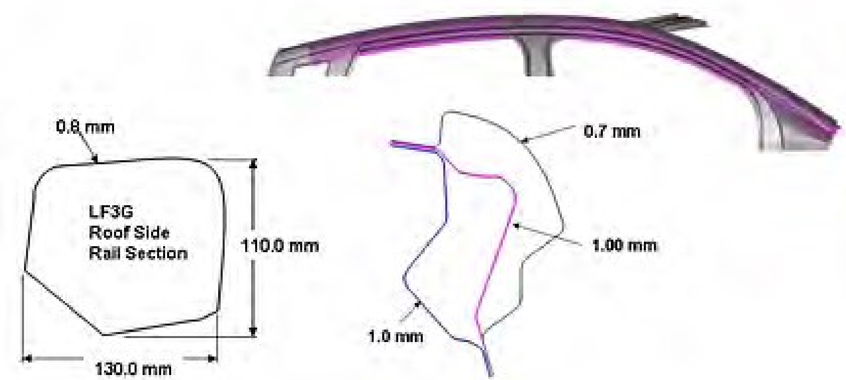
  - Rocker
  - B-pillar
  - Roof side rail
  - Rear rail
  - Front rail
  - Front upper rail (shotgun)
  - Battery upper & lower



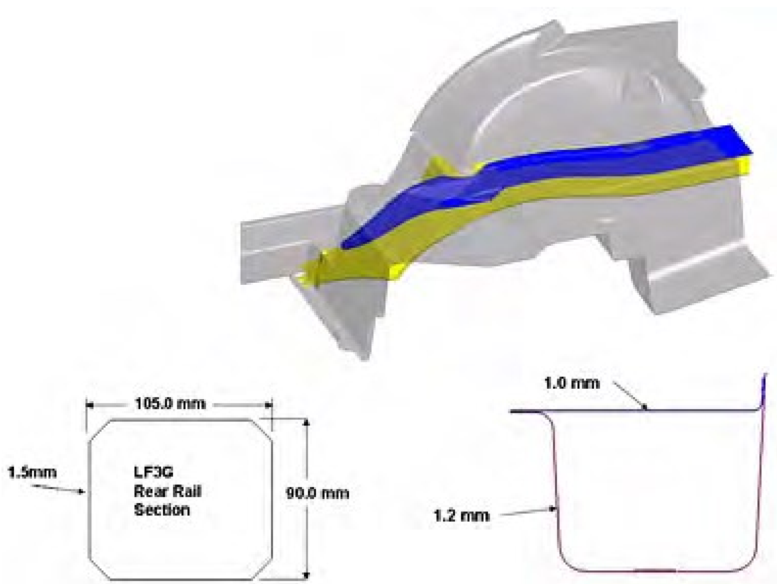
Rocker / B-pillar / Roof side rail

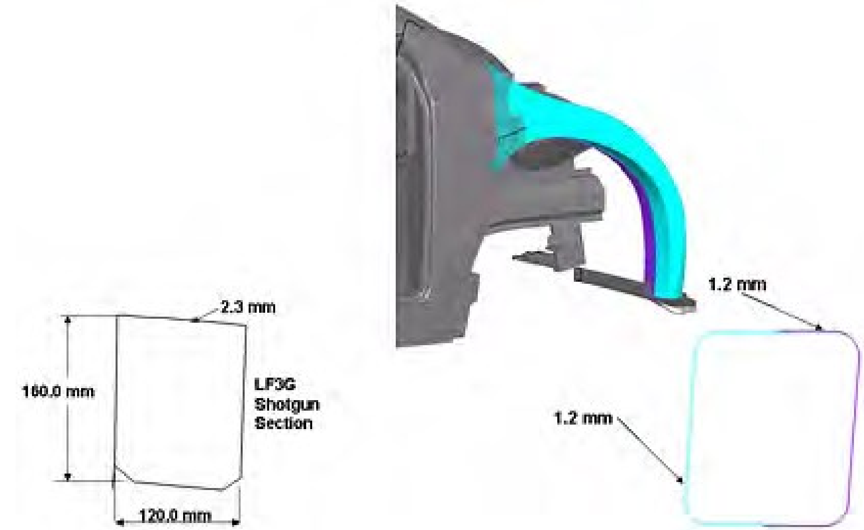


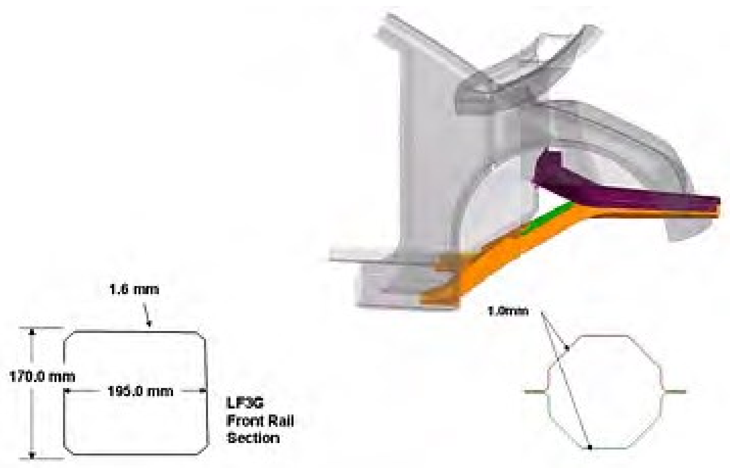


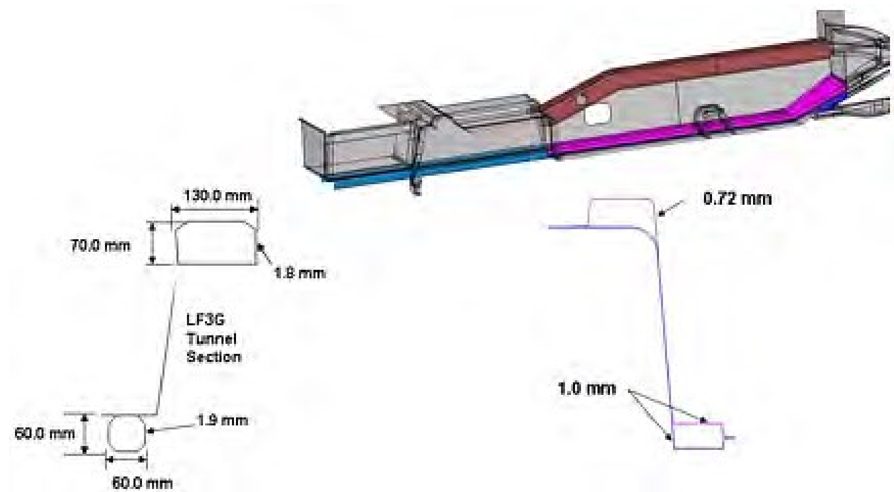


Rear rail / Front rail / Shotgun / Tunnel rails









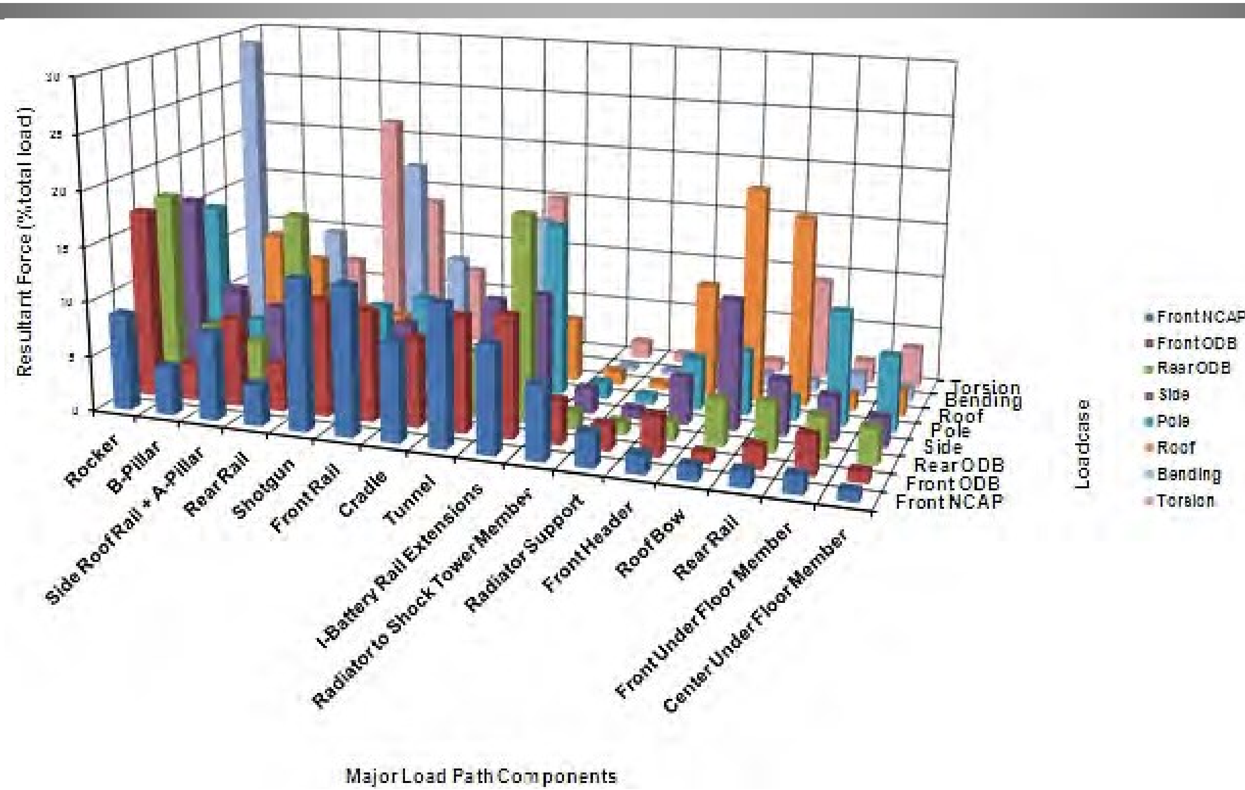
Structural Sub-System Design Optimization

- Objective
- Loadpath mapping
- Sub-System
  - Rocker
  - B-pillar
  - Side roof rail
  - Rear rail
  - Battery tunnel rail
  - Shotgun
  - Front rail

Objective & Optimization Methodology

- best combination of material grade, gauge, geometry and manufacturing process for particular sub-system
- basic steps for the sub-system optimization
  - Sub-system development and validation
  - Initial design representing manufacturing approach
  - Establish design space
  - Parameterize geometry
  - Time history, constraints and targets from LF3G
  - Detailed 3G optimization; geometry (shape), grade (material) and gauge

