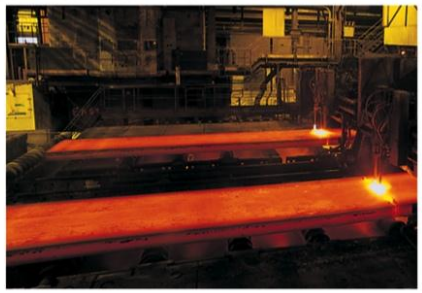




A Great American Steel Company

AK Steel

SAFETY | QUALITY | PRODUCTIVITY

This Is AK Steel

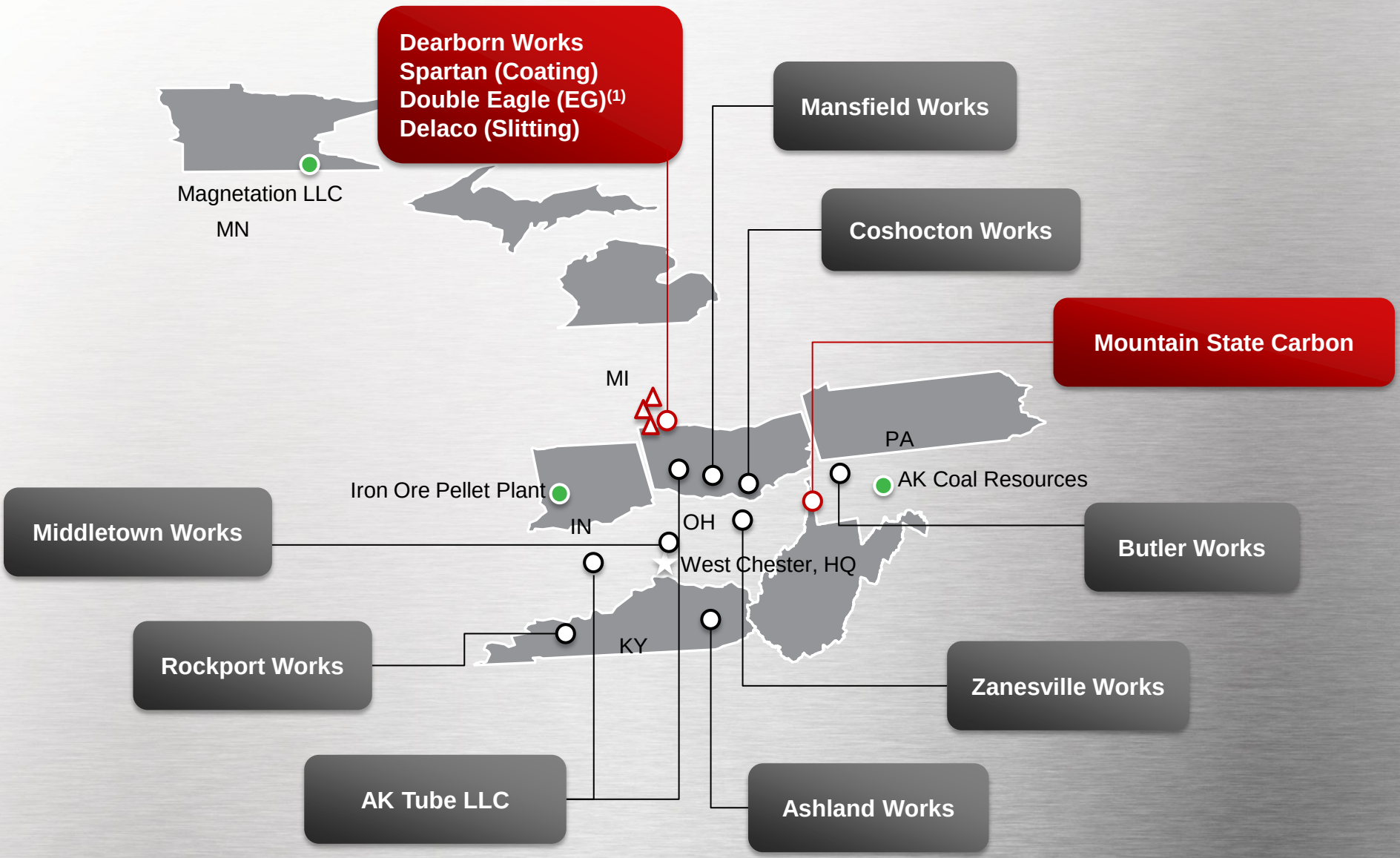
- NYSE: AKS
- Key values:
  - Safety
  - Quality
  - Productivity

Max Eward
Safety Award Winner

Company Heritage

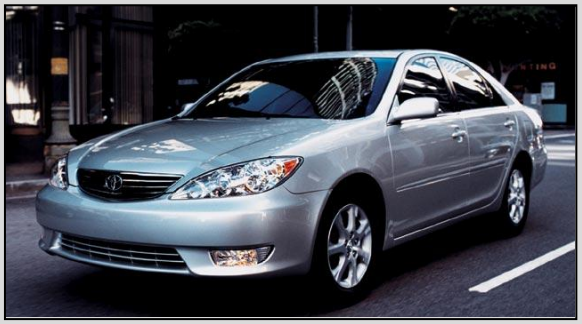
First Heat: February 7, 1901

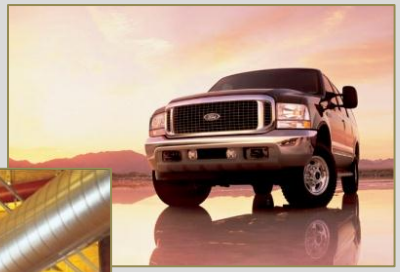
Facilities and Strategic Investments

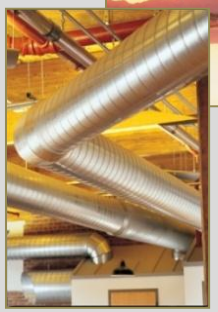


Products

Carbon Steels

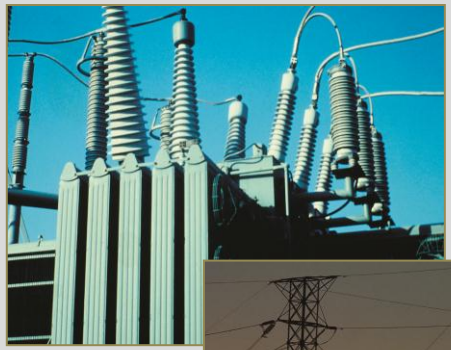


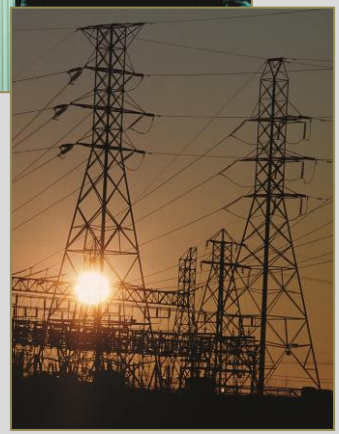




Stainless Steels

Electrical Steels





FutureSteelVehicle

Nature's Way to Mobility

Design Optimization Technologies in the Development of the Future Steel Vehicle (FSV)

October 28th 2014

AK Steel

Presentation Topics

FutureSteelVehicle

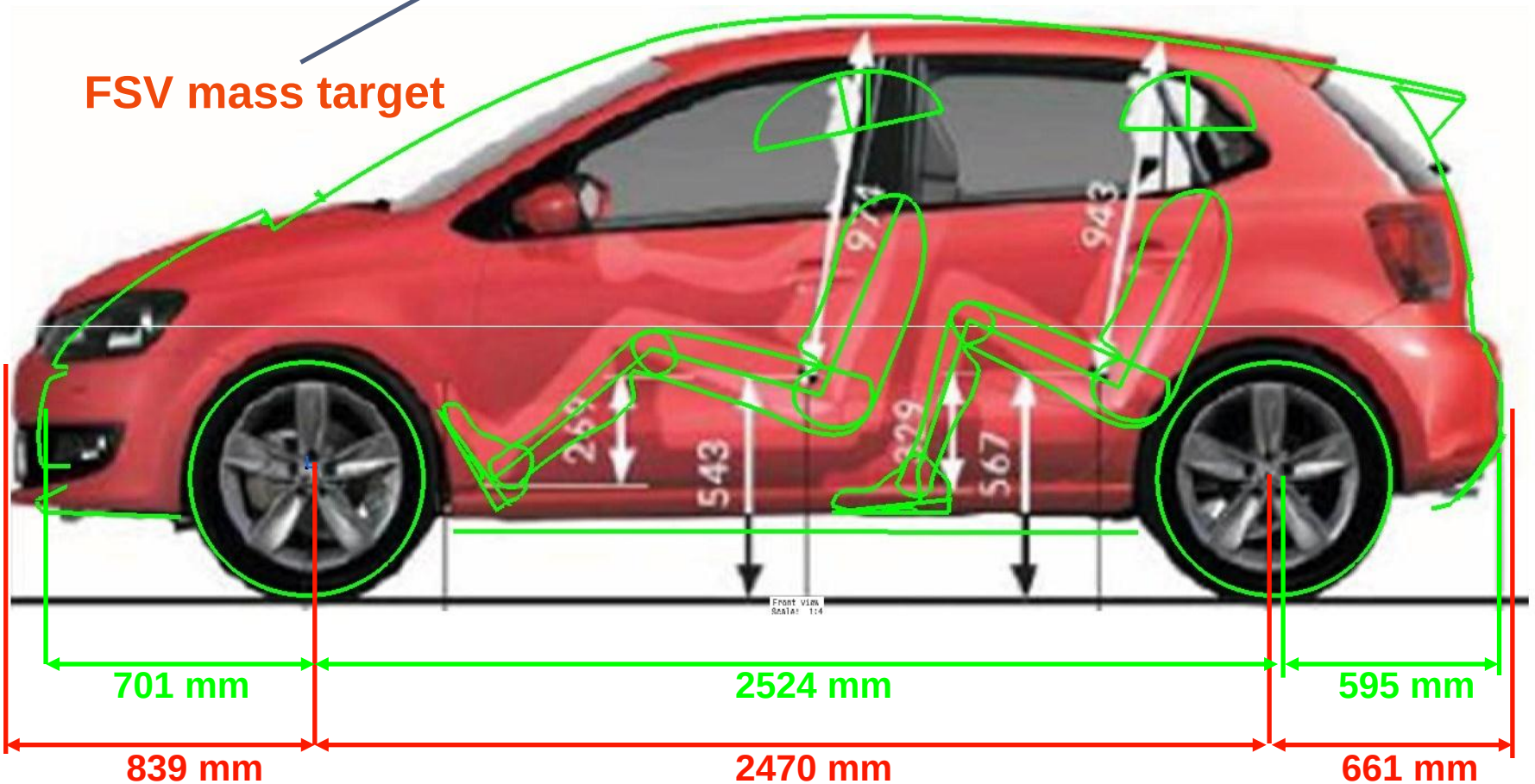
- Objectives
- Design Methodology W/ Focus on GENESIS Topomentry Optimization
- Results

FSV Design Drivers

- Mass reduction
- Cost
- Total vehicle carbon footprint - GHG Emissions; CO2e (kg)
  - Material Manufacture
  - Vehicle Manufacture
  - Vehicle use phase (200,000 km)
  - Vehicle recycling

Mass Target Setting

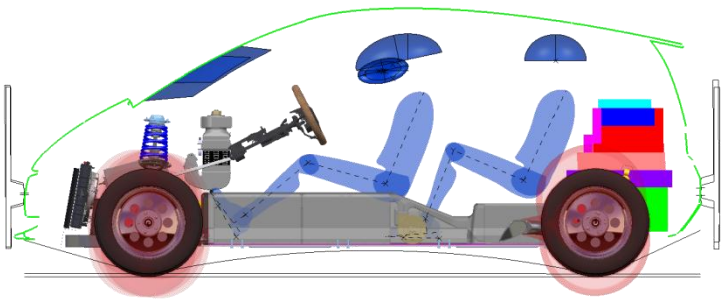
	Body Structure Mass (kg)	Powertrain Mass (kg)
FSV	190	329
VW Polo 2010	231	233



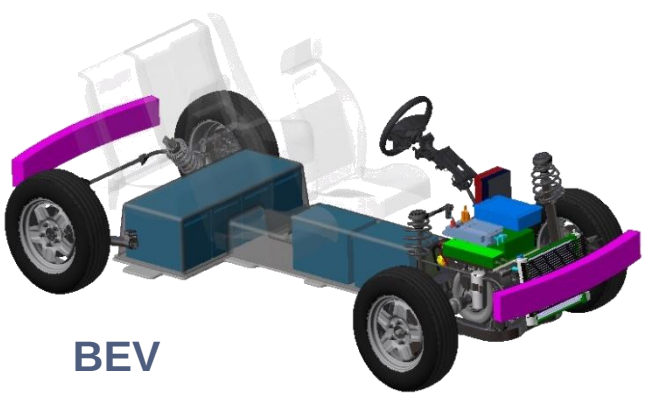
AK Steel

Advanced Powertrain Options

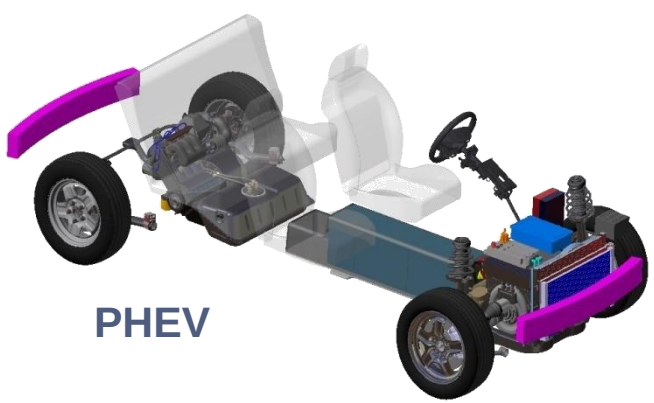
FSV 1 4-door hatchback 3700 mm	**PHEV20** Electric Range: 32km Total: 500km Max Speed: 150km/h 0-100 km/h 11-13 s	**BEV** Total Range: 250km Max Speed: 150km/h 0-100 km/h 11-13 s
FSV 2 4-door sedan 4350 mm	**PHEV40** Electric Range: 64km Total: 500km Max Speed: 161km/h 0-100 km/h 10-12 s	**FCEV** Total Range: 500km Max Speed: 161km/h 0-100 km/h 10-12 s