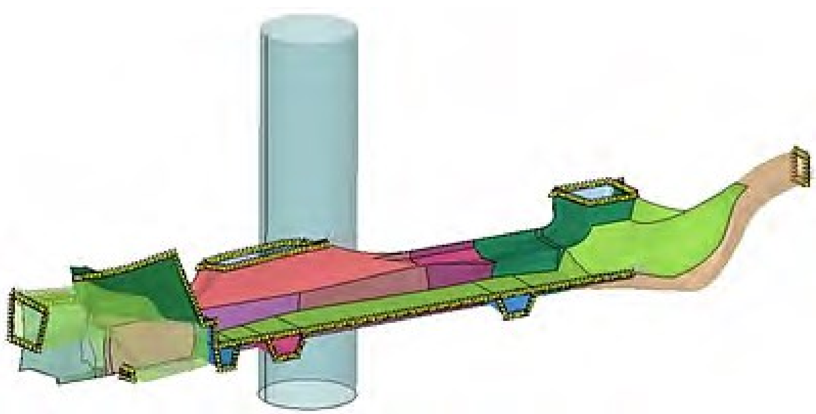
LF3G Loadpath Mapping

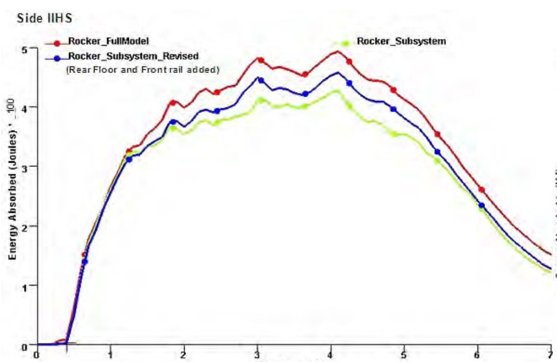


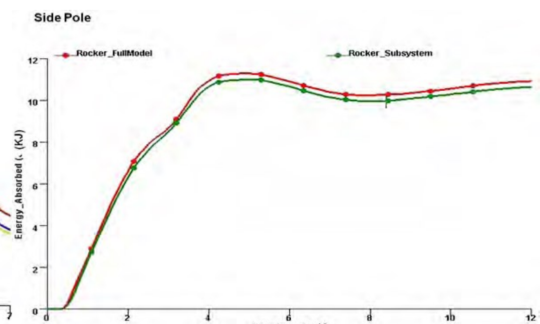
SUBSYSTEM	LOADCASE				
	1	2	3	4	5
Rocker	Front NCAP	Front ODB	Rear ODB	IIHS Side	Pole
B-Pillar	IIHS Side	Roof Crush			
Side Roof Rail	Front ODB	Rear ODB	IIHS Side	Pole	Roof Crush
Rear Rails	Rear ODB	Torsional Stiffness			
Tunnel Rails	Front ODB	Rear ODB	IIHS Side	3G Jounce	
Shotgun	Front NCAP	Front ODB			
Front Rail	Front ODB				

Rocker Sub-System

- Development of Sub-System from the Full Model
  - rocker and the major attachment components it is attached to such as the B-pillar, hinge pillar, rear rail, floor and underbody crossbeams
- Generating Boundary Conditions
  - nodal displacement time history is used so that it behaves in a similar manner to the full LF3G model





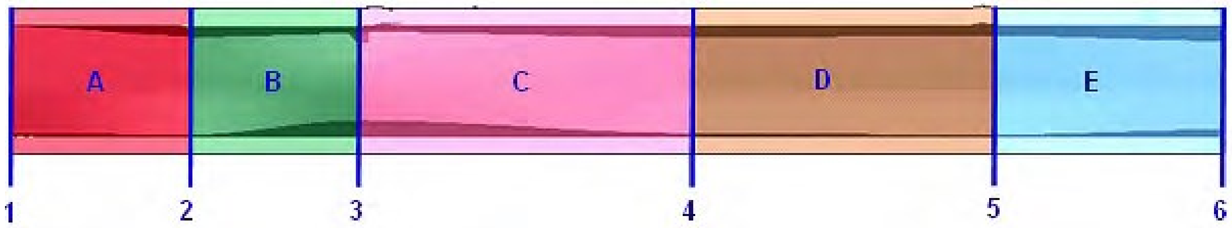


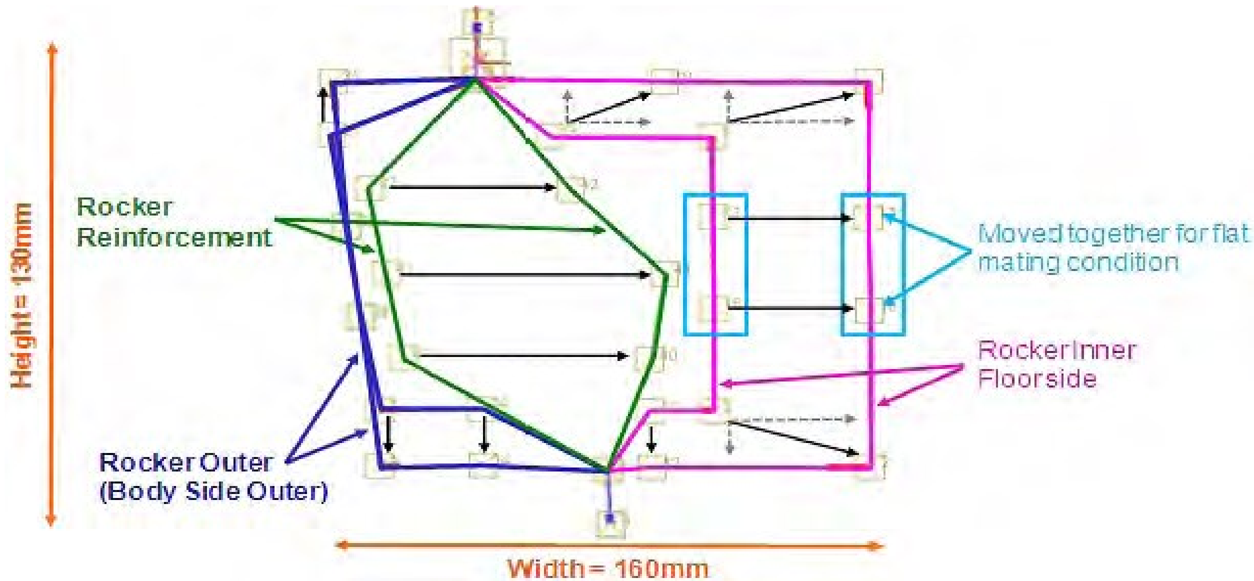
Stamped Rocker Concept

- Grade and Gauge Geometry Design Space
- Geometry Parameterization
- Optimization Setup
  - Objective: maintain the performance of the rocker so that the
  - total strain energy remains the same as the LF3G for front NCAP, front ODB, rear ODB, IIHS side and pole impacts. The mass of the LF3G rocker is 12.4 kg
  - Target: minimize the mass of the rocker
  - Constraint: energy absorbed by the rocker in the LF3G model (full model)
    - For IIHS side and pole impacts, +/-15% (plastic deformation)
    - For Front NCAP, front ODB and rear ODB impact, ≤ 650 J (elastic deformation)
  - Design solution

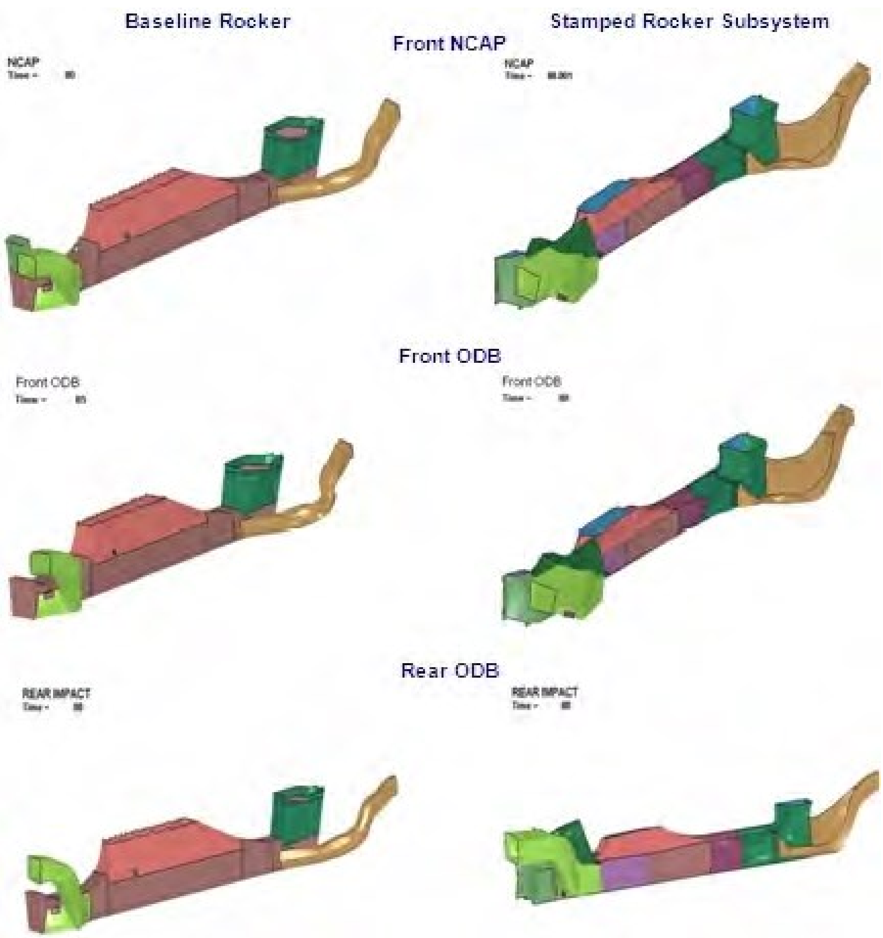
Stamped Rocker: Design Space & Geometry Parametrization

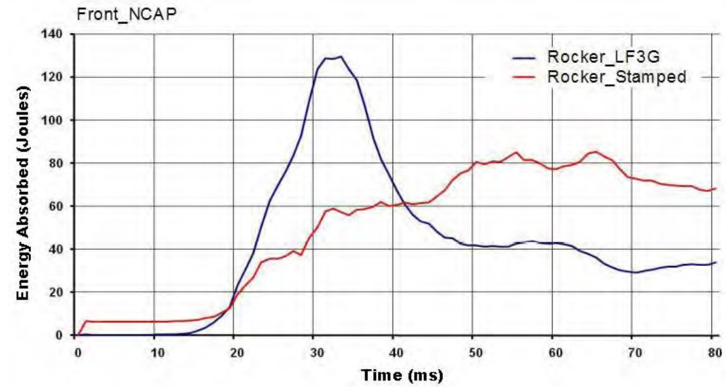
STAMPED ROCKER GAUGE CHOICES			STAMPED ROCKER GRADE CHOICES	
FROM	0.5 mm (INNER & OUTER)	In 0.01 mm increments	ULTIMATE TENSILE (MPa)	MAT 270
	0.2 mm (REINFORCEMENT)			MAT 340
TO	2.0 mm			MAT 450
				MAT 500
				MAT 600
				MAT 800
				MAT 1000
				MAT 1300
				MAT 1500

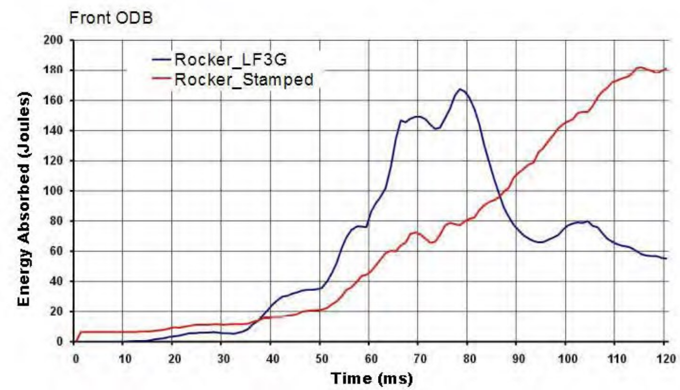


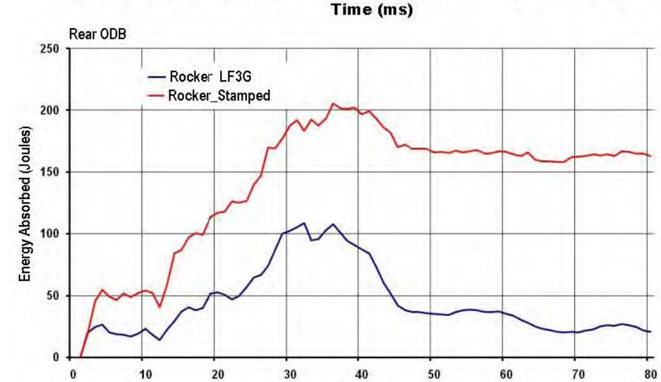


Stamped Rocker: Design Solution (Longitudinal Impact)

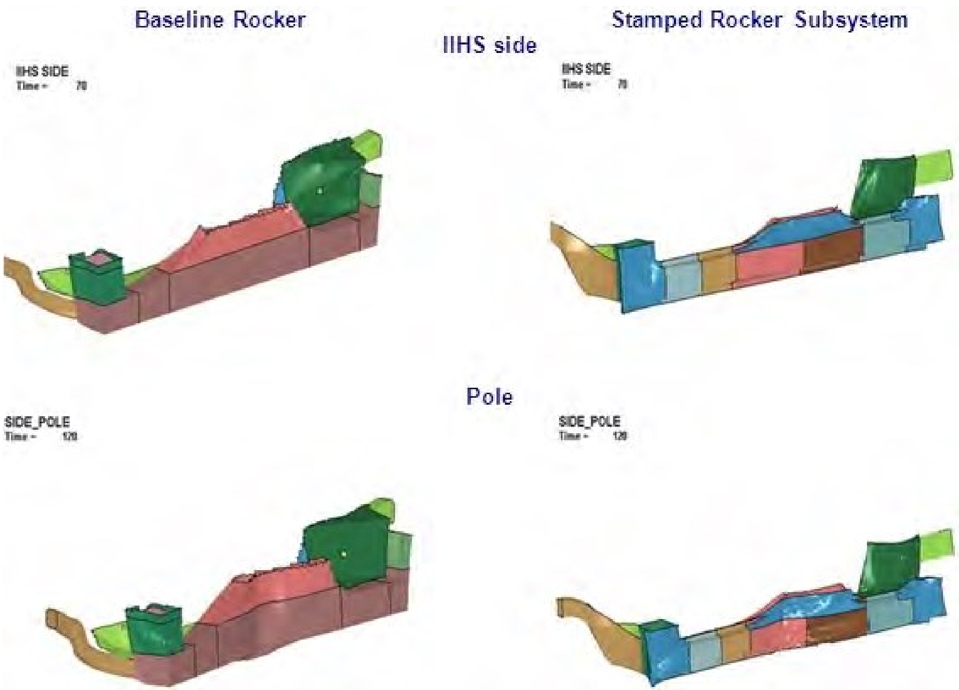


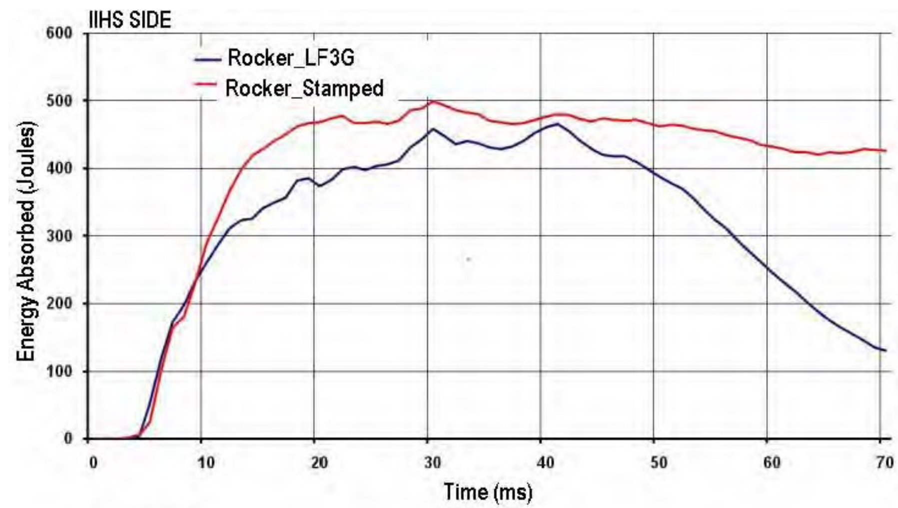


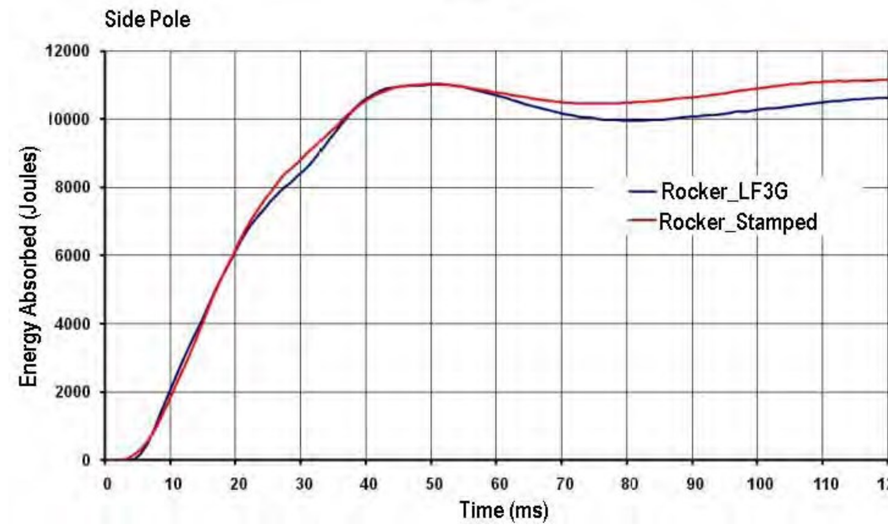




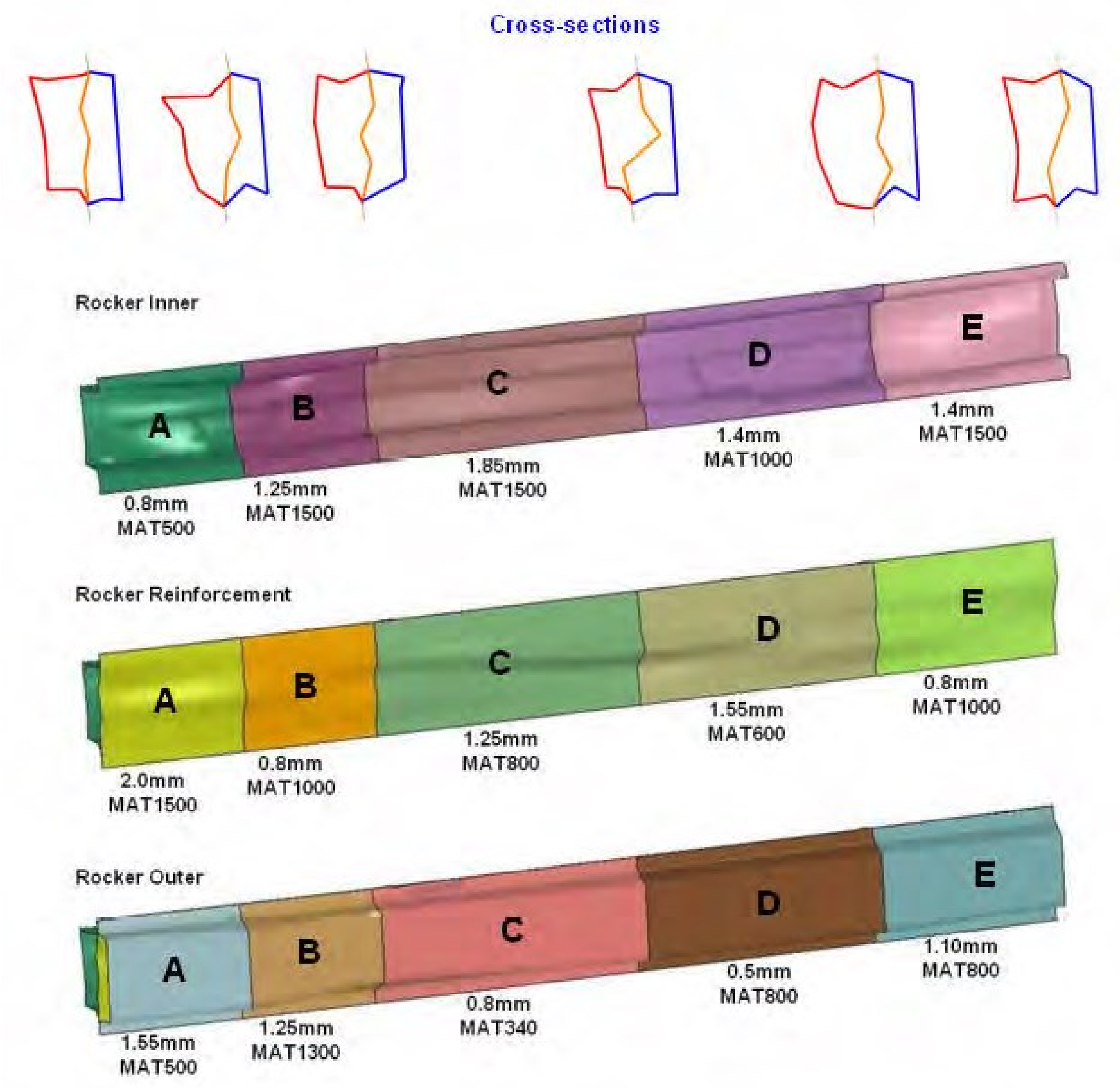
Stamped Rocker: Design Solution (Side Impact)







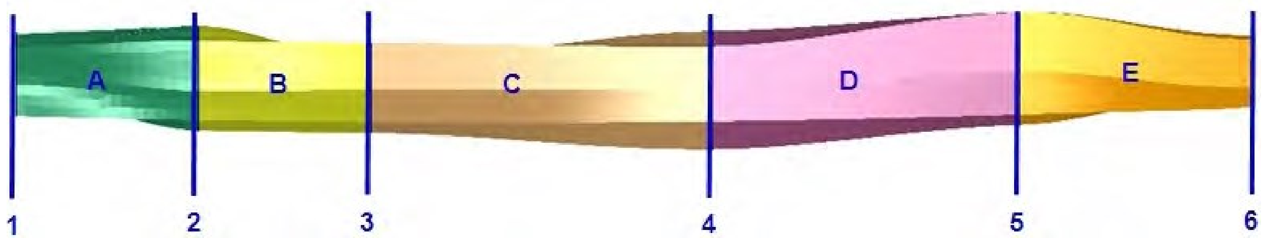
Stamped Rocker: Design Solution (Final)