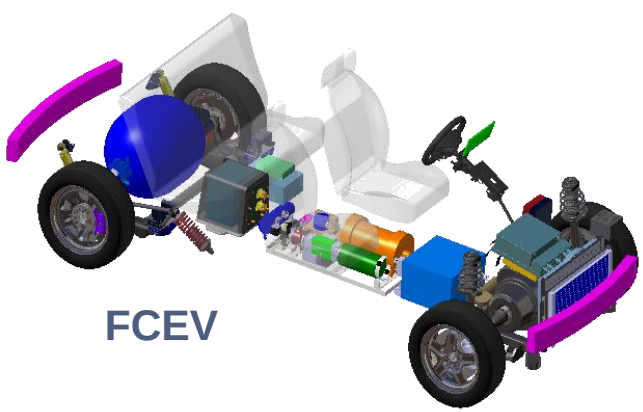
Occupant Package



BEV



PHEV



FCEV

AK Steel

FSV Steel Portfolio

Expanded Range of Steel Grades

Mild 140/270	DP 350/600	TRIP 600/980
BH 210/340	TRIP 350/600	TWIP 500/980
BH 260/370	SF 570/640	HSLA 700/780
BH 280/400	HSLA 550/650	DP 700/1000
IF 260/410	TRIP 400/700	CP 800/1000
IF 300/420	SF 600/780	MS 950/1200
DP300/500	CP 500/800	CP 1000/1200
FB 330/450	DP 500/800	DP 1150/1270
HSLA 350/450	TRIP 450/800	MS 1150/1400
HSLA 420/500	CP 600/900	CP 1050/1470
FB 450/600	CP 750/900	HF 1050/1500
HSLA 490/600		MS 1250/1500

denotes steel included in ULSAB-AVC

denotes steel grades added for FSV

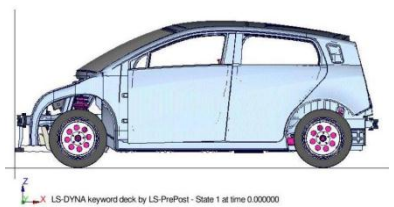
AK Steel

Design Optimisation Automated Process

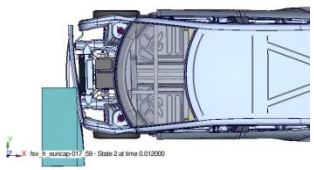
State-of-the-Future Design Development

FSV Crash Safety Analyses

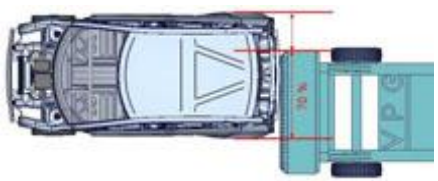
Global Reach Requirements



US NCAP

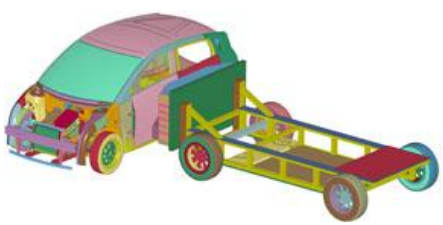


EURO NCAP

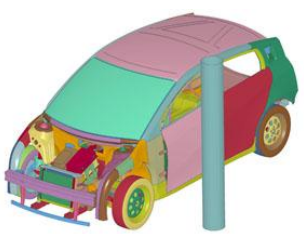


FMVSS 301 Rear

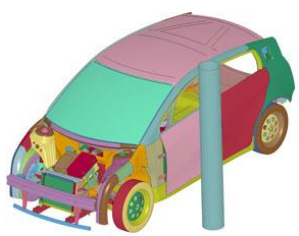
ECE R32



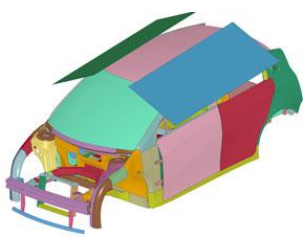
IIHS Side



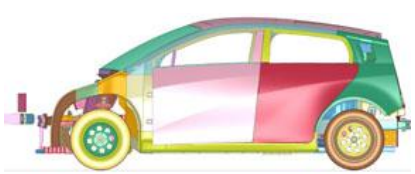
FMVSS 214 Pole



EURO NCAP Pole



FMVSS 216a, IIHS Roof



RCAR/IIHS Low Speed

AK Steel

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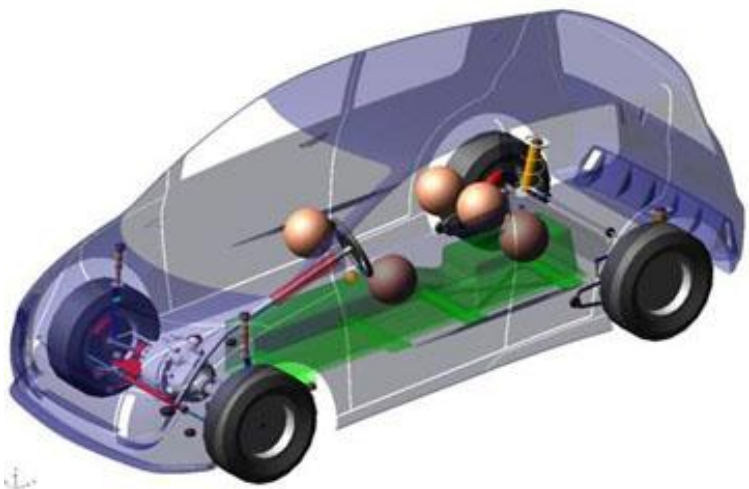
Durability and NVH Analysis

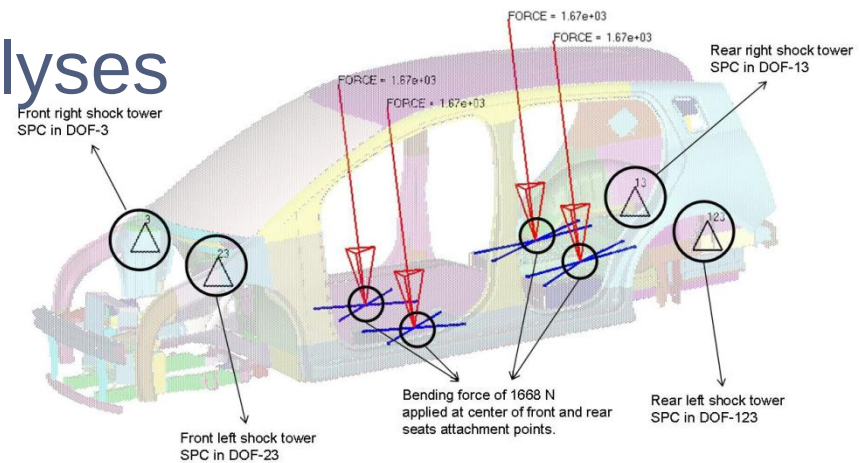
Durability, Ride and Handling Analyses

- Fish-hook test
- Double lane change maneuver (ISO 3888-1)
- 3g pothole test
- 0.7g constant radius turn test
- 0.8g forward braking test



Static and Dynamic Stiffness Analyses

- Torsion Stiffness
- Bending Stiffness
- Global Modes



AK Steel

14

FSV Design Methodology

Phase1
Technology Assessment

Packaging

Styling &
aerodynamic

T1

Linear-Static
Topology
Optimisation

T2

Non-Linear Dynamic
Optimization
(LF3G)