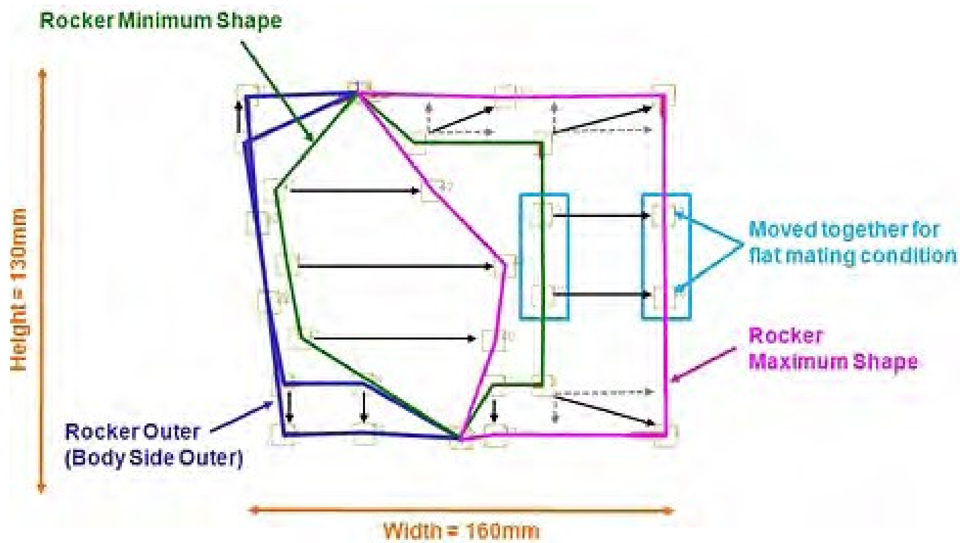


Hydroformed Rocker Concept

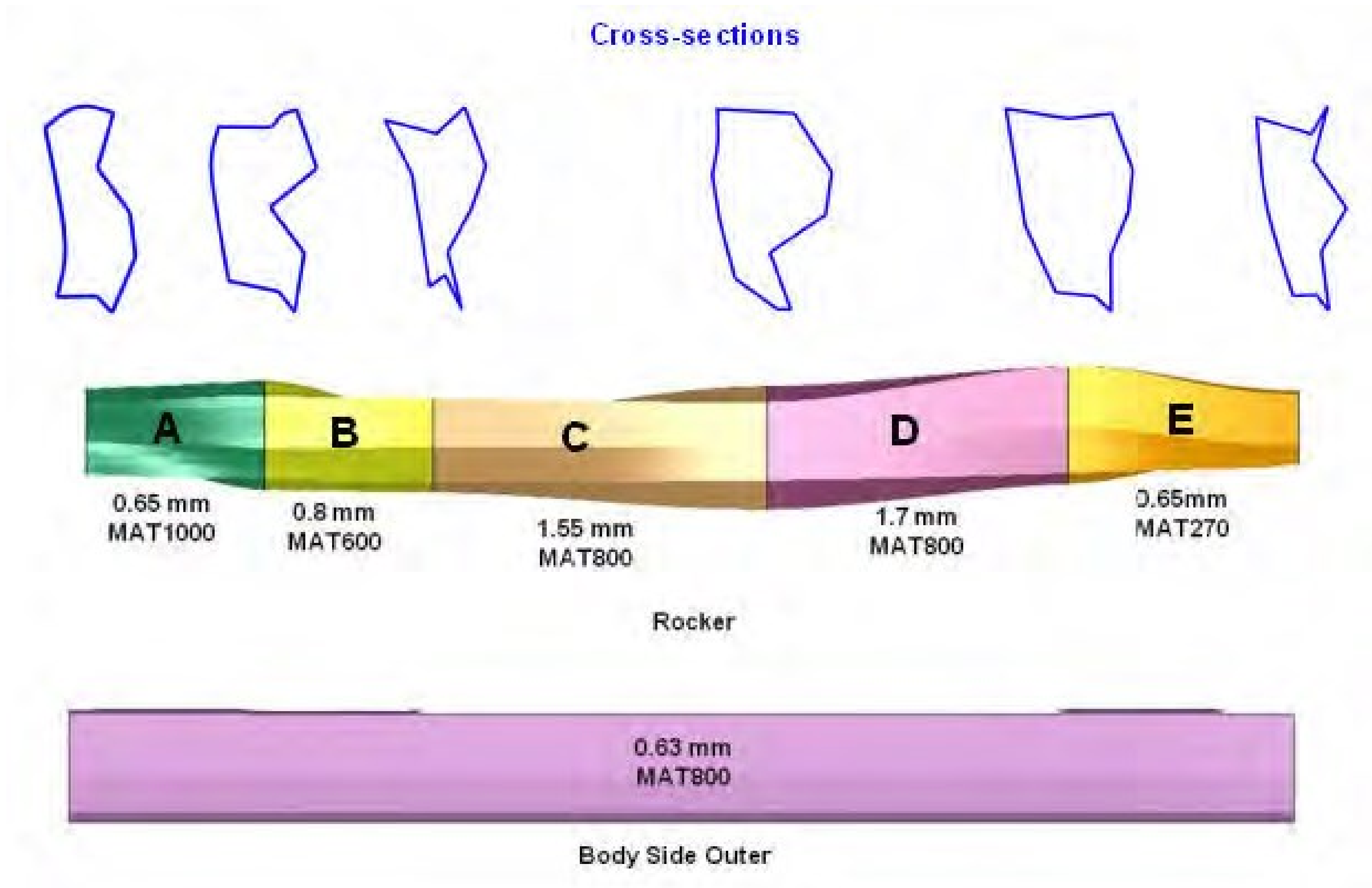
HYDROFORMED ROCKER GAUGE CHOICES		
FROM	0.5 mm (INNER & OUTER)	In 0.01 mm increments
TO	2.0 mm	

HYDROFORMED ROCKER GRADE CHOICES	
ULTIMATE TENSILE (MPa)	MAT 270
	MAT 340
	MAT 450
	MAT 500
	MAT 600
	MAT 800
	MAT 1000

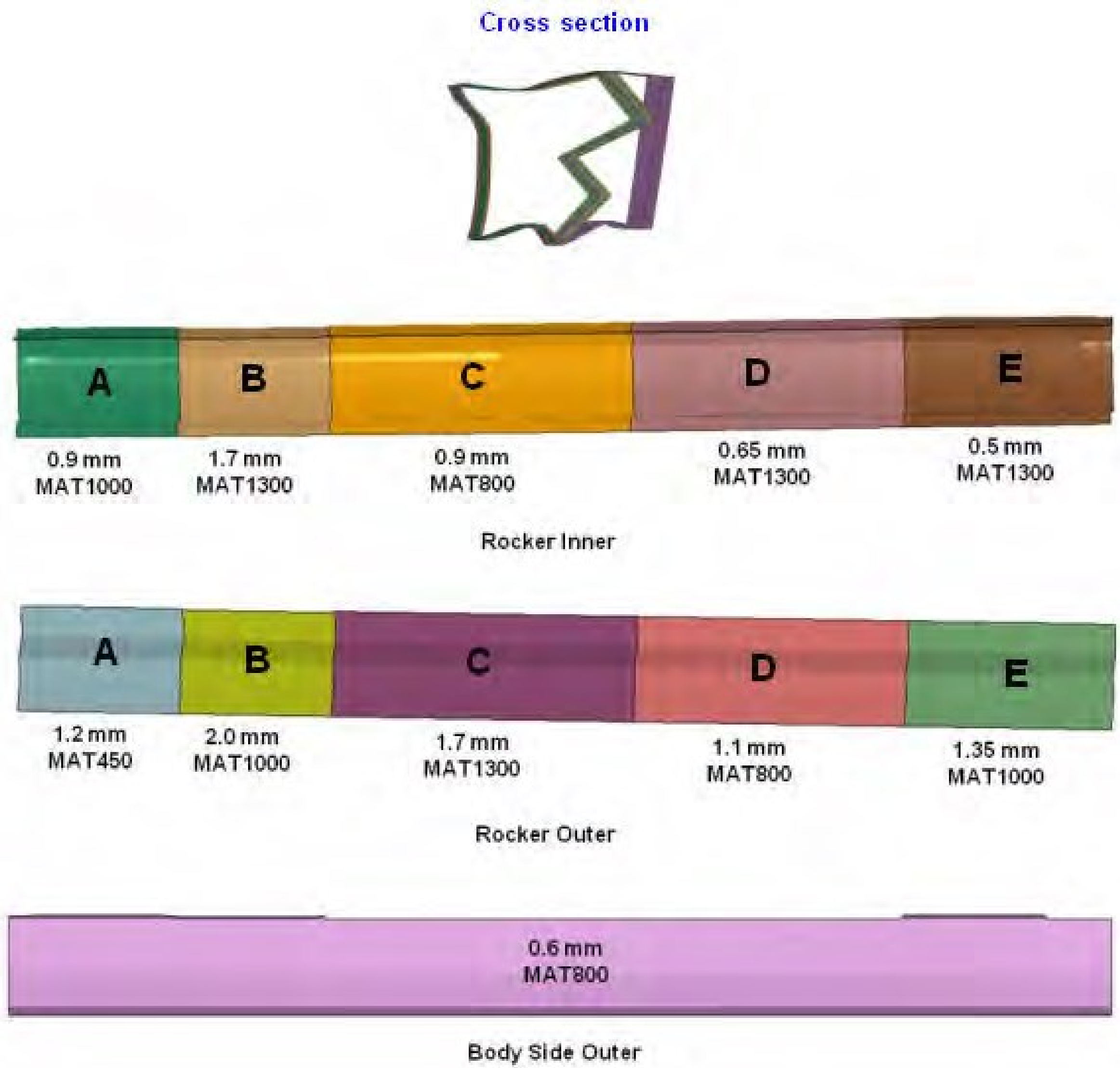




Hydroformed Rocker: Design Solution (Final)



Roll formed Rocker: Design Solution (Final)

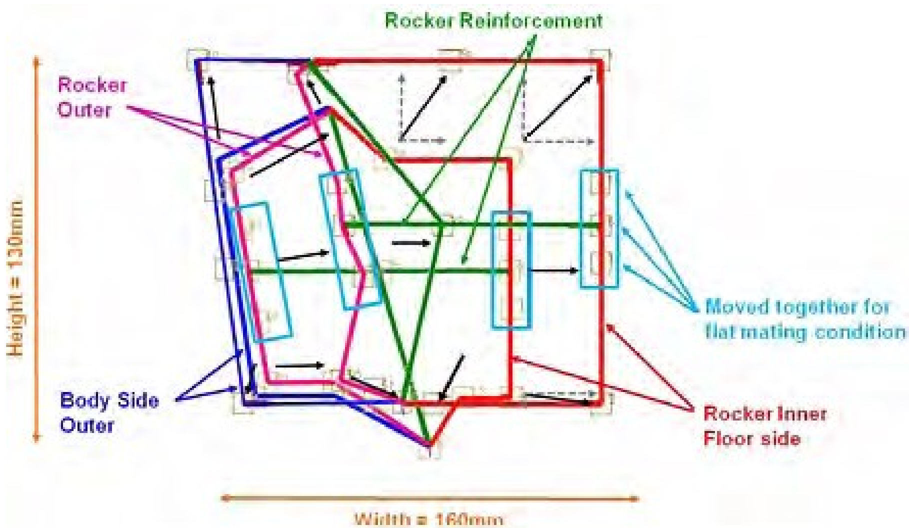


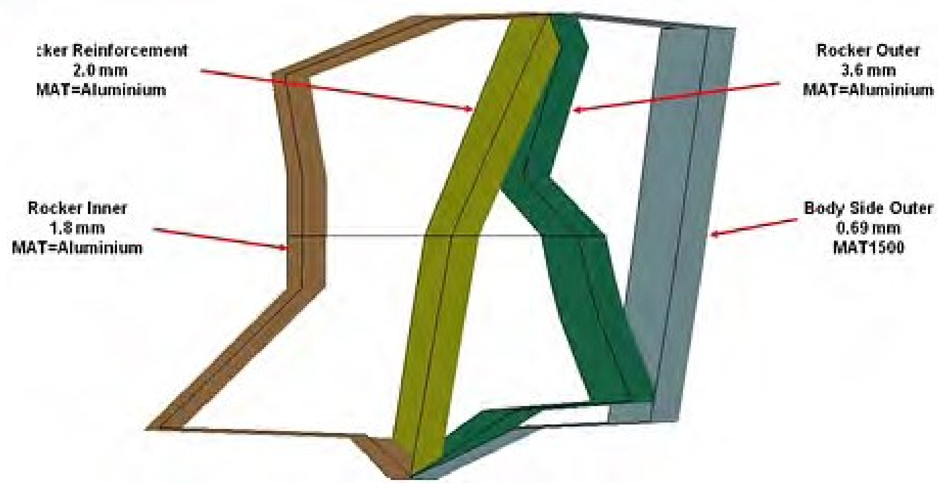
Extruded Aluminum Roll Rocker

EXTRUDED ALUMINUM ROCKER GAUGE CHOICES		
FROM	2.0 mm	In 0.01 mm increments
TO	6.0 mm	

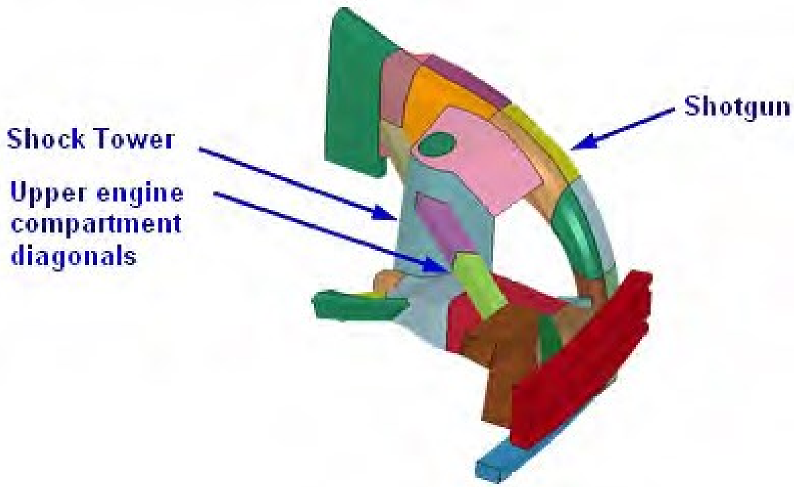
EXTRUDED ALUMINUM ROCKER GRADE CHOICES	
ALUMINUM GRADE	AL 6061

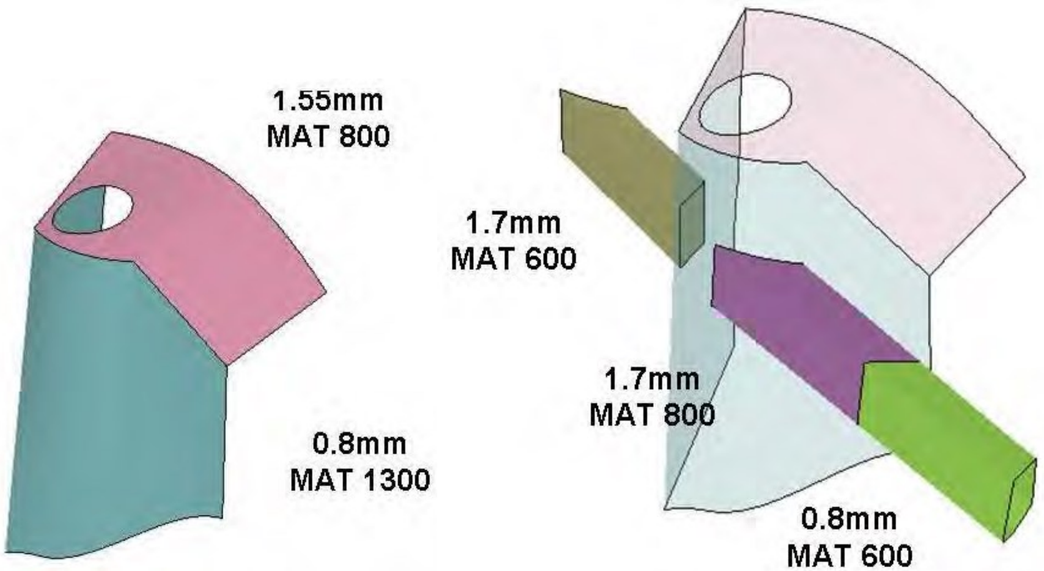
EXTRUDED ALUMINUM ROCKER GRADE CHOICES (Steel Bodyside Outer Only)	
ULTIMATE TENSILE (MPa)	MAT 270
	MAT 340
	MAT 450
	MAT 500
	MAT 600
	MAT 800
	MAT 1000
	MAT 1300
	MAT 1500





Front End Optimization

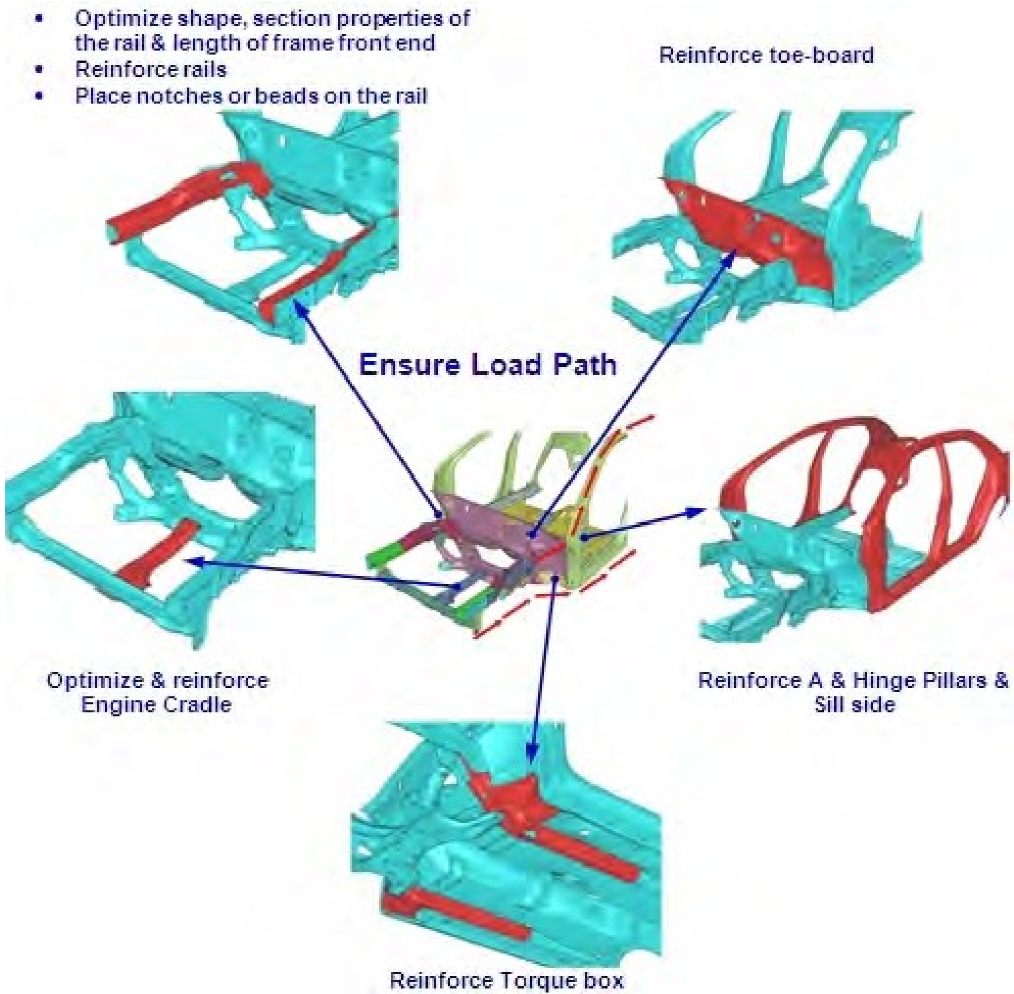




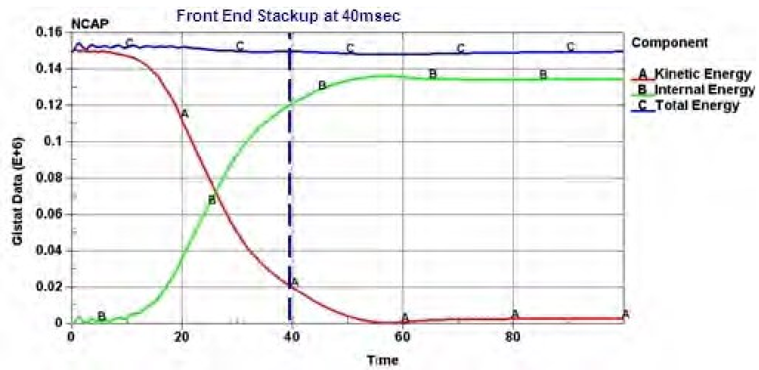
COMPONENT	LF3G BASELINE (kg)	DESIGN SOLUTION (kg)	MASS SAVING	
			Kg.	%
Shotgun (Stamped)	10.6	6.4	4.2	40%
Shaw Member	2.13	1.7	0.43	20%
Shock Tower	3.6	1.6	2	56%
All Parts (LH/RH)	32.66	19.4	13.26	41%

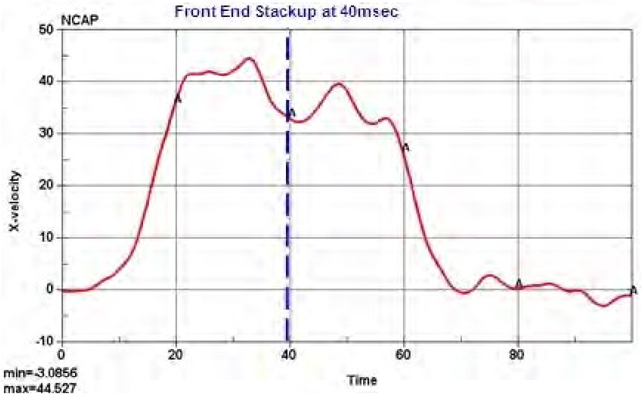
Front End: Load Path

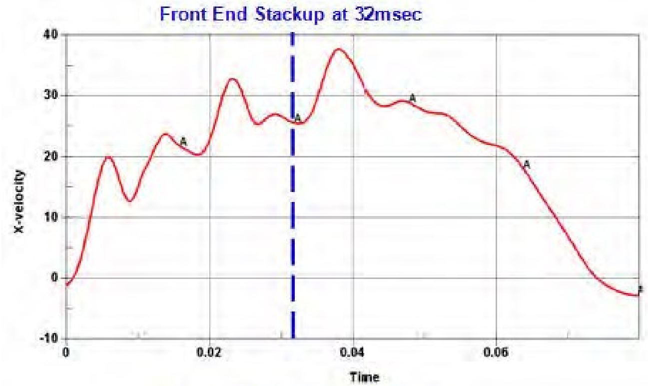
– loadpath and energy management strategies to both absorb and then transfer load: reduce the mass in the remaining structure