T3

Sub-System
Optimization

T4

Detail Design

T5

Design
Confirmation

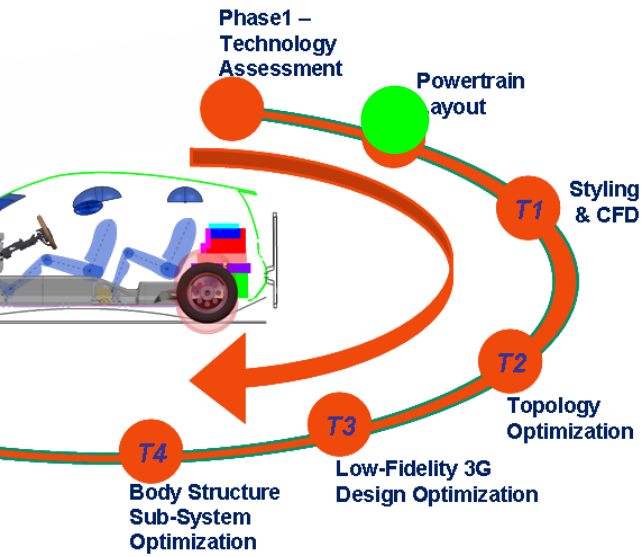
Gauge
Optimisation

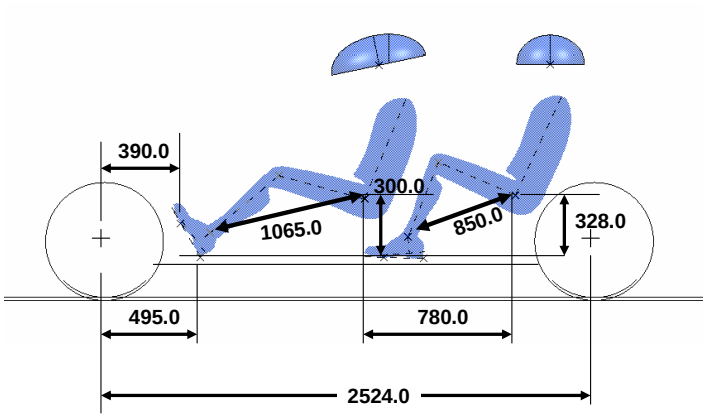
T6

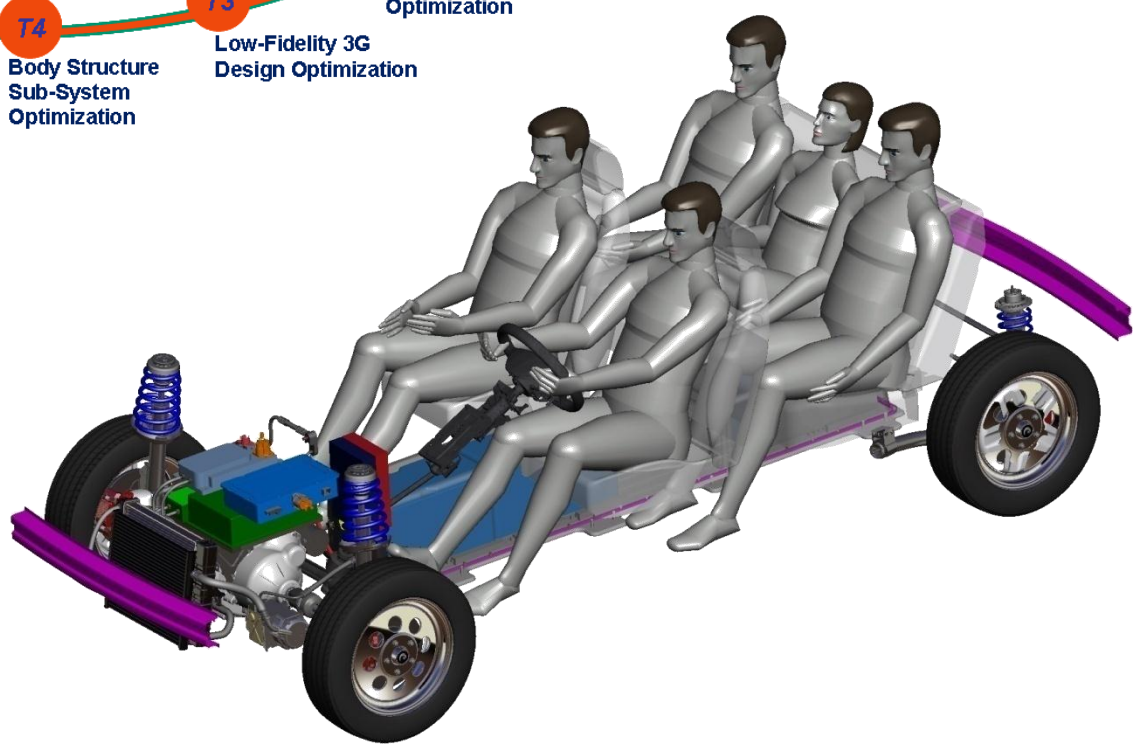
Final Design
Confirmation

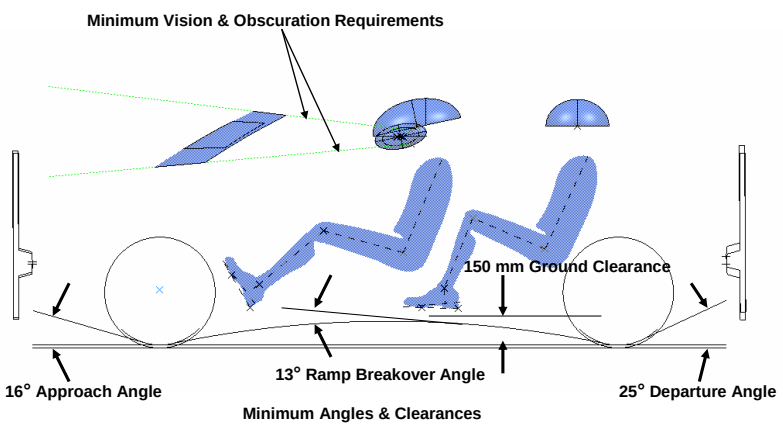
Phase 2
Report

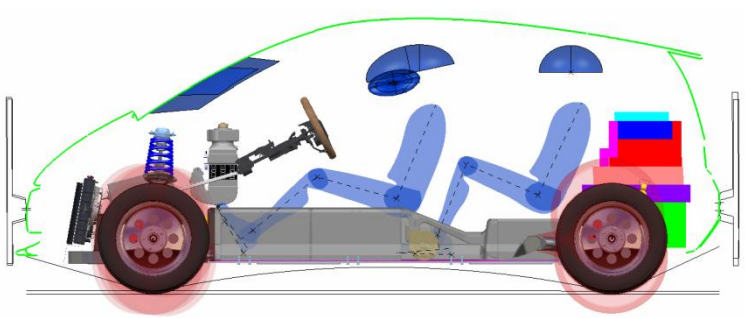
FSV BEV Packaging



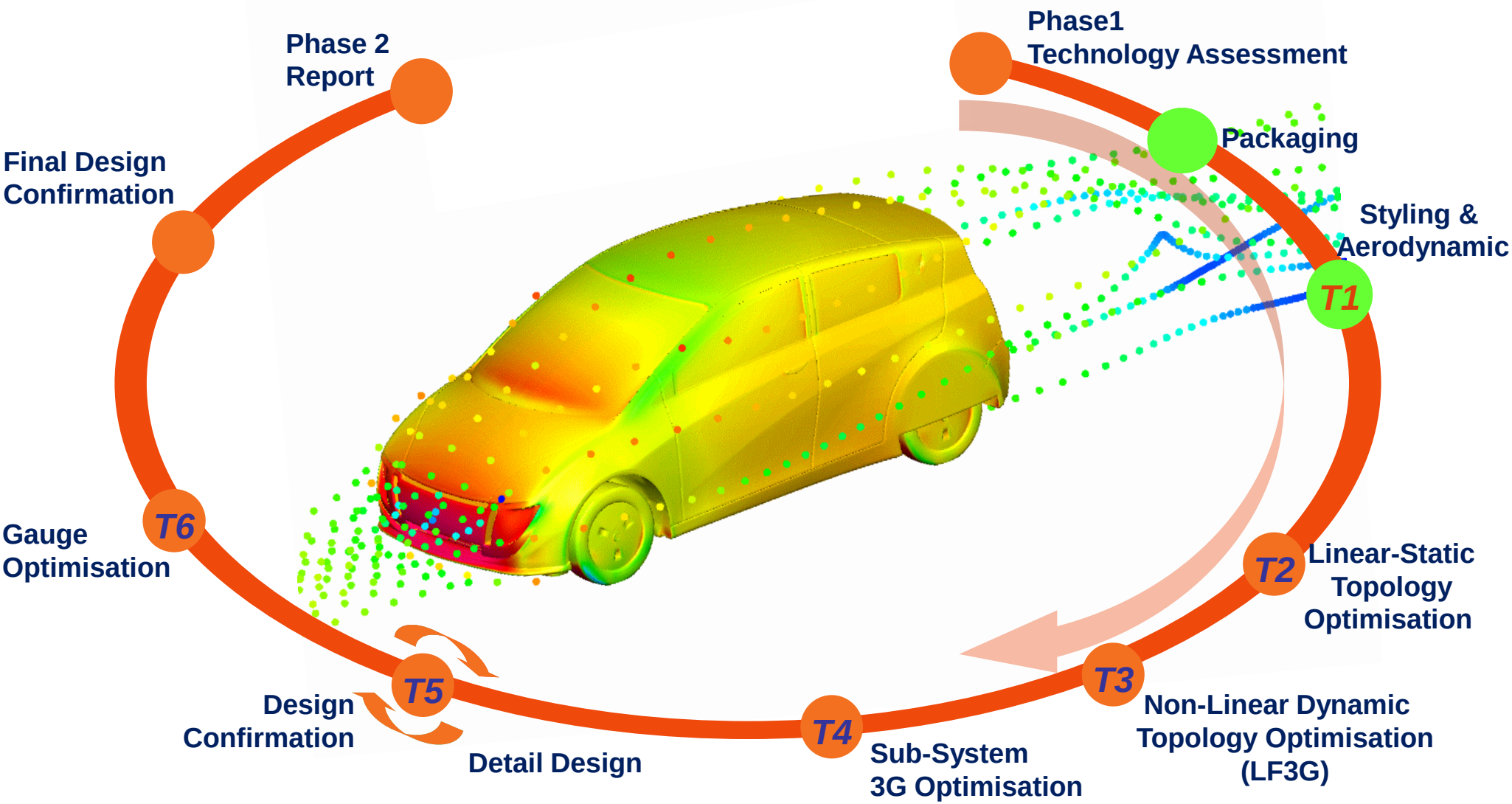




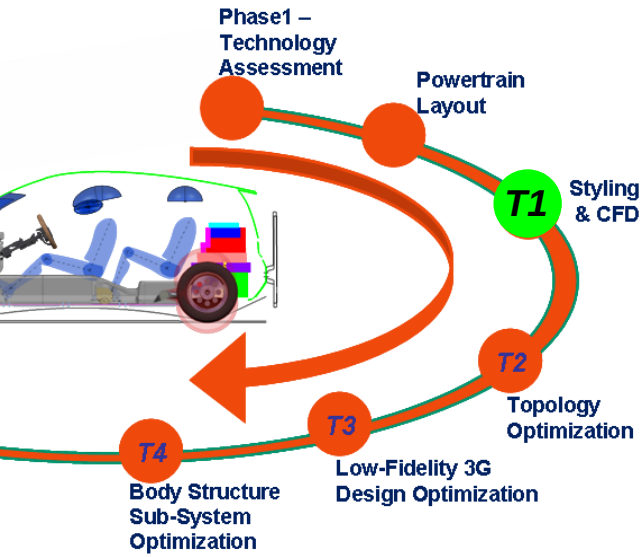


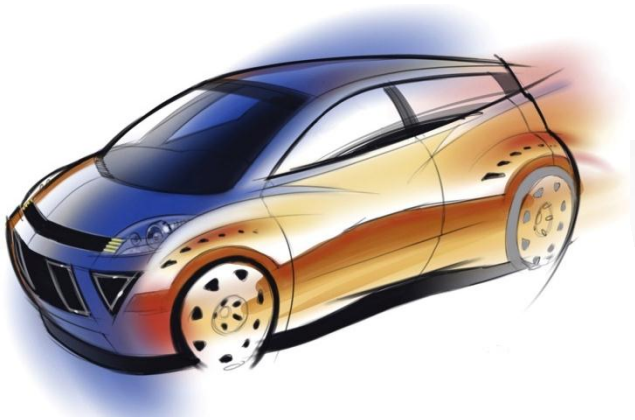


Aerodynamics & Styling

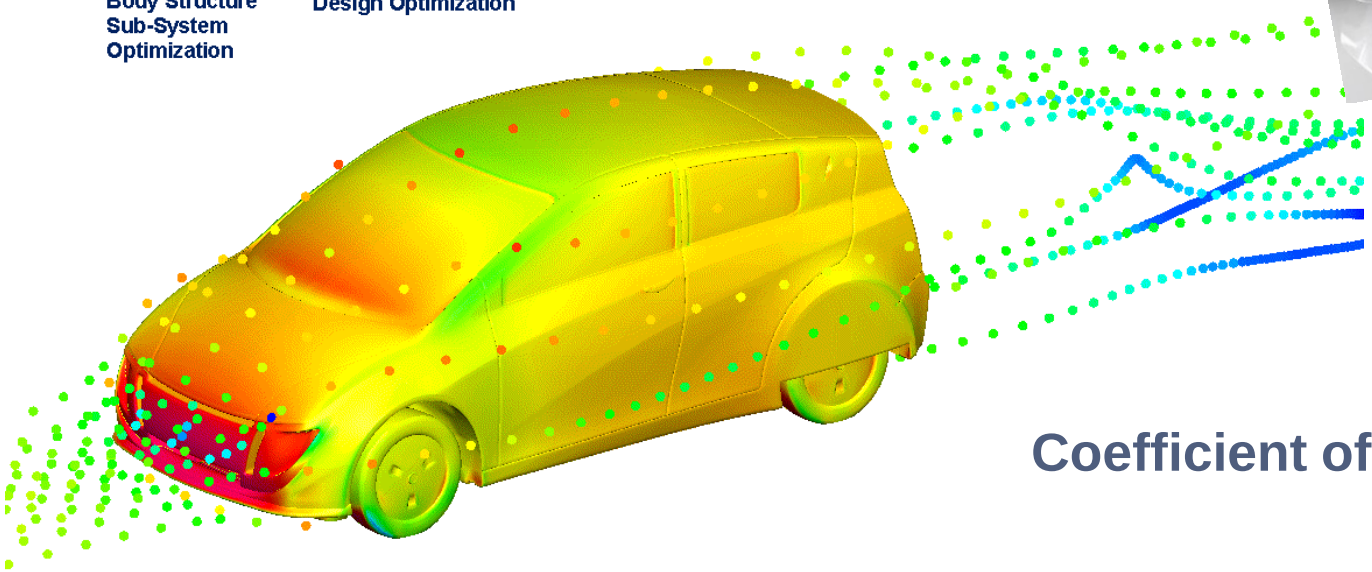


Styling & CFD





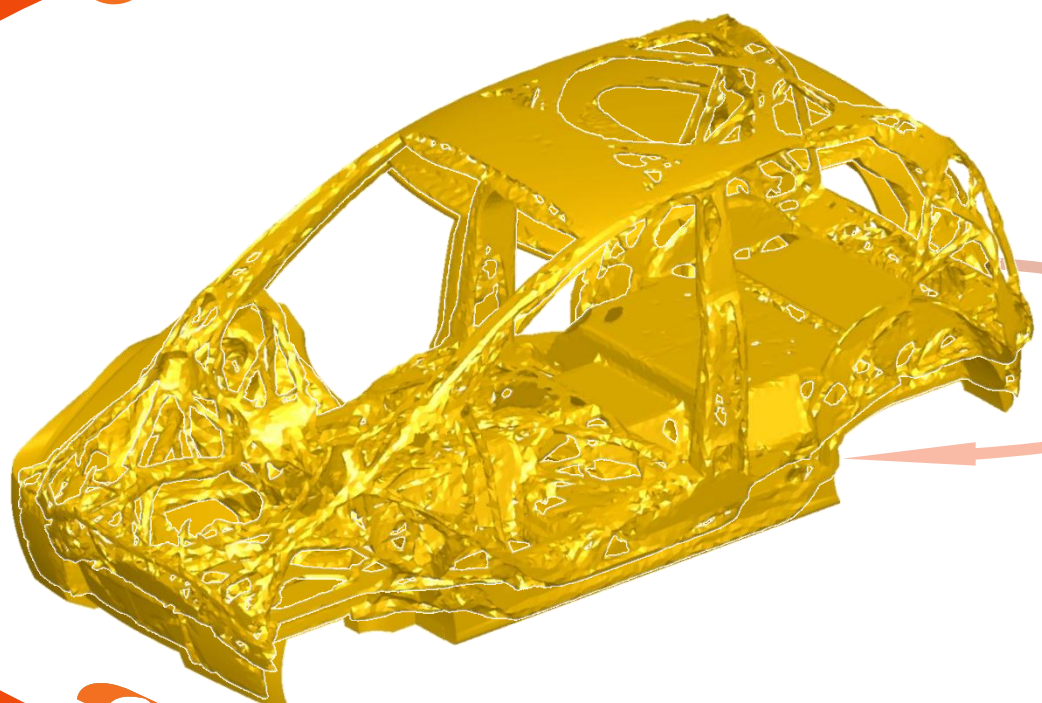
First styling theme



Coefficient of Drag (CD) Target: 0.25

Latest Styling CD: 0.24

Linear-Static Topology Optimization (GENESIS)



Phase1
Technology Assessment

Packaging

Styling &
Aerodynamic

T2 Linear-Static
Topology
Optimisation

T3 Non-Linear Dynamic
Optimization
(LF3G)

T4 Sub-System
Optimization

T5 Design
Confirmation

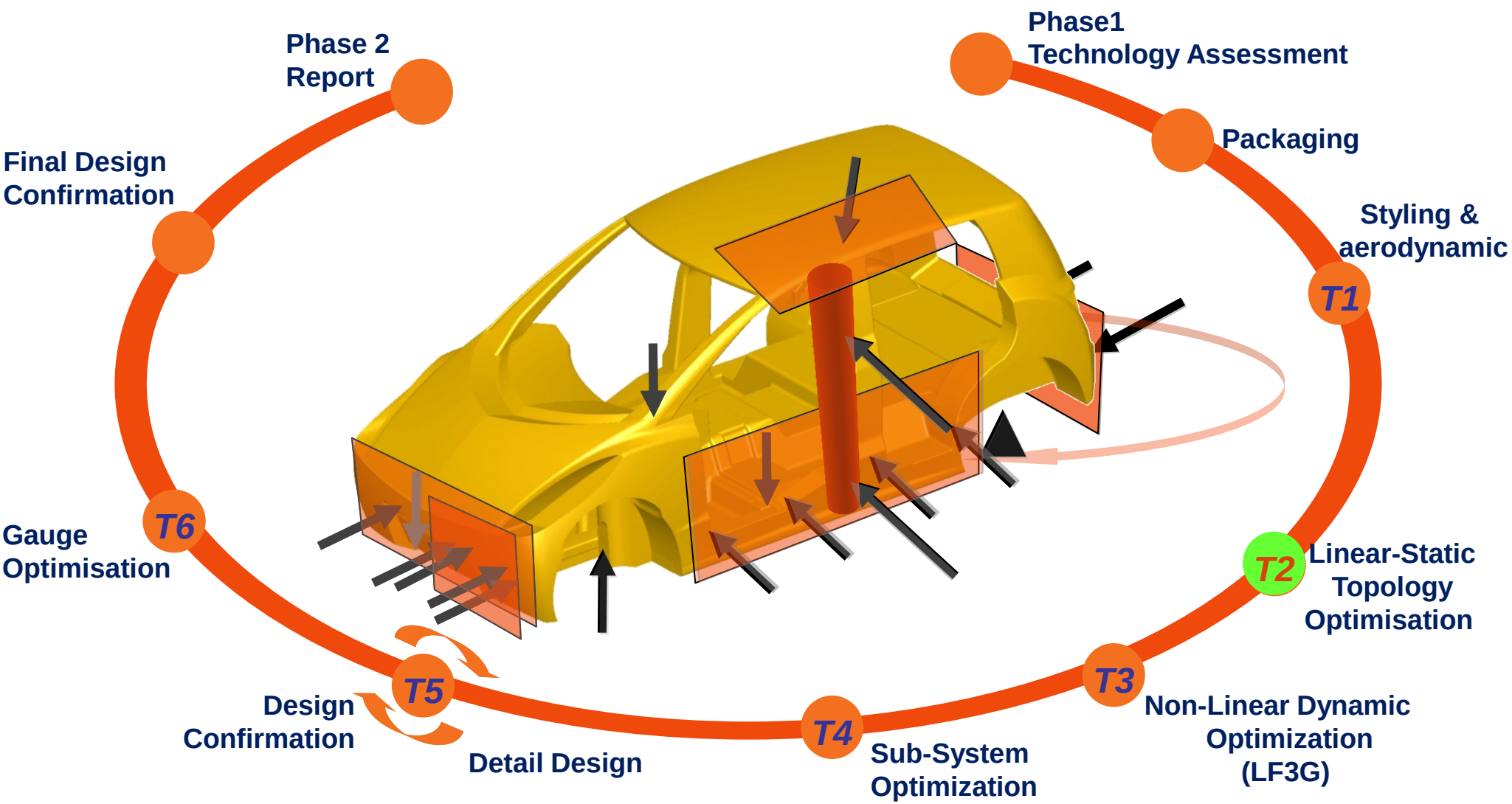
Detail Design

T6 Gauge
Optimisation

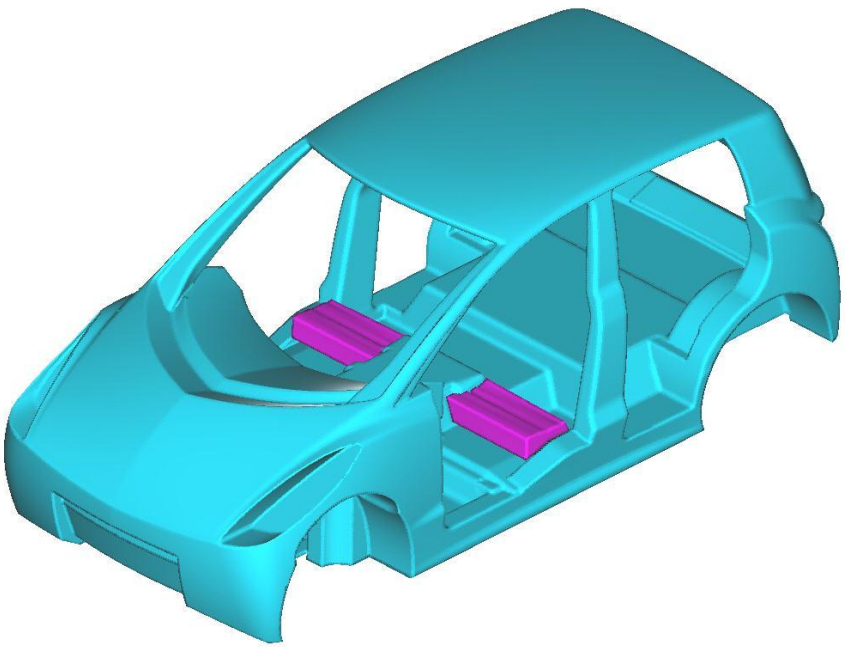
Final Design
Confirmation

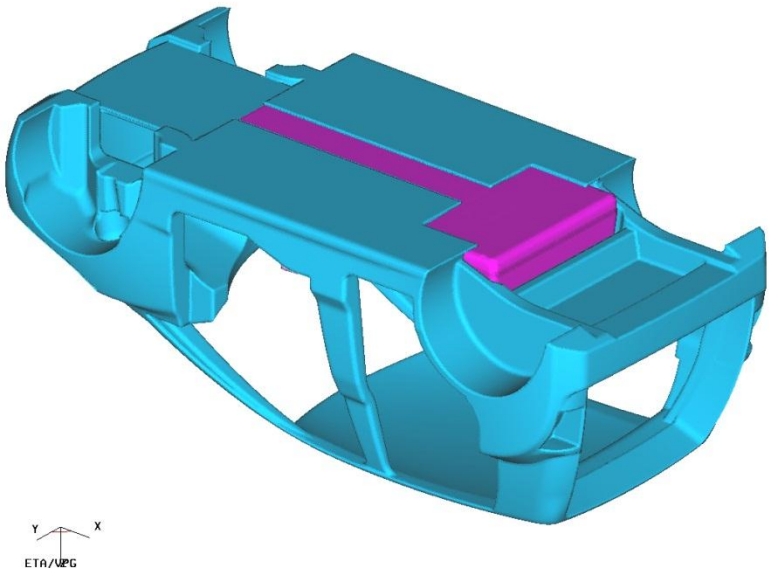
Phase 2
Report

Topology Optimization Load Cases (GENESIS)



Optimization Design Space



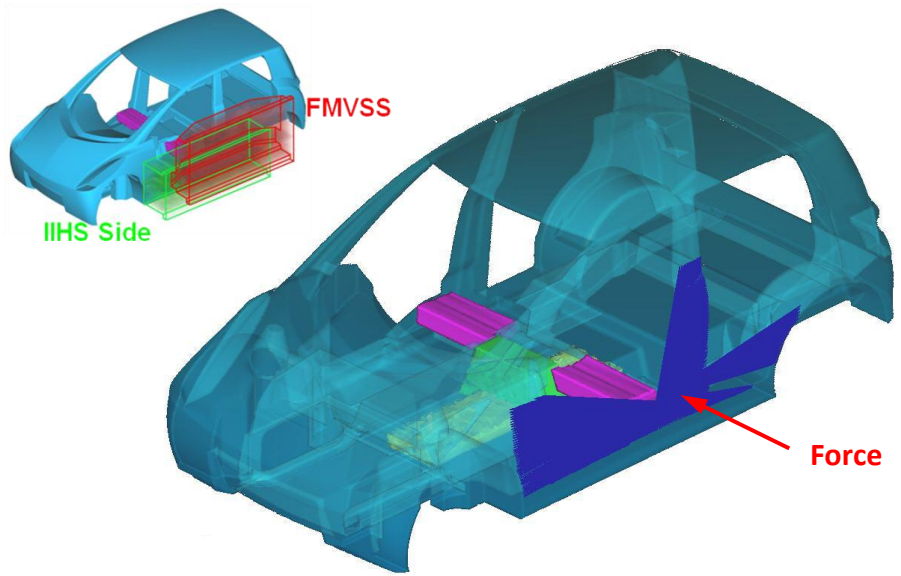


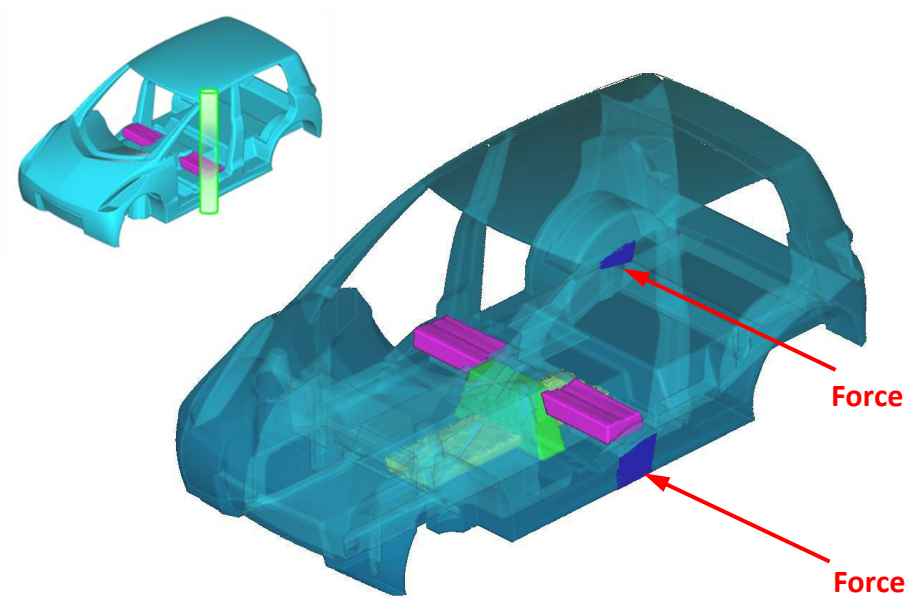
Multiple Vehicle Design Spaces:
Battery Floor
Battery Bulkhead
Seat Cross-member
BIW (Body-In-White)

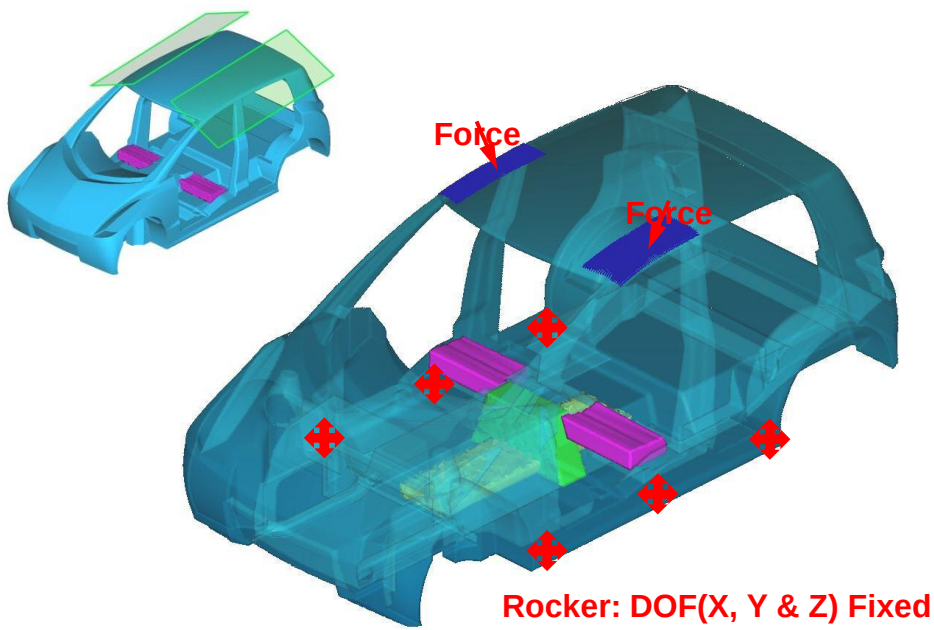
AK Steel

Linearized Load Cases (GENESIS Inputs)

LOADCASES		WEIGHTING FACTOR
Longitudinal	IIHS Front Impact 40% ODB	1
	NCAP Front Impact	
	FMVSS 301 Rear Impact 70% ODB	
Lateral	IIHS Side Impact	1
	FMVSS 214 Pole Impact	
Vertical	FMVSS 216 Roof Crush	1
Static Bending Stiffness		1
Static Torsional Stiffness		1
TOTAL NUMBER OF OBJECTIVES		5

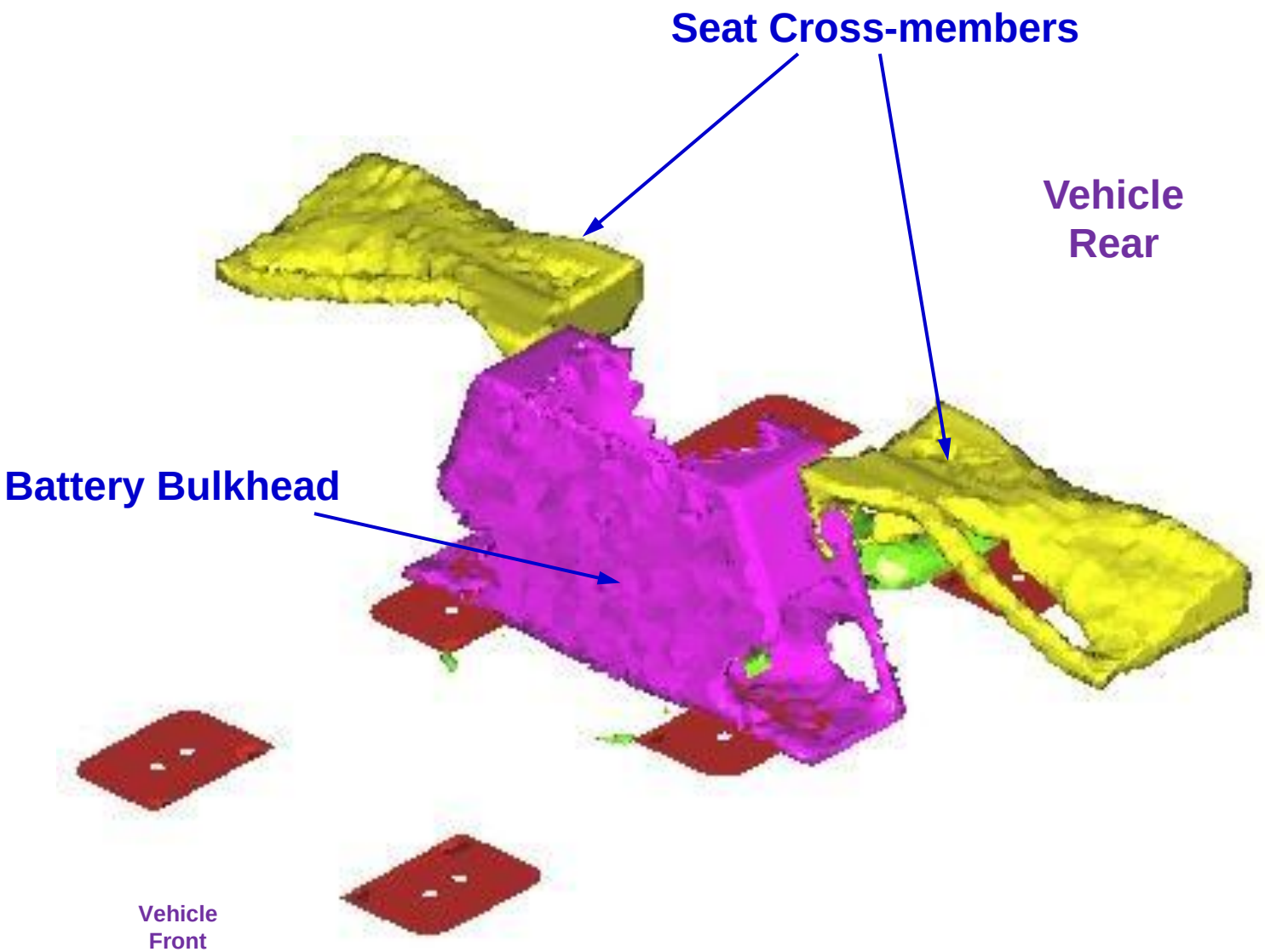




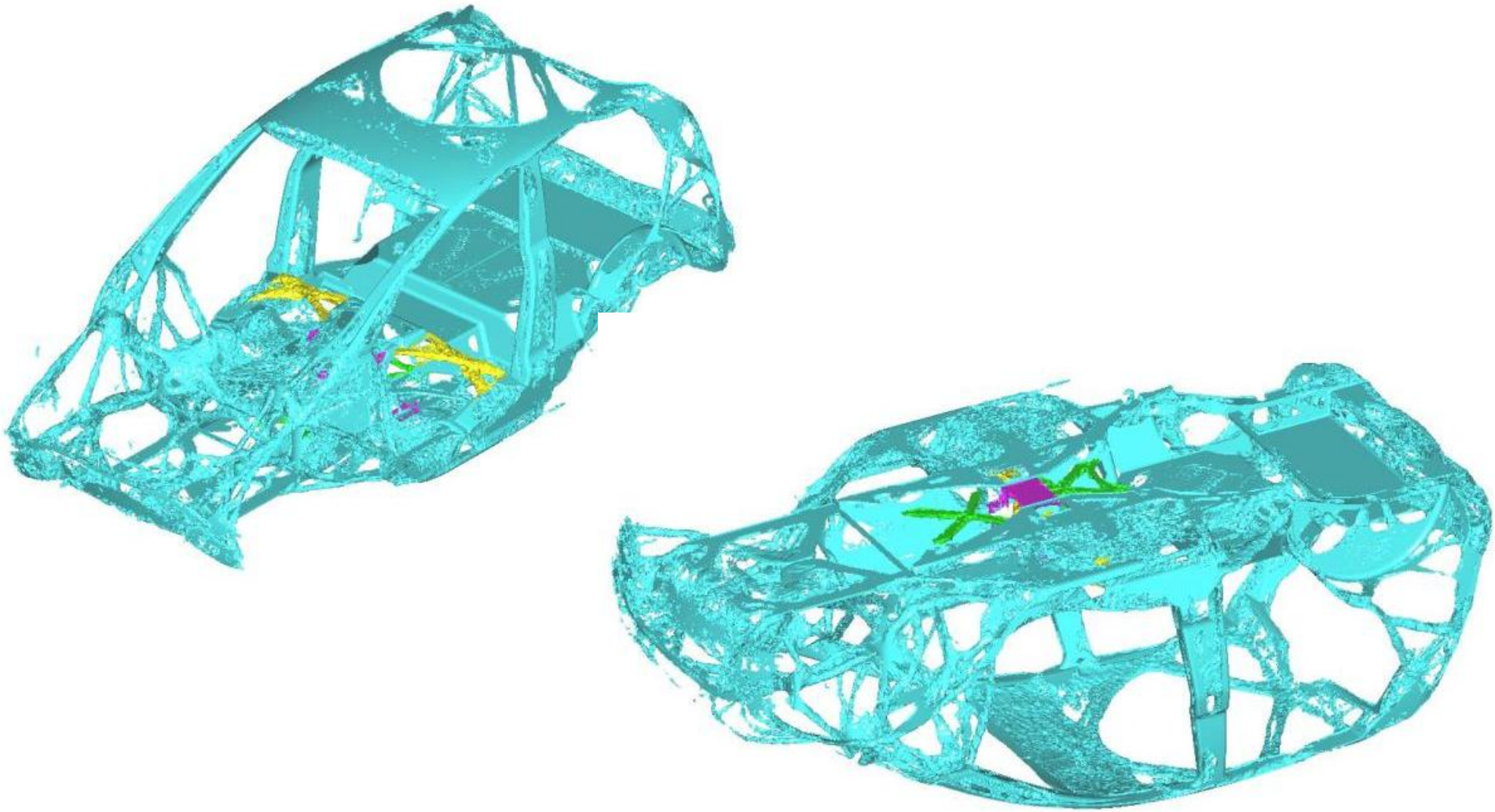


AK Steel

Interpreting Results Sub Design Spaces



Interpreting Results BIW Design Space



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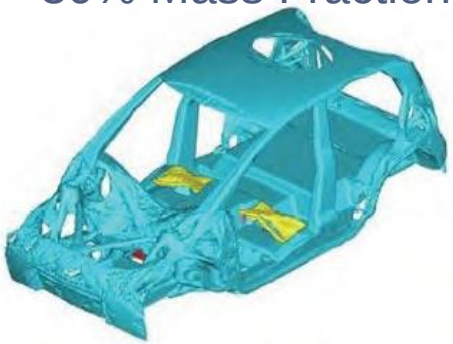
Topology Optimization Mass Fractions

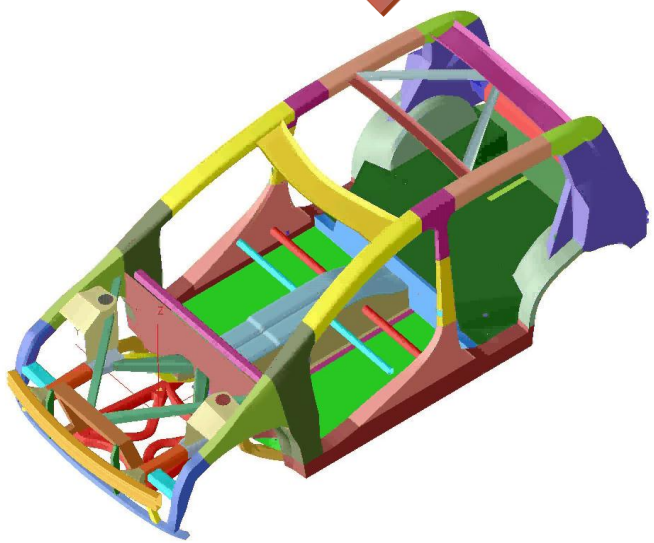
30% Mass Fraction



20% Mass Fraction

10% Mass Fraction

Creation of Sheet Structure

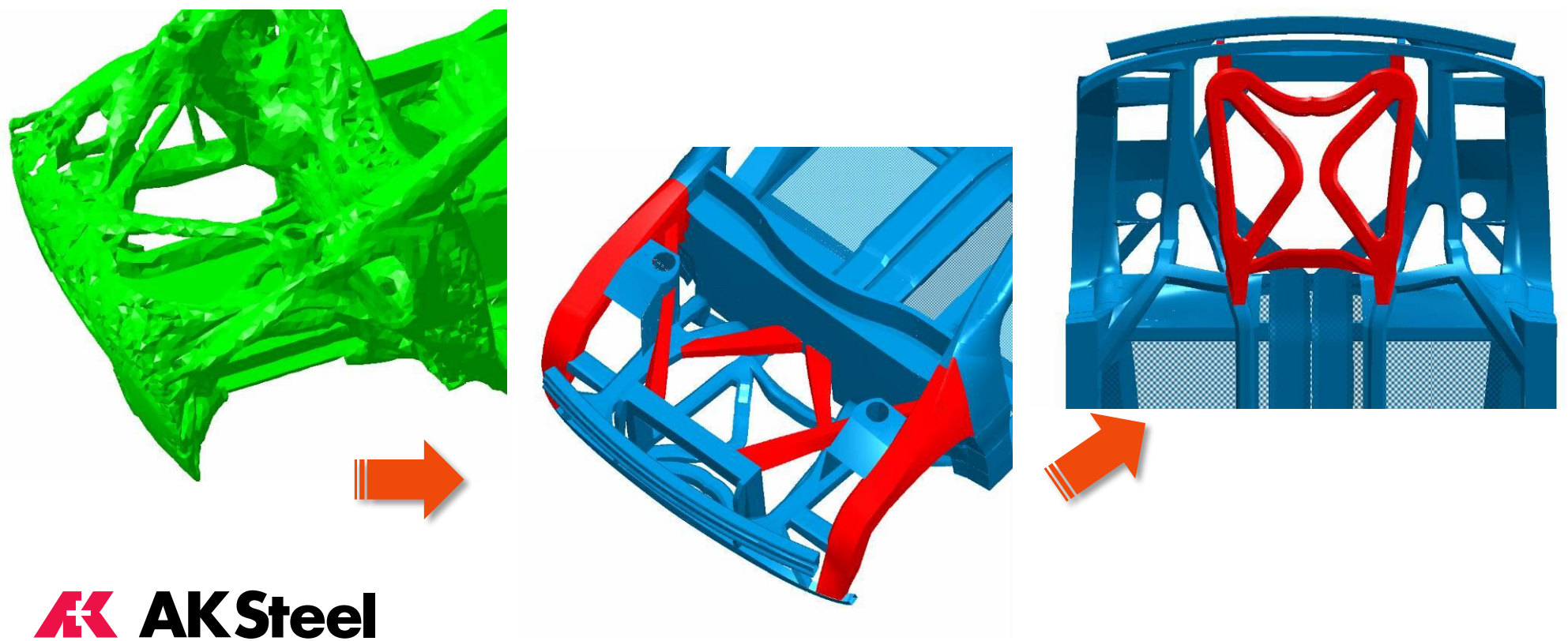


Interpreted CAD Geometry

AK Steel

Linear-Static Topology Optimisation Results

- Topology optimization drives the material of structure to where it is most effective.
- Allow Topology Load Path Optimisation to influence locations and shape of components based on Packaging.
- Topology Optimisation is interpreted by engineering judgment.