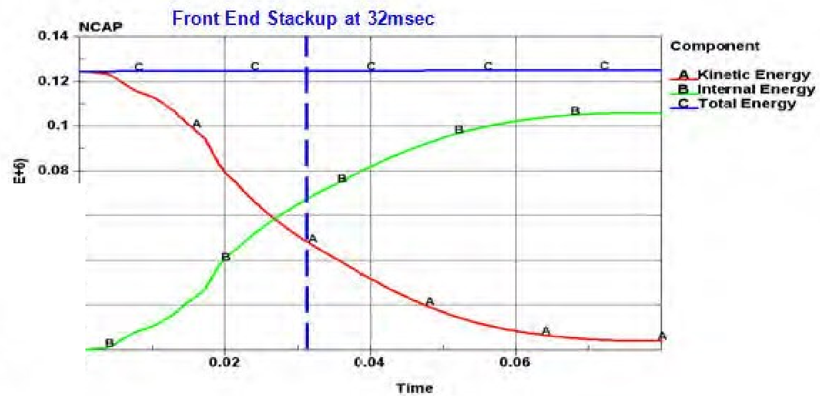


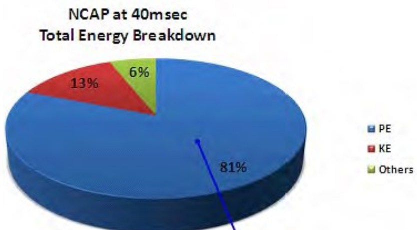
Front NCAP: FSV vs. Conventional

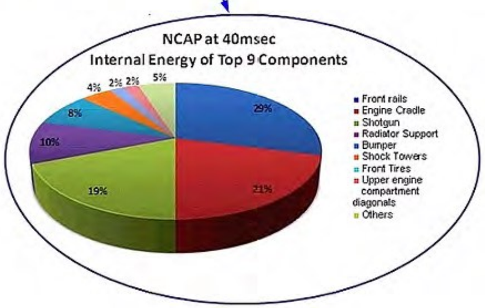


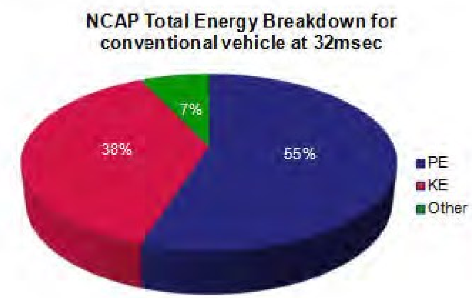








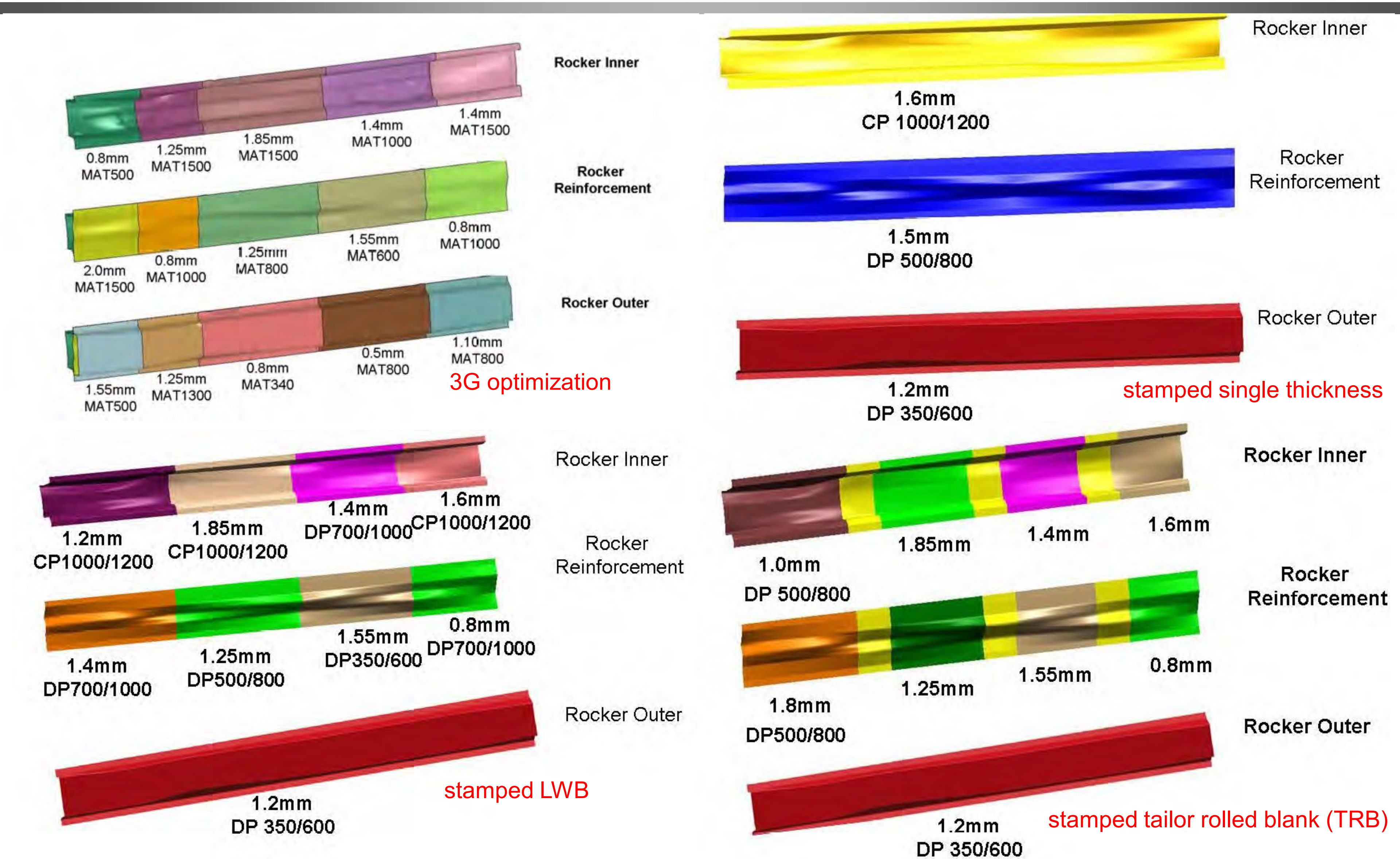




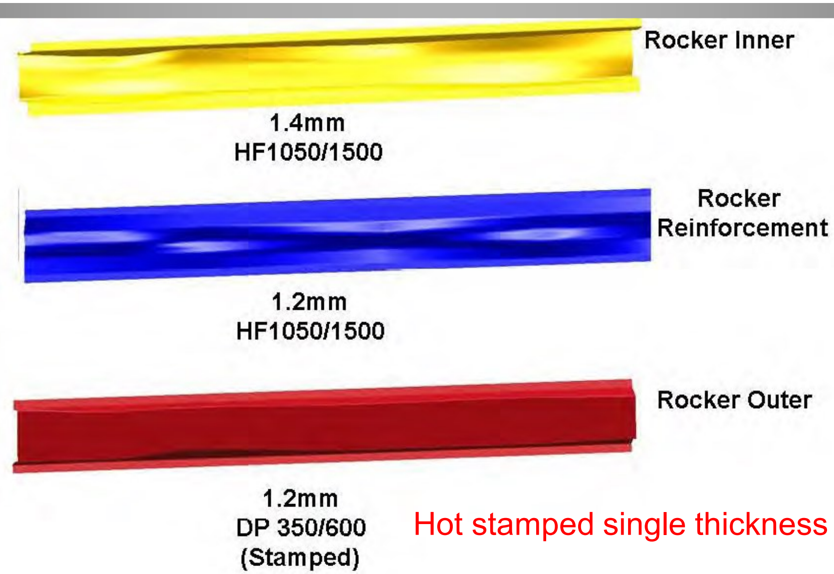
Structural Sub-System Design and Manufacturing Interpretation

- structural sub-system multidiscipline 3G optimization → assess considering the respective manufacturing technology guidelines, to ensure manufacturibility of the sub-system
  - Sub-system 3G Optimized Solution
  - Manufacturing Interpretation (Design for Manufacturing)
  - Verification of Interpreted Results

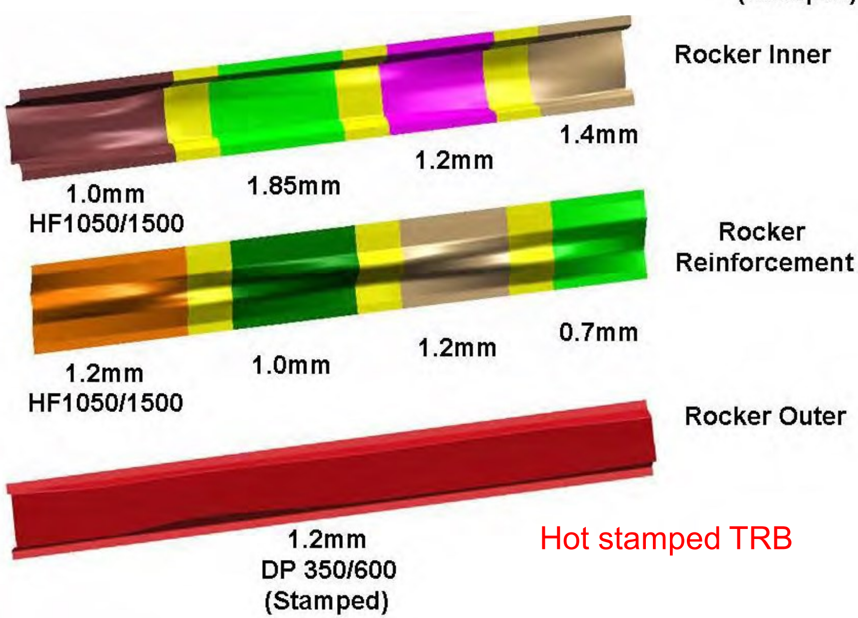
Rocker: Stamped



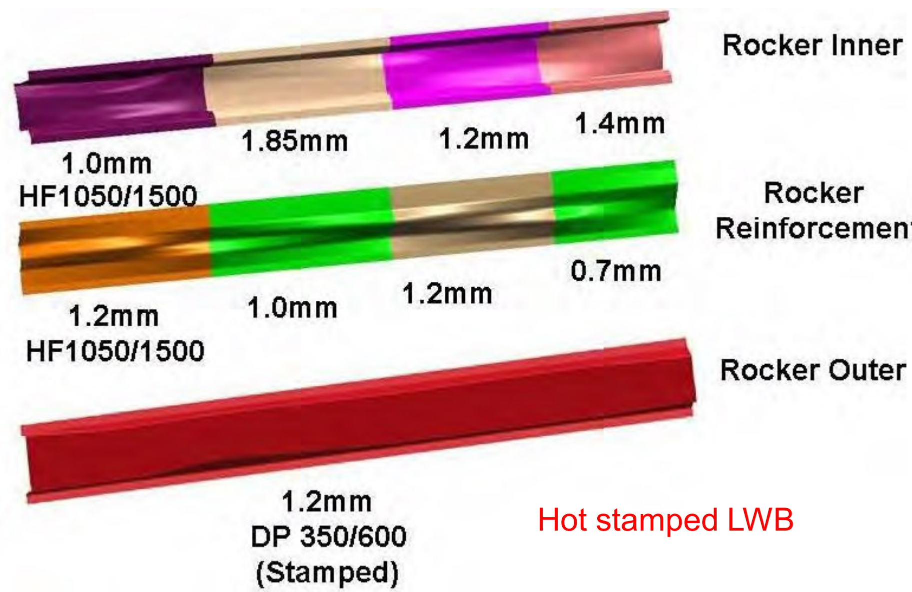
Rocker: Hot Stamped



Hot stamped single thickness

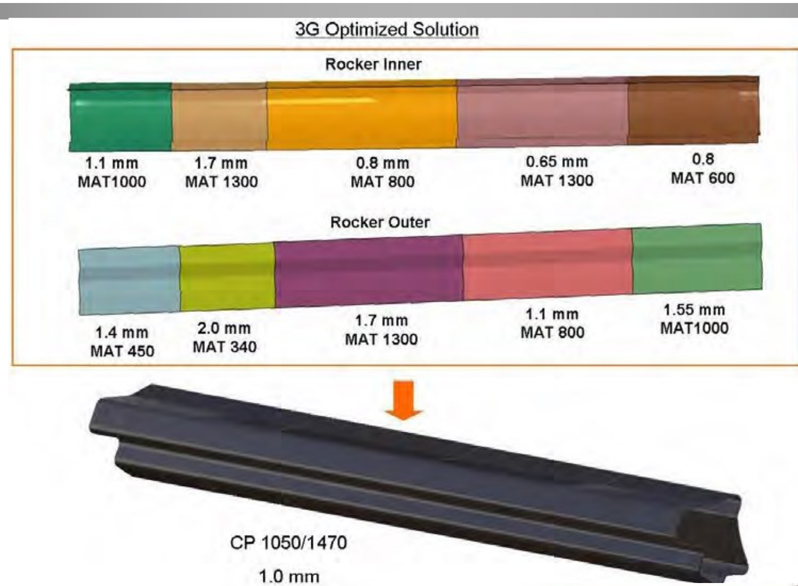


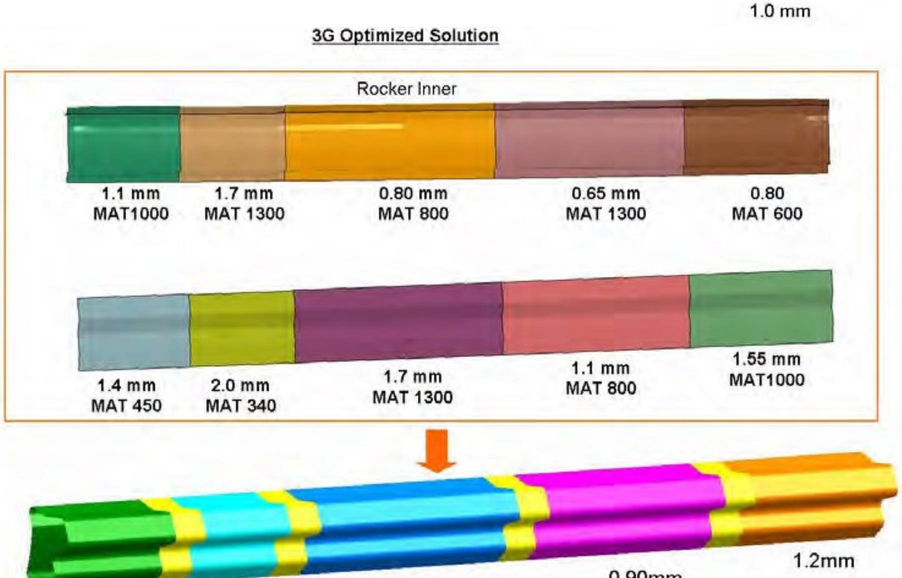
Hot stamped TRB



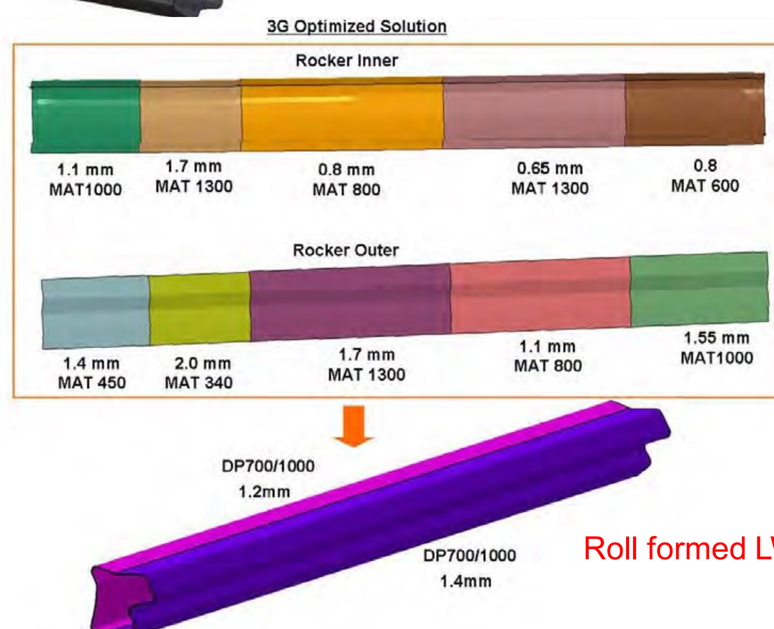
Hot stamped LWB

Rocker: Tubular (Roll Formed)



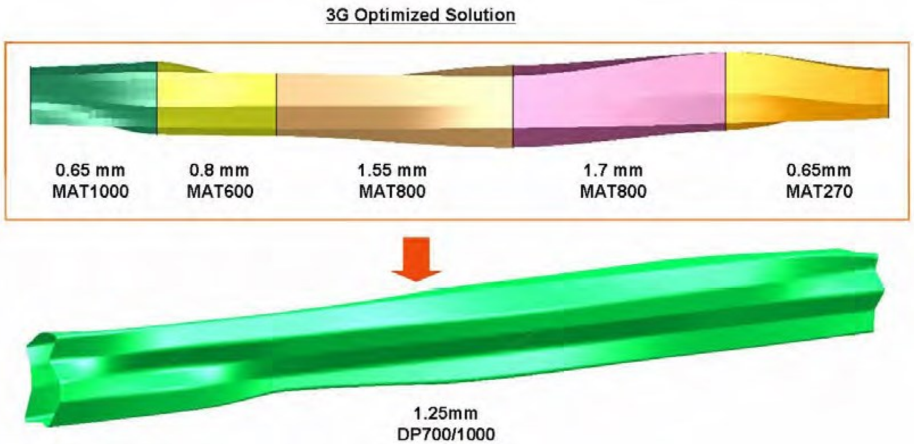


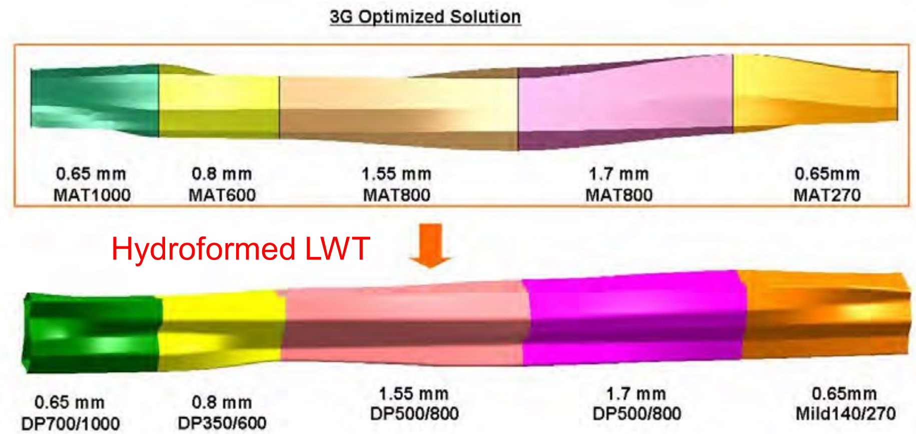
Roll formed TRB



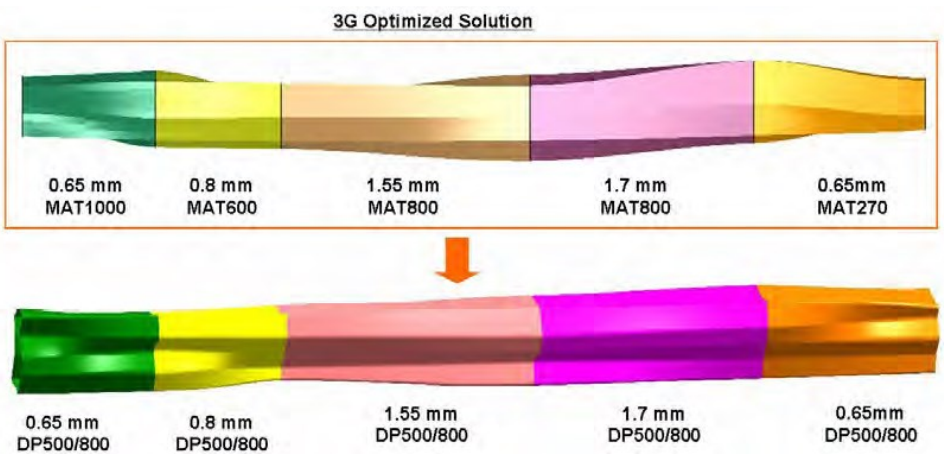
Roll formed LWC

Rocker: Tubular (Hydroformed)

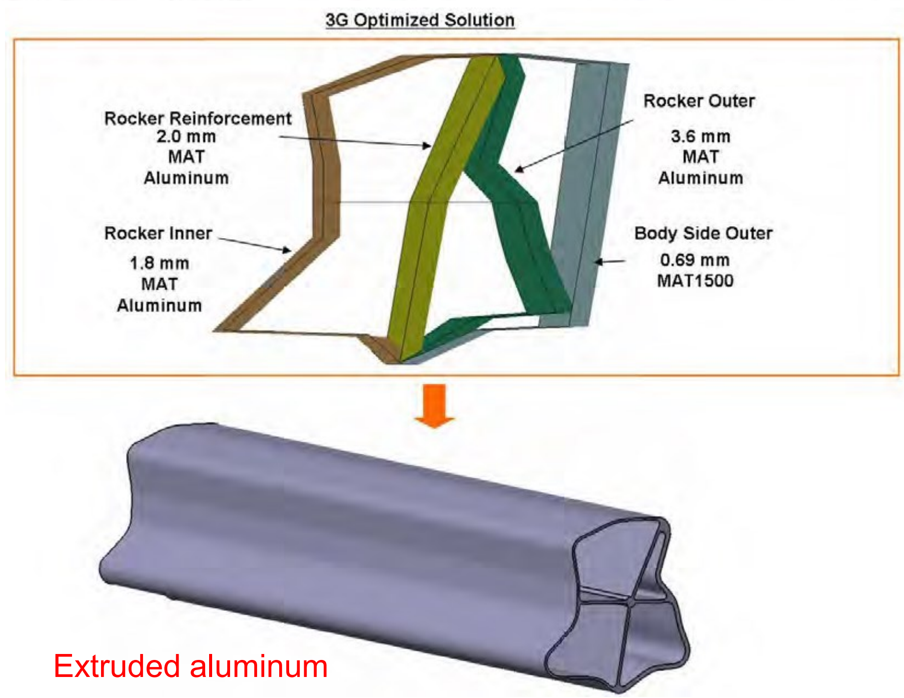




Hydroformed LWT



Hydroformed TRT (Tailor Rolled Tube)



Extruded aluminum

Sub-Systems Selection Methods

- Every automobile manufacturer uses a certain selection criterion dependent on the market segment, demographics and relevant government regulations
- Mass
  - part mass and blank mass (influences the material costs, energy costs and the CO2e emissions)
- Costs
  - the manufacturing costs were assessed for the various sub-systems using a cost model
- CO_2e Life Cycle Assessment
  - an environmental assessment, of Greenhouse Gases (GHG) emissions, was conducted for each sub-system over the complete vehicle life cycle

Manufacturing processes and operations sequence

Manufacturing Portfolio

	Stamping	Stamping Tailor Rolled Blank (TRB)	Stamping Laser Welded Blank (LWB)	Hot Stamping	Hot Stamping Tailor Rolled Blank (TRB)	Hot Stamping Laser Welded Blank (LWB)
Material Price	Steel Material Prices	Steel Material Prices + Rolling Premium	Steel Material Prices	Steel Material Prices	Steel Material Prices + Rolling Premium	Steel Material Prices
Operation #1	Blanking (Single)	Blanking (Single)	Blanking (Multiple)	Blanking (Single)	Blanking (Single)	Blanking (Multiple)
Operation #2	Stamping	Stamping	Laser Welding	Blank heating	Blank heating	Laser Welding
Operation #3	Trimming	Trimming	Stamping	Hot forming	Hot forming	Blank heating
Operation #4			Trimming	Laser Trimming	Laser Trimming	Hot forming
Operation #5						Laser Trimming