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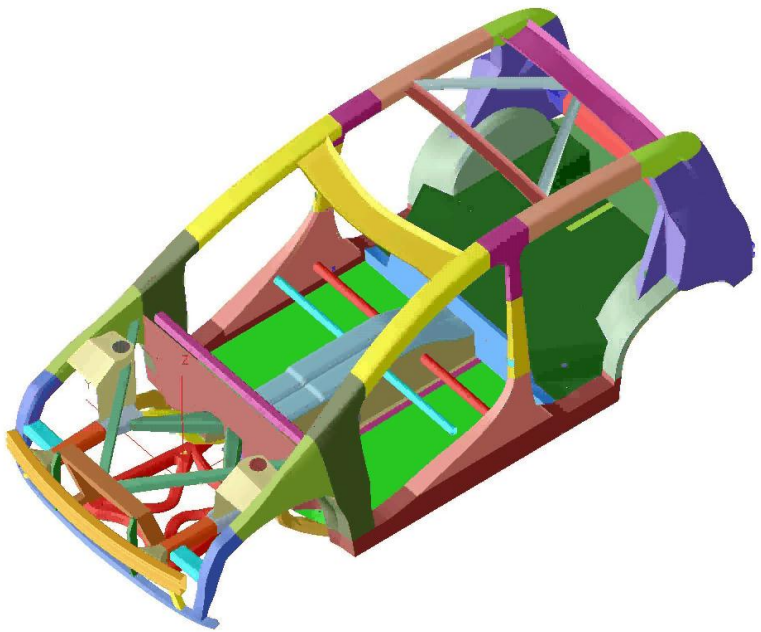
LF3G Load Path and 3G Optimisation



Phase1
Technology Assessment

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aerodynamic

T1

Linear-Static
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Non-Linear Dynamic
Topology Optimization
(LF3G)

T4

Sub-System
Topography
Optimization

T5

Detail Design

Design
Confirmation

T6

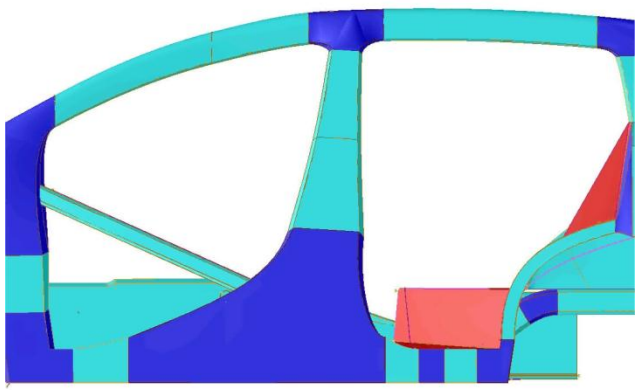
Gauge
Optimization

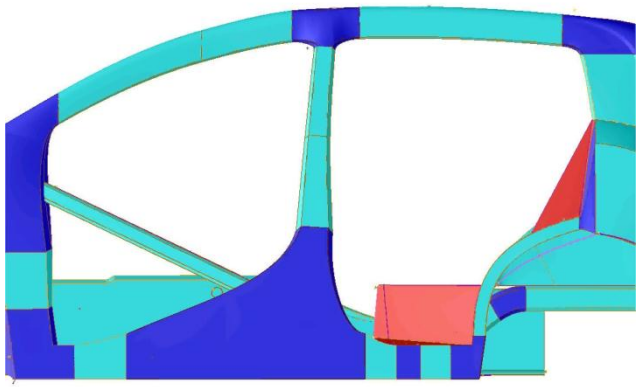
Final Design
Confirmation

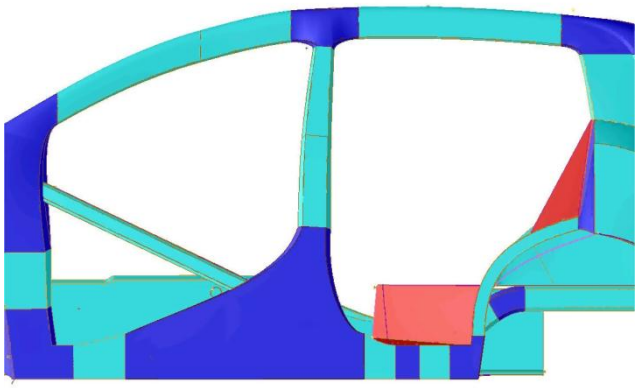
Phase 2
Report

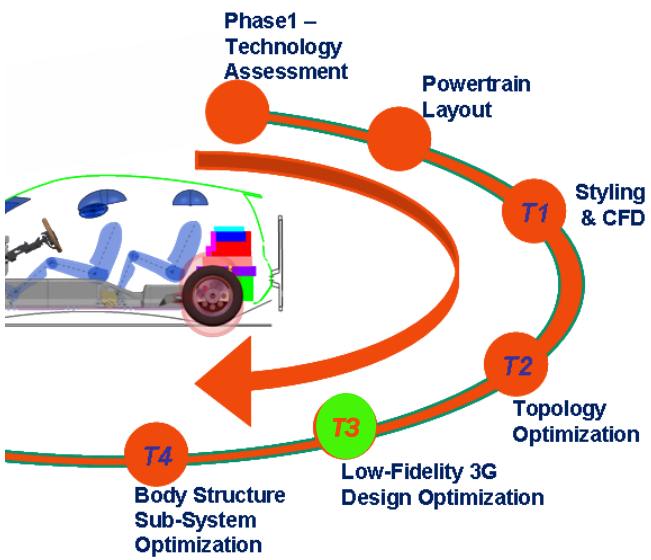
AK Steel

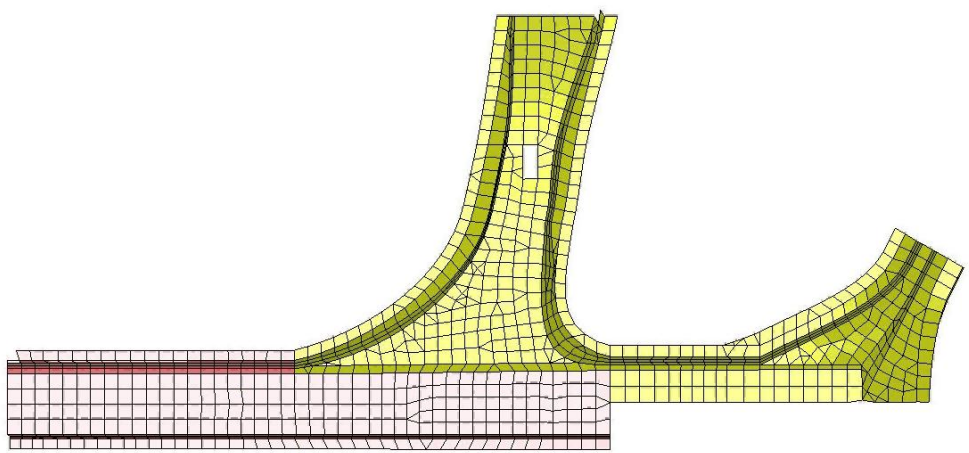
Low Fidelity 3G (Geometry, Gauge & Grade) Optimisation



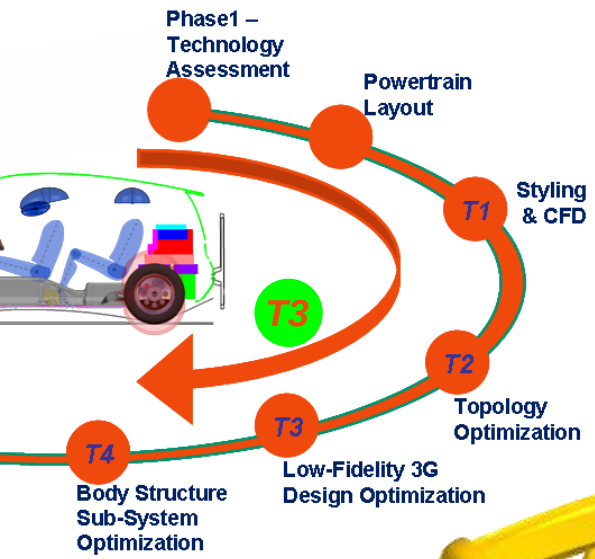


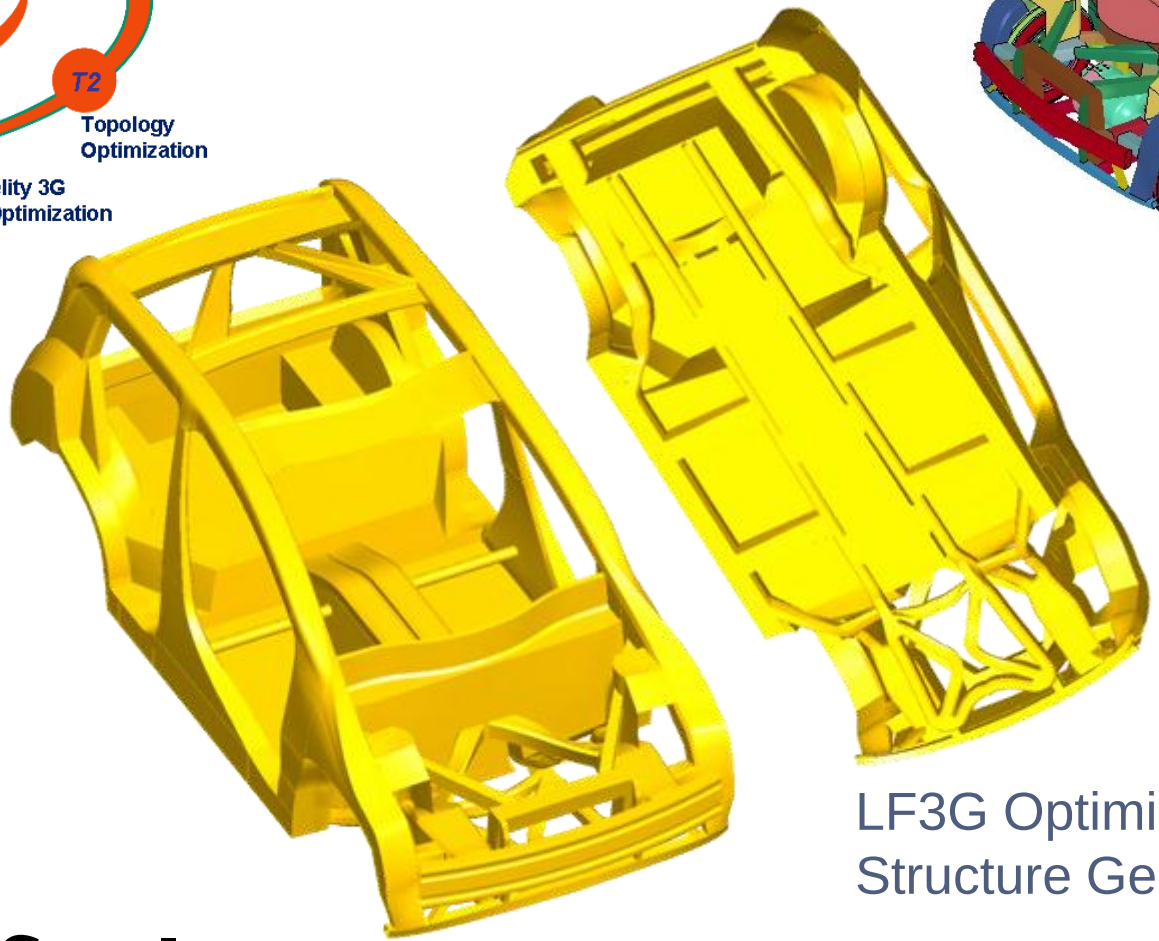






Low Fidelity 3G (LF3G) Optimization – Results





LF3G Optimized Body Structure Geometry

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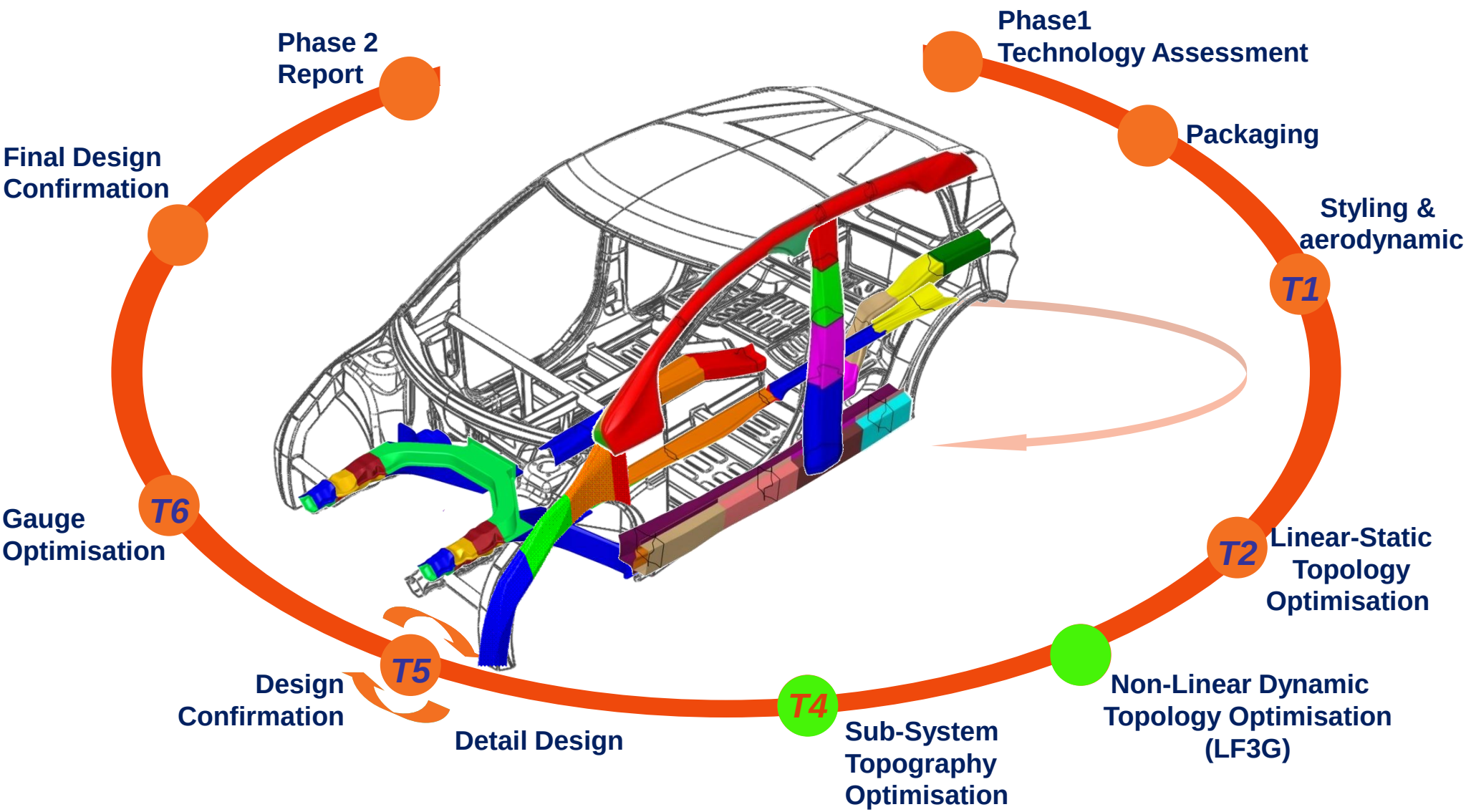
Sub-Systems 3G Optimisation



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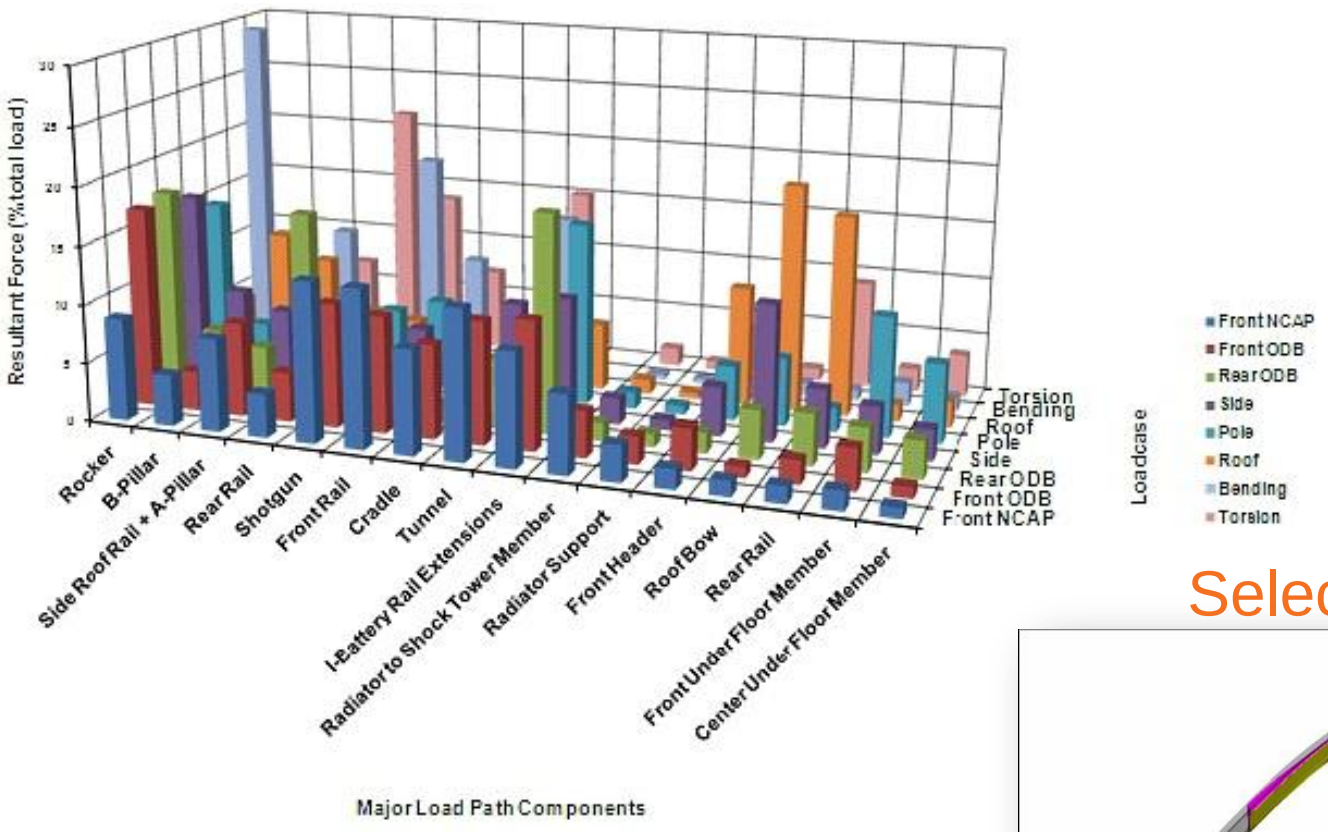
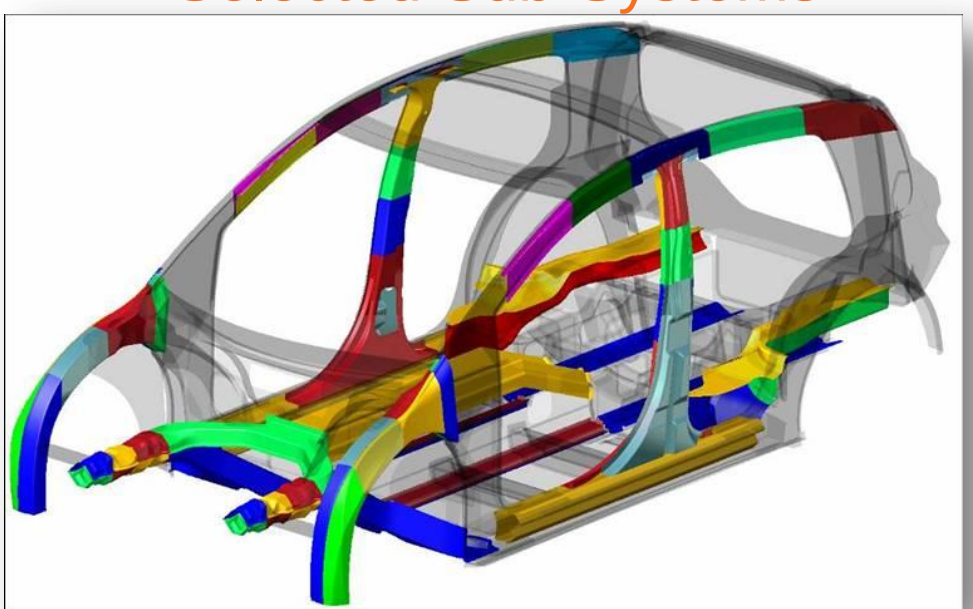
T4 Load Path Mapping



Selected Sub-Systems



- Front Rail
- Shot Gun
- Rocker
- B-Pillar
- Rear Rail
- Roof Rail
- Tunnel Reinforcement

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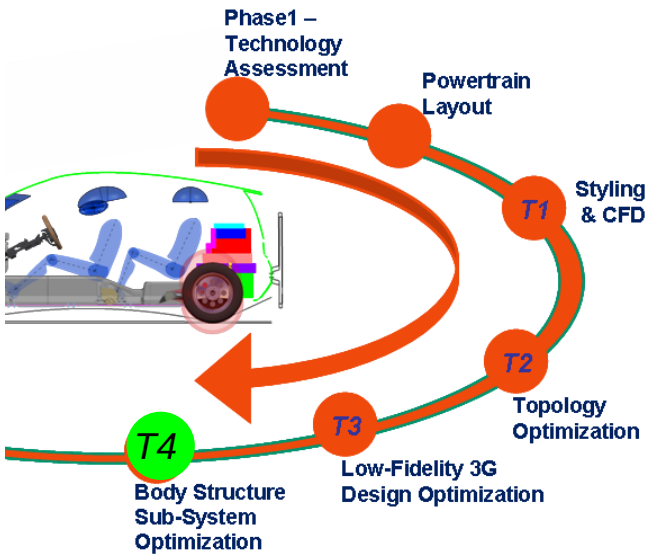
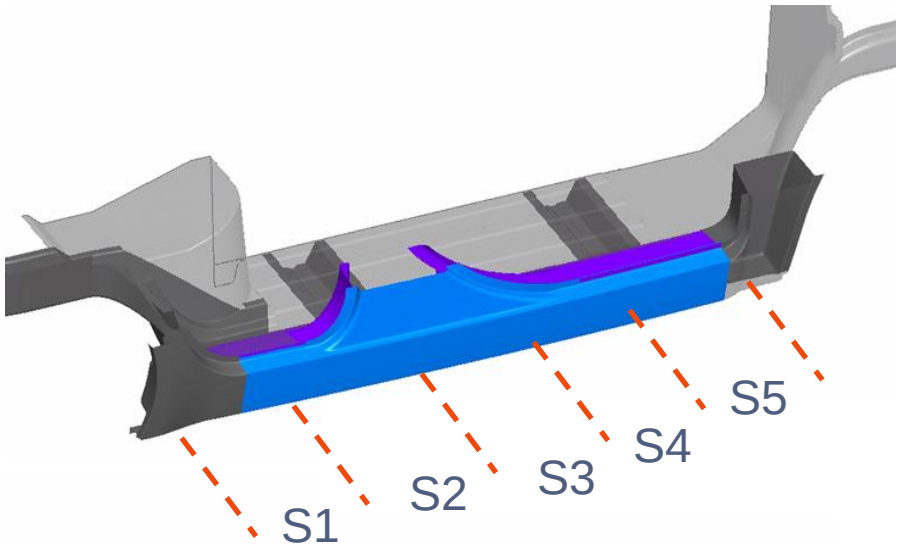
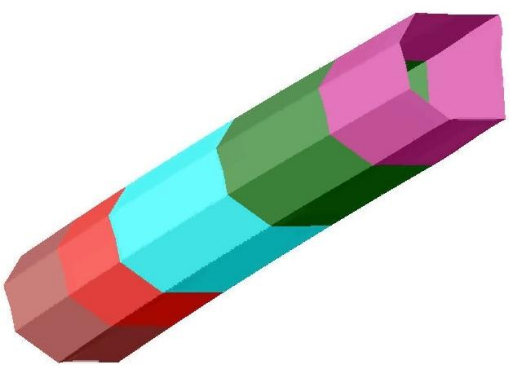
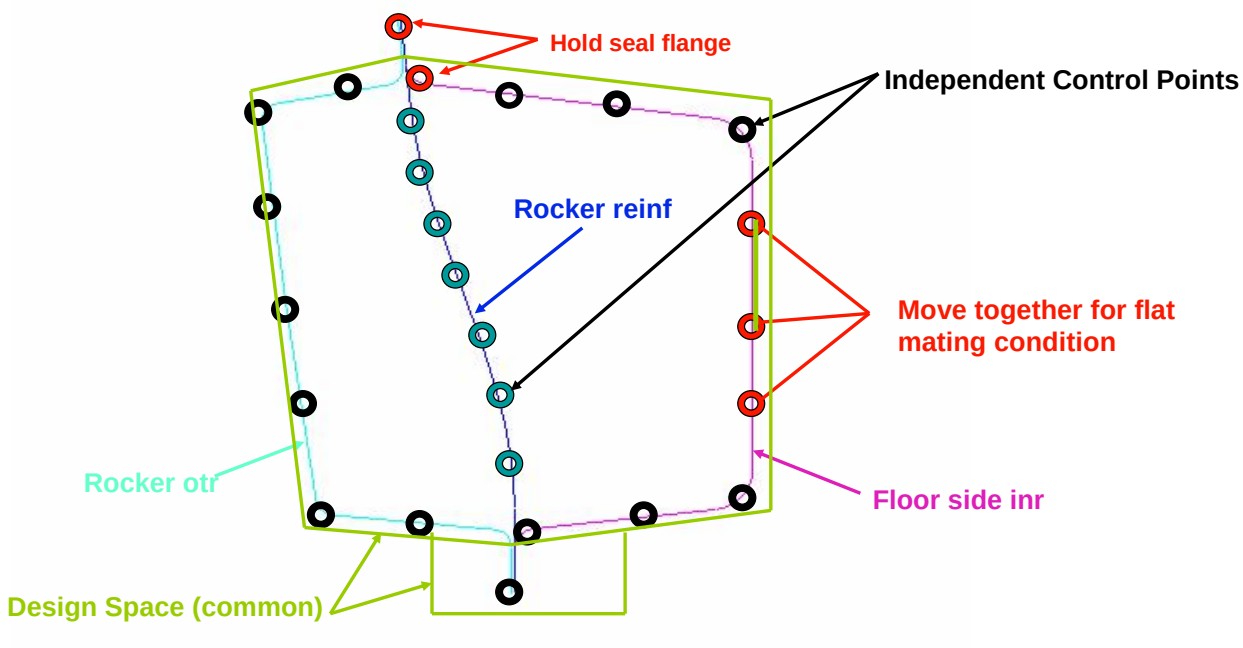
Body Structure – Sub-System 3G Optimisation









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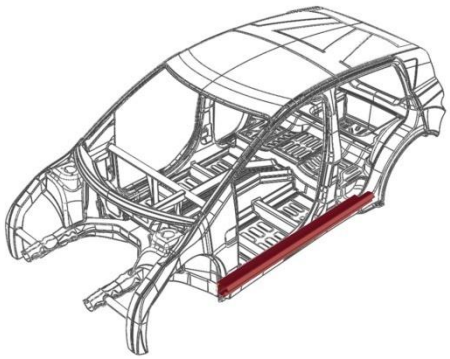
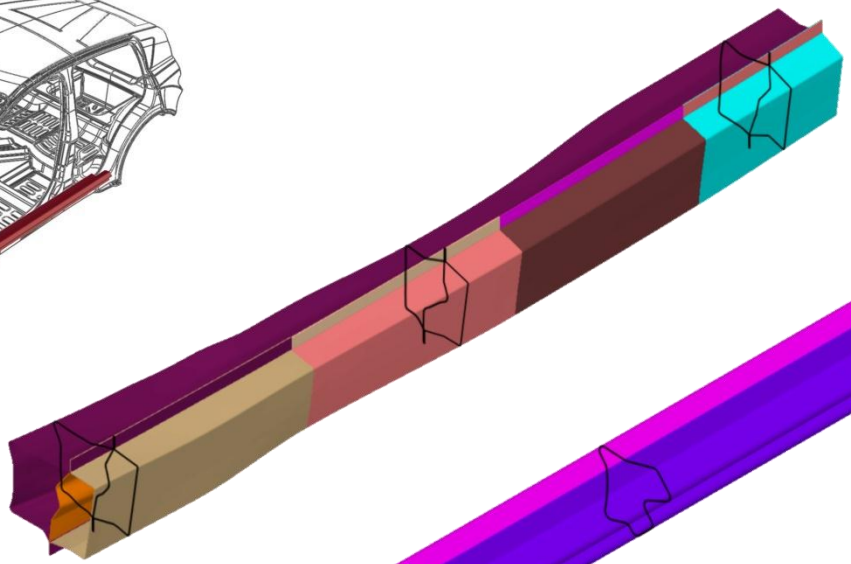
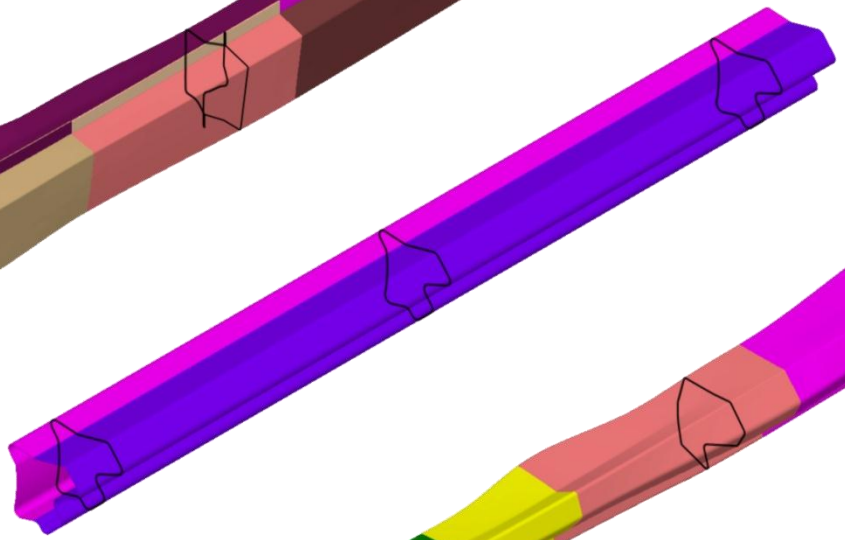
Body Structure Sub-System – Rocker Solutions

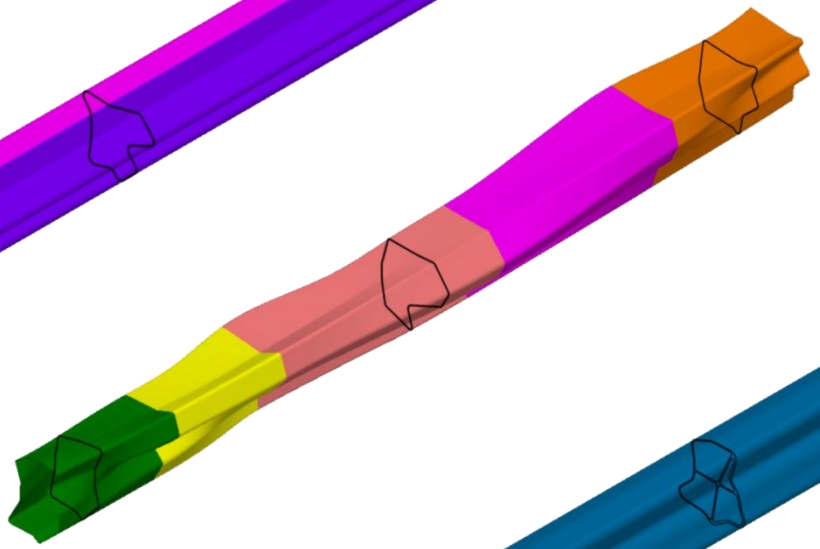




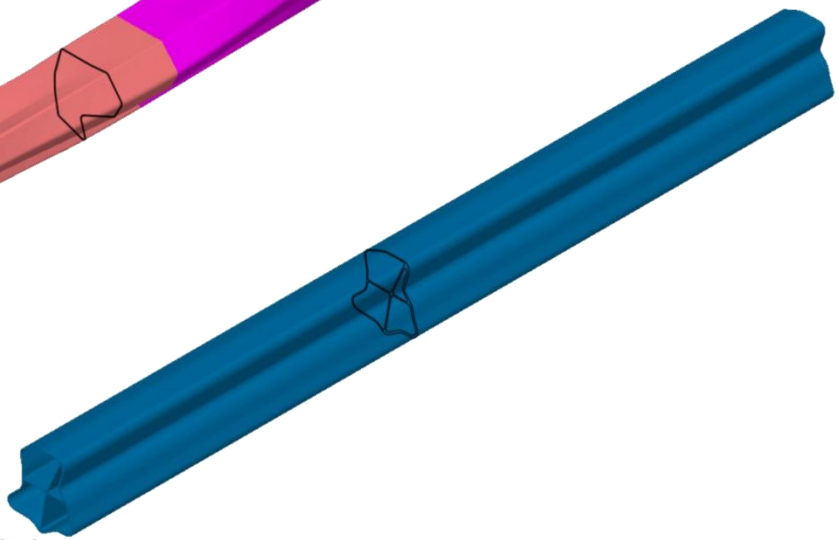
Stamping
AHSS



Roll-forming
AHSS



Hydroforming
AHSS



Extrusion
Aluminum

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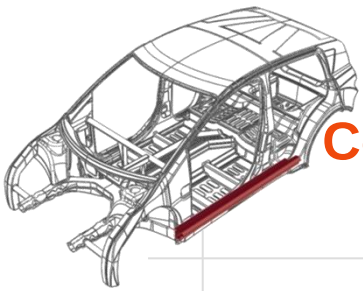
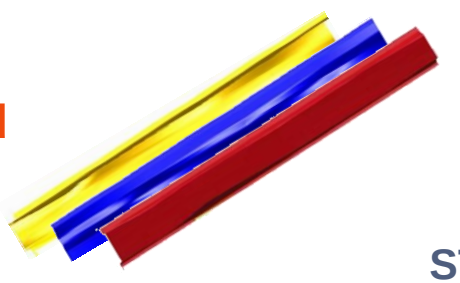
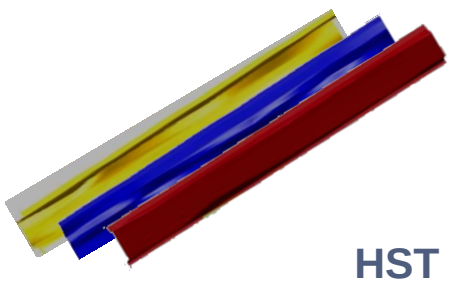
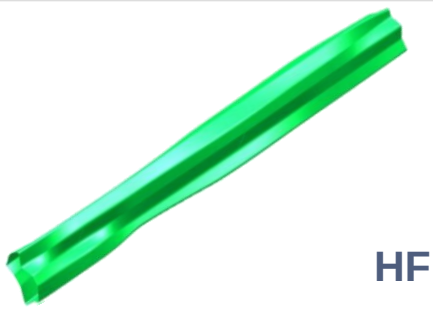
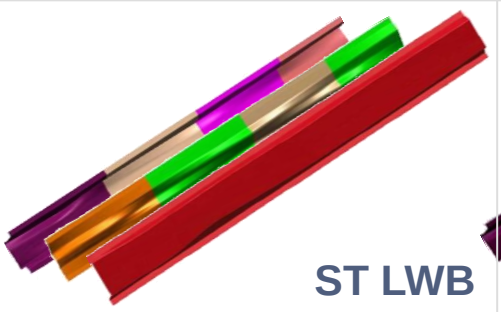
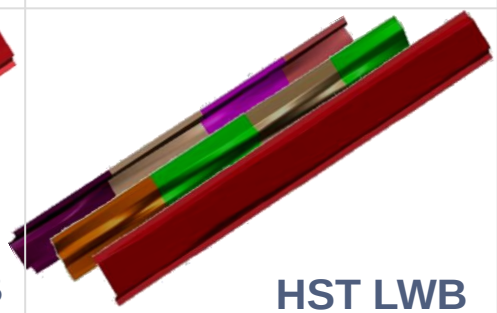
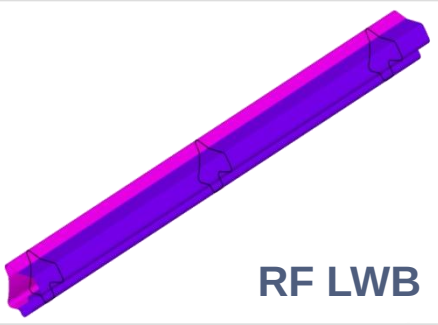
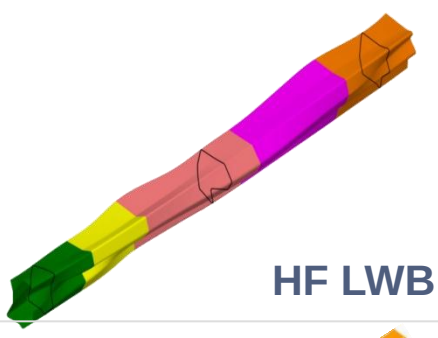
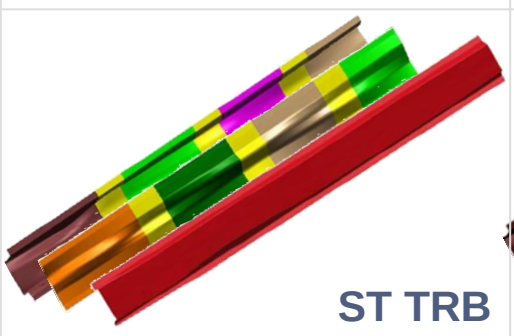
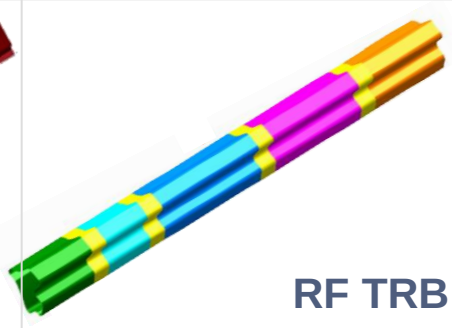
Body Structure Sub-System – Rocker Solutions



	Conventional Stamping	Hot Stamping	Roll Forming	Hydroforming
Standard Blanks	 ST	 HST	 RF	 HF
Laser Welded Blanks	 ST LWB	 HST LWB	 RF LWB	 HF LWB
Tailor Rolled Blanks	 ST TRB	 HST TRB	 RF TRB	 HF TRB

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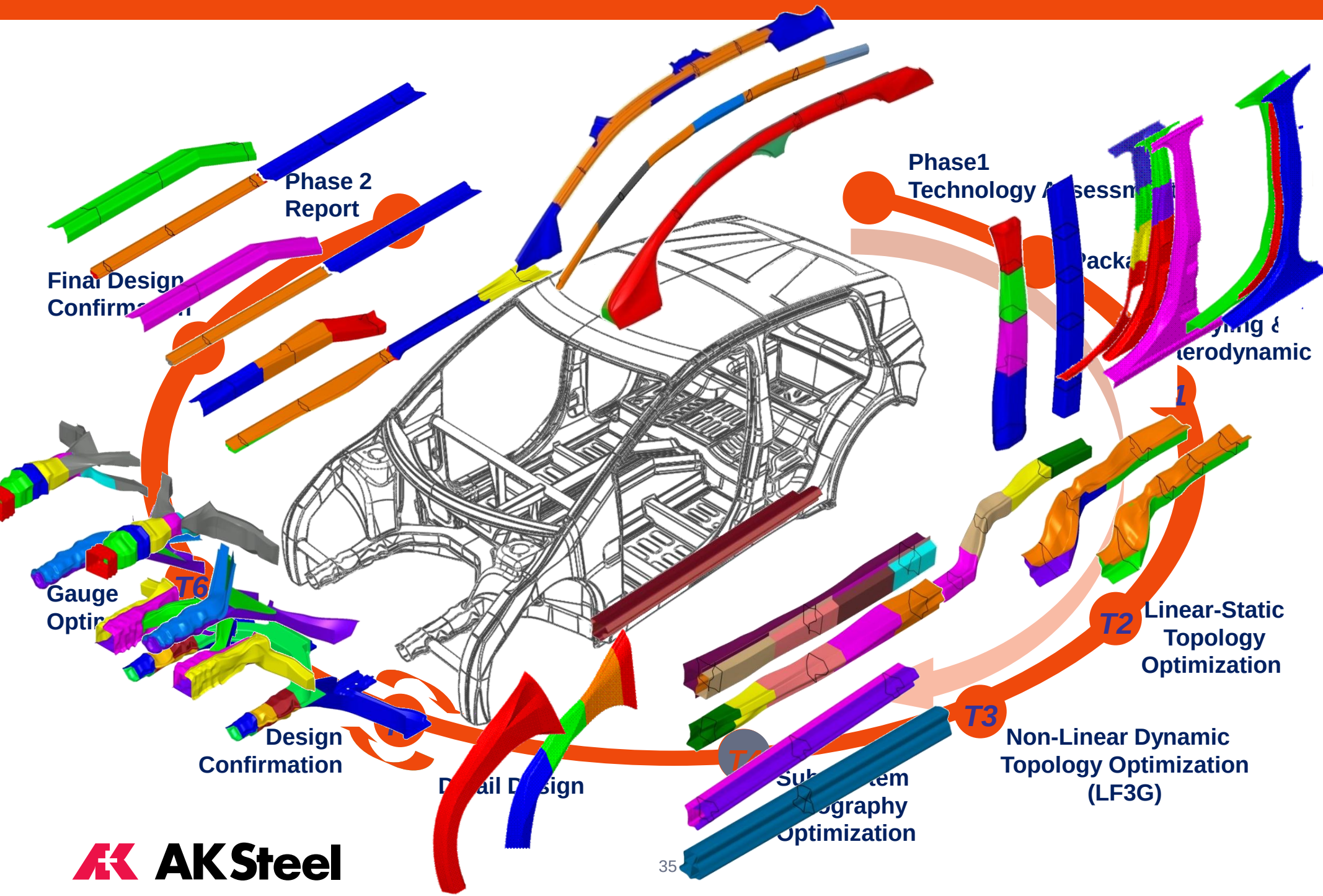
FSV Task 4 Decisions



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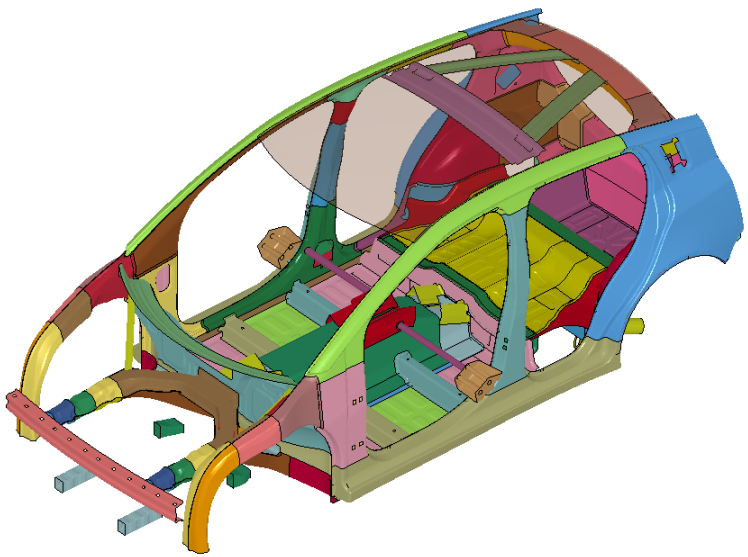
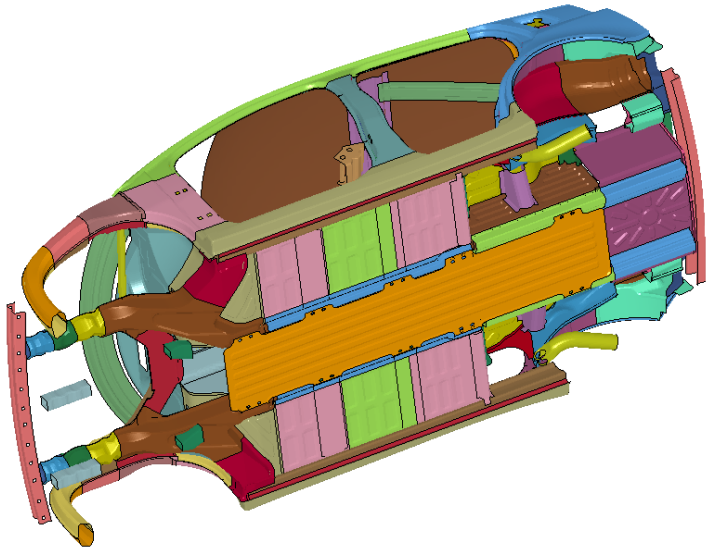
Final Grade & Gauge (2G) Full System Optimisation

Best Design: #336





Baseline OPT Parts Mass	= 213.7 kg
Optimized Design 336	= 190.6 kg
Total Mass Savings	**= 23.1 kg (10.8%)**
Baseline BIW Mass	= 203.7 kg
Optimized Design 336 BIW	**= 188.0 kg**
BIW Mass Savings	**= 15.7 kg (8.4%)**

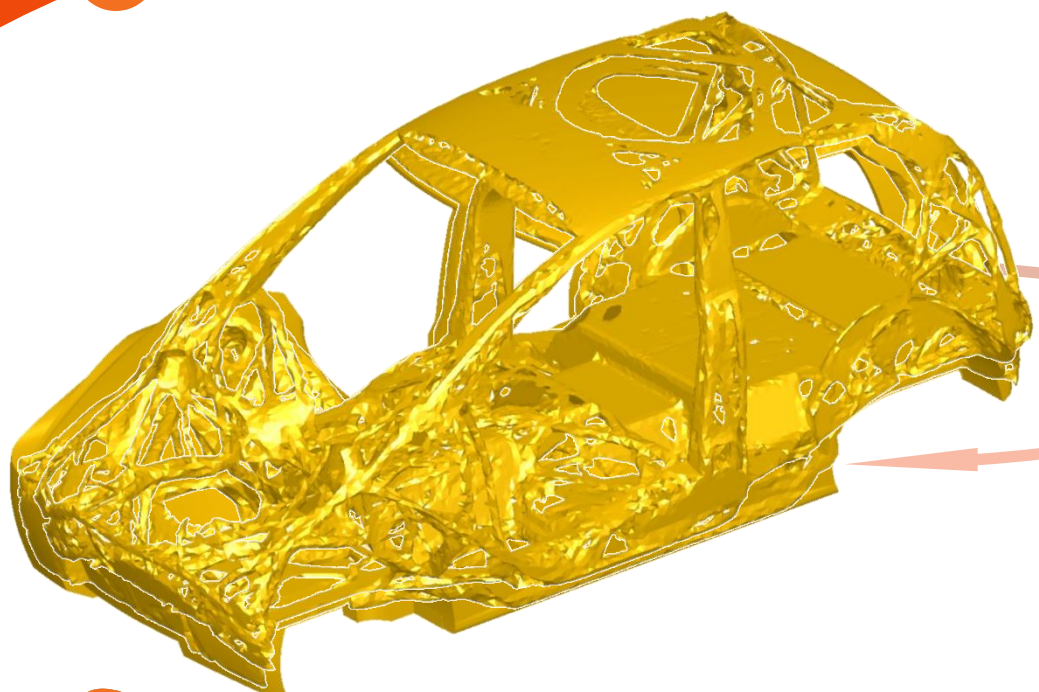
Results

FutureSteelVehicle

- Objectives
- Design Methodology
- **Results**

7 Key Achievements

#1 – State of the Future Design Innovations



Phase1
Technology Assessment

Packaging

Styling &
Aerodynamic

T1

Linear-Static
Topology
Optimisation

T2

Non-Linear Dynamic
Topology Optimisation
(LF3G)

T3

Sub-System
Topography
Optimisation

T4

Detail Design

T5

Design
Confirmation

T6

Gauge
Optimisation

Final Design
Confirmation

Phase 2
Report

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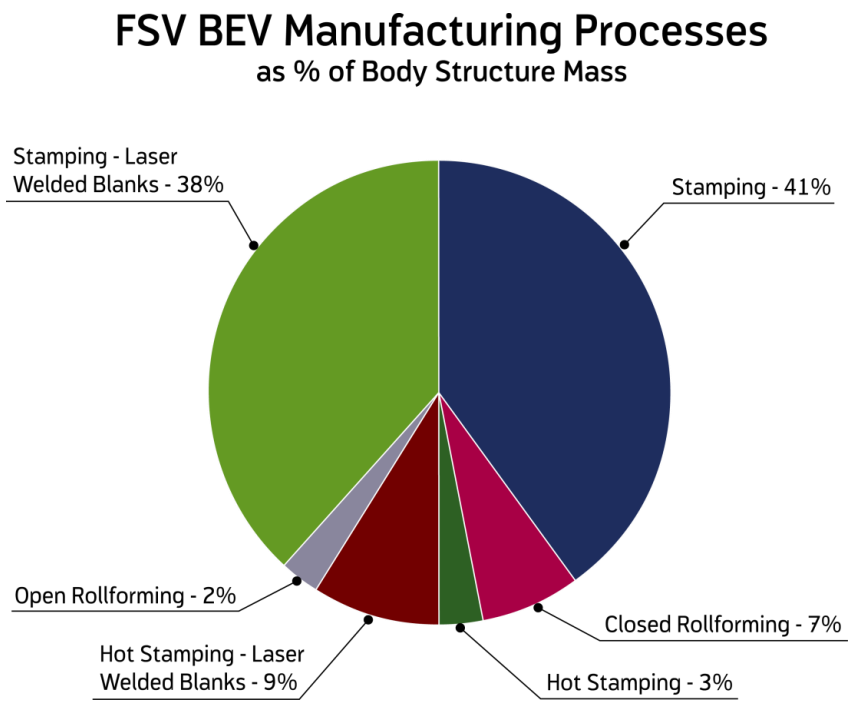
#2 – 35% Mass Savings



Body Structure	FSV-1 BEV Mass (kg)
Benchmark	290
Target	190
Achieved	188

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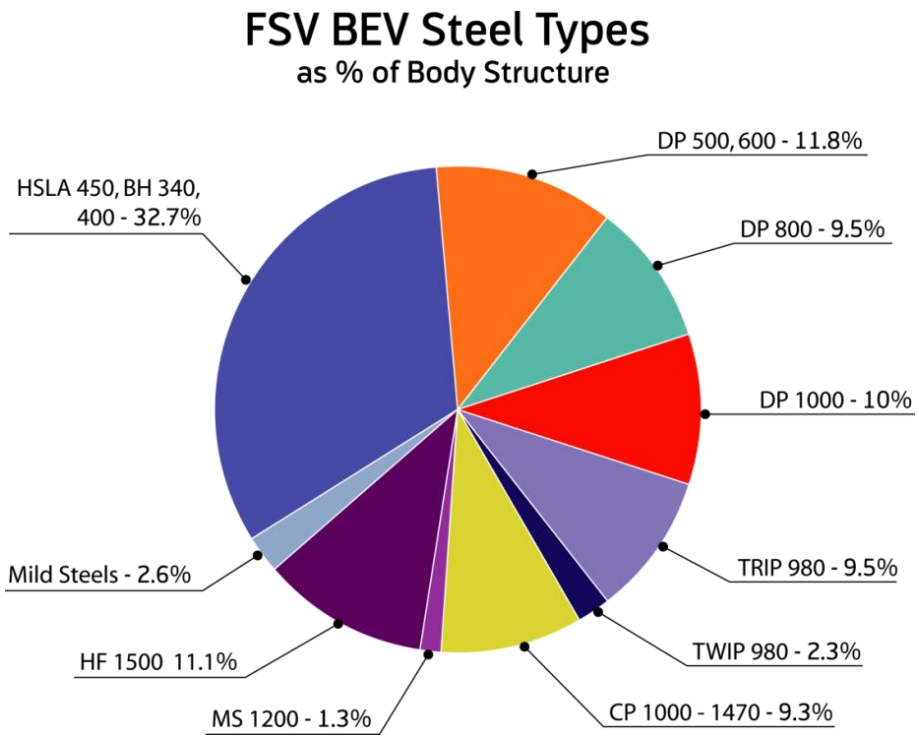
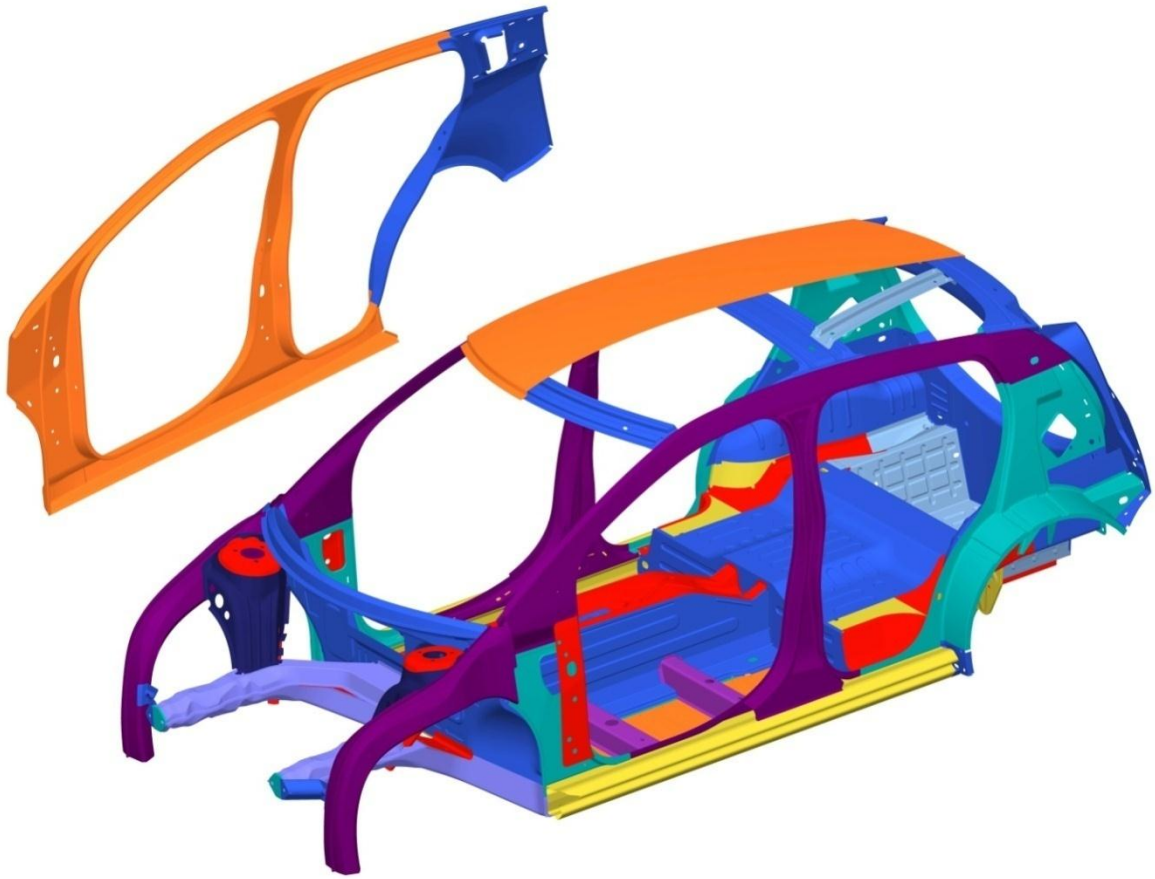
#3 – 97% HSS and AHSS



Body Structure	FSV-1 BEV Mass (kg)
Benchmark	290
Target	190
Achieved	188



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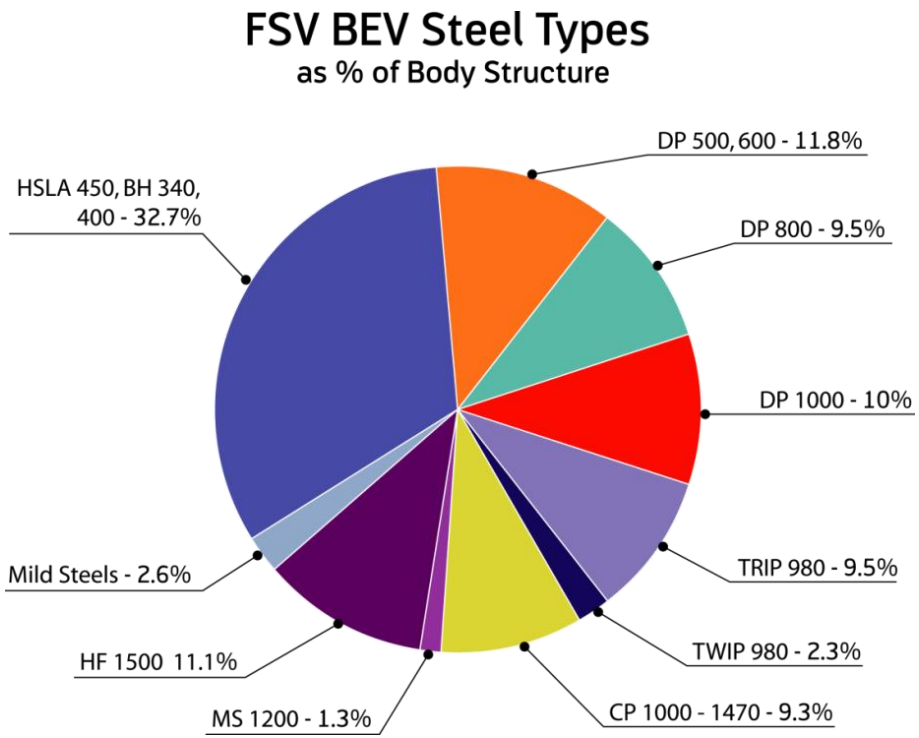
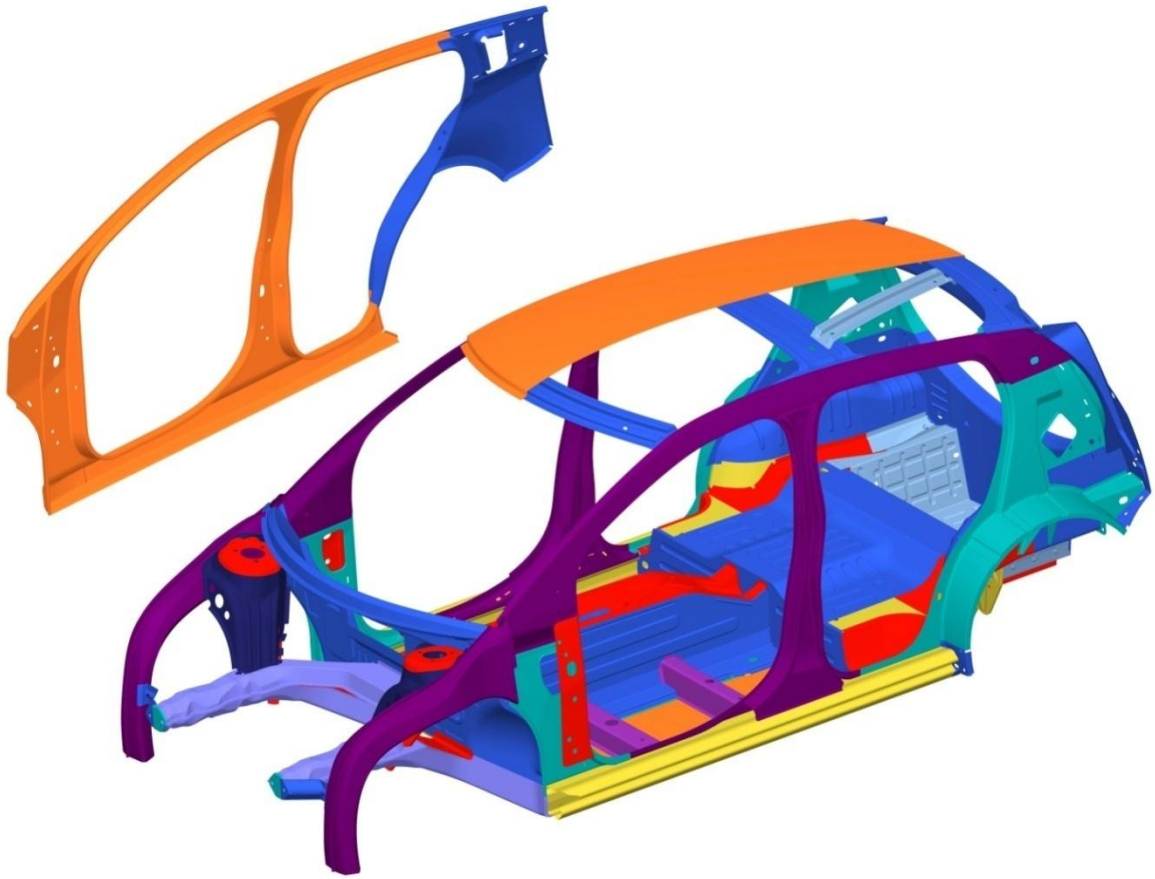
#4 – Nearly 50% GigaPascal Steels





Body Structure	FSV-1 BEV Mass (kg)
Benchmark	290
Target	190
Achieved	188

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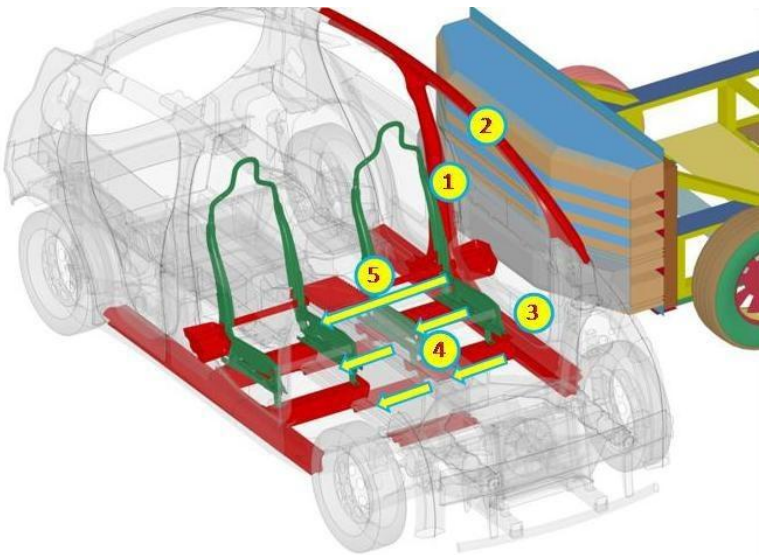
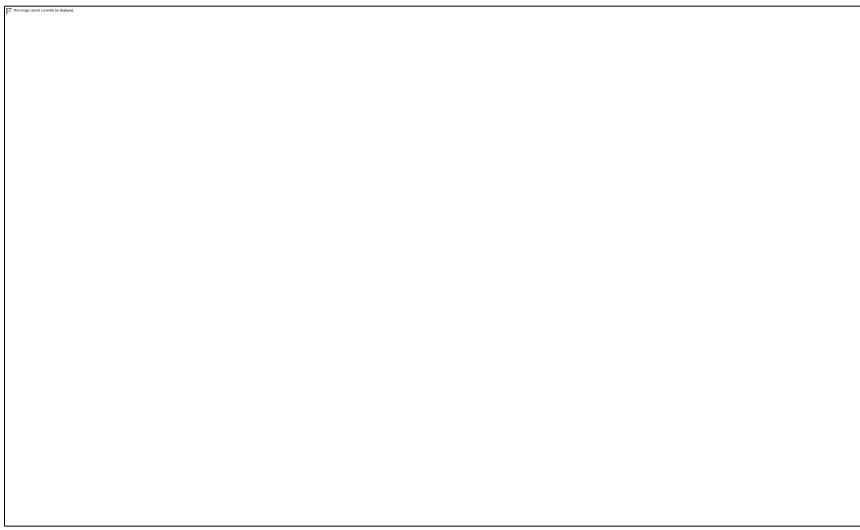
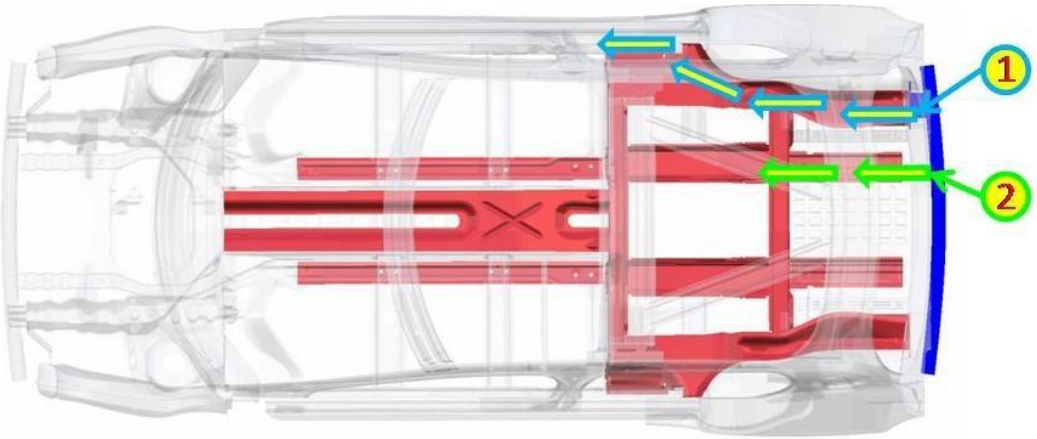