	Closed Roll Form	Open - Roll Form	Hydroform	Hydroform Laser Welded Tubes (LWT)	Hydroform Multiple Walled Tubes (MWT)	Aluminium Extrusion
Material Price	Steel Material Prices	Steel Material Prices	Steel Material Prices + Tubing Premium	Steel Material Prices	Steel Material Prices + MWT Premium	Aluminum Material Prices
Operation #1	Forming	Forming	Bending	Blanking (Multiple)	Bending	Cutting Billet
Operation #2	Welding	Trimming	Pre-forming	Laser Welding	Pre-forming	Extrusion
Operation #3	Trimming		Hydroforming	Master Shearing	Hydroforming	Straightening
Operation #4			Trimming	Tube Rolling/Welding	Trimming	Hydrosizing
Operation #5				Bending		Machining
Operation #6				Pre-forming		
Operation #7				Hydroforming		
Operation #8				Trimming		

Sub-System Cost Assessment

- “technical cost modeling“ approach similar to the one used by MIT in the ULSAB AVC and Future Generation Passenger Compartment (FGPC)
  - no supplier cost assessments conducted for any of the parts costs and assembly costs
  - costs for each of the operations involved in the manufacturing process, starting from blanking the steel coil, until the final operation to fabricate the component
  - Material, Labor, Equipment, Tooling, Energy, Building, Maintenance
  - determination of the component related inputs such as blank size, cycle time and tooling costs
  - remaining inputs that were crucial: Program Parameters, Plant Parameters, Process parameters

Parameters	FSV Assumptions
Model year	2015-2020
Annual Production Volume	100,000
Parts volume	only consider BEV
Production life	5 years
Energy cost	$0.12 /kWh

Plant Parameters	FSV Assumptions
Working days	235 days/yr
Annual Paid Time	3525 hrs/yr
Indirect workers (Overhead)	0.25 per direct worker
Wage (including benefits)	$45.00 /hr
Interest (Equipment, Building etc.)	10%
Equipment life	20 yr
Building life	25 yr
Building unit cost	$1,500 /sqm

Process Parameters	FSV Blanking Assumptions	FSV Stamping Assumptions
Energy consumption rate	300 kW/hr	150 kW/hr
Space requirement	115 sqm/line	150 sqm/line
Manpower	1 worker/line	part dependent
Unplanned downtime	2 hrs/day	3 hrs/day
Maintenance Percentage	10%	10%
Material loss percent	1%	NA
Reject rate	0.10%	part dependent
Press line die average change time	NA	30 mts
Press line lot size	NA	1500 parts/lot
Cycle Time	2000 hits/hr	part dependent

Process Parameters	FSV Welding Assumptions	FSV Trimming Assumptions
Energy consumption rate	400 kW/hr	150 kW/hr
Space requirement	250 sqm/line	200 sqm/line
Manpower	1 per line	2 per line
Unplanned downtime	4 hrs/day	NA
Maintenance Percentage	5%	5%
Installation Percentage	25%	NA
Auxiliary Equipment Percentage	NA	NA
Reject rate	0.1%	0.5%
Press line lot size	part dependent	1500
Line rate	part dependent	500 hits/hr
Die Change time	NA	30 mts

Rocker sub-system Costs

Part	Manufacturing Portfolio											
	T4 - Sub System Rocker Analysis Solution 1											
	Stamping		Stamping (TRB)		Stamping (LWB)		Hot Stamping		Hot Stamping (TRB)		Hot Stamping (LWB)	
Name	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)
Rocker Inner	4.92	$10.15	4.46	$11.72	4.61	$13.77	4.31	$12.07	4.15	$14.32	4.15	$15.73
Rocker Reinforcement	2.66	$5.44	2.69	$6.73	2.49	$8.37	2.13	$7.18	2.14	$7.63	2.14	$10.15
Rocker Outer	3.37	$5.90	3.37	$5.90	3.37	$5.90	3.37	$5.90	3.37	$5.90	3.37	$5.90
Total	10.95	$21.50	10.52	$24.36	10.47	$28.04	9.80	$25.16	9.66	$27.86	9.66	$31.78

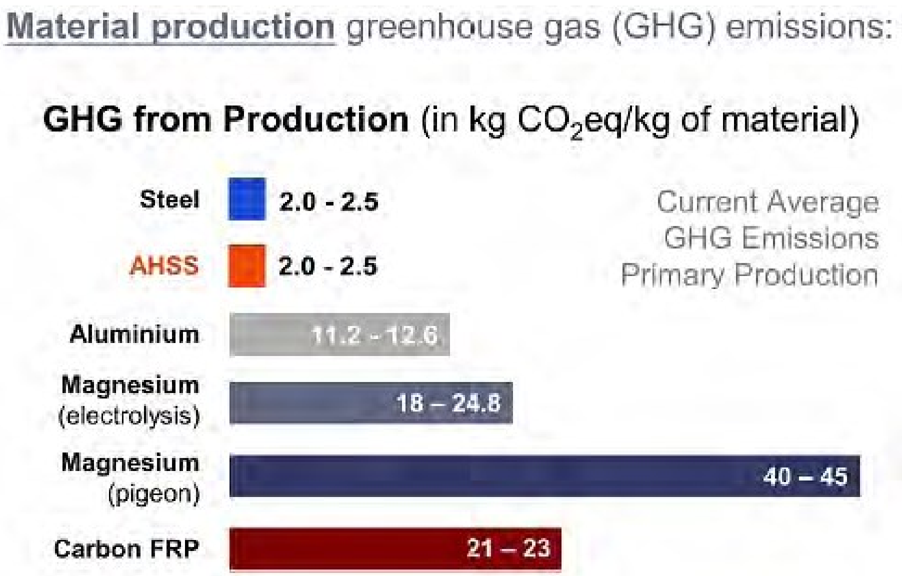
Part	Solution 2		Solution 3		Solution 4						Solution 5	
	Closed Roll Form		Closed Roll Form (TWC)		Hydroform		Hydroform (LWT)		Hydroform (MWT)		Aluminium Extrusion	
Name	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)
Rocker Inner-Reinforcment	6.30	$11.00	6.39	$12.48	5.37	$19.62	5.28	$24.71	5.28	$20.73	5.85	$36.52
Rocker Outer(Stamped)	1.68	$3.27	1.68	$3.27	1.68	$3.27	1.68	$3.27	1.68	$3.27	1.68	$3.27
Total	7.98	$14.27	8.07	$15.74	7.05	$22.88	6.96	$27.98	6.96	$24.00	7.53	$39.78

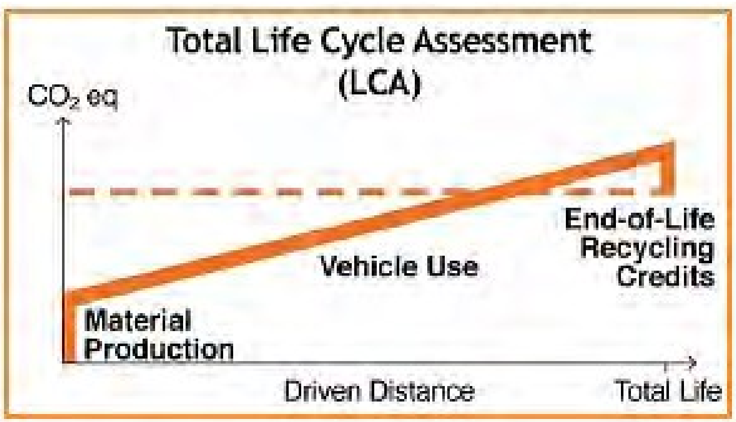
B-pillar sub-system Costs

Part	Manufacturing Portfolio											
	T4 - Sub System B-Pillar Analysis Solution 1											
	Stamping		Stamping (TRB)		Stamping(LWB)		Hot Stamping		Hot Stamping (TRB)		Hot Stamping (LWB)	
Name	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)
B-Pillar Inner	2.44	$8.62	2.39	$12.58	2.39	$9.01	2.32	$11.57	2.00	$14.31	2.00	$12.01
B-Pillar Reinforcement	1.62	$6.47	1.37	$10.71	1.37	$7.48	1.30	$8.35	1.29	$13.09	1.29	$11.34
B-Pillar Outer	2.19	$7.08	2.19	$7.08	2.19	$7.08	2.19	$7.08	2.19	$7.08	2.19	$7.08
Total	6.25	$22.17	5.95	$30.37	5.95	$23.57	5.81	$27.00	5.48	$34.48	5.48	$30.44
Part	Solution 2		Solution 3		Solution 4						Solution 5	
	Closed Roll Form		Open - Roll Form		Hydroform		Hydroform (LWT)		Hydroform (MWT)		Aluminium Stamping	
Name	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)	Mass (kg)	Piece Cost ($)
B-Pillar Inner, Outer + Reinforcement	3.99	$8.32	x	x	x	x	2.94	$20.82	x	x	NA	NA
B-Pillar Inner	NA	NA	x	x	x	x	NA	NA	x	x	2.71	$27.42
B-Pillar Reinforcement	NA	NA	x	x	x	x	NA	NA	x	x	0.39	$8.56
B-Pillar Outer	2.19	$7.08	x	x	x	x	2.19	$7.08	x	x	1.59	$22.97
Total	6.18	$15.40	x	x	x	x	5.13	$27.91	x	x	4.69	$58.95

Total Life Cycle Assessment

– metric CO_2e: typical greenhouse gases and their Global Warming Potential
  - Carbon dioxide has a GWP of 1
  - Methane has a GWP of 21
  - Nitrous oxide has a GWP of 310
  - Perfluorocarbons (HFC) has a GWP range of 140 to 11,700
  - Sulphur Hexafluoride has a GWP of 23.90





Total vehicle life cycle emissions: Rocker

FSV Sub-system	Material CO_2e	Manufacturing CO_2e	Use CO_2e	Recycling CO_2e	Total Vehicle Life Cycle CO_2e
Rocker, Baseline	2290.8	5.7	14640.2	(956.8)	15980.0
Solution 1 - Stamping	2299.4	6.1	14688.3	(960.6)	16033.2
Solution 1 - Stamping TRB	2292.9	6.0	14654.8	(957.6)	15996.1
Solution 1 - Stamping LWB	2292.3	16.9	14658.1	(957.3)	16010.0
Solution 2 - Hot Stamping	2272.9	9.7	14608.1	(947.7)	15942.9
Solution 2 - Hot Stamping TRB	2271.7	9.7	14598.5	(947.2)	15932.7
Solution 2 - Hot Stamping LWB	2271.7	20.4	14598.5	(947.2)	15943.4
Solution 3 - Closed Roll Form	2246.0	5.1	14481.6	(935.3)	15797.4
Solution 3 - Closed Roll Form (TRB)	2238.4	4.8	14479.5	(931.3)	15791.5
Solution 3 - Closed Roll Form (TWC)	2245.5	4.8	14487.9	(934.9)	15803.3
Solution 5 - Hydroform	2223.3	15.9	14416.8	(924.2)	15731.9
Solution 5 - Hydroform LWT	2223.1	25.6	14410.6	(924.2)	15735.1
Solution 5 - Hydroform TRT	2222.5	15.9	14410.6	(923.9)	15725.1
Aluminium Extrusion	2350.8	8.6	14425.1	(1008.5)	15775.9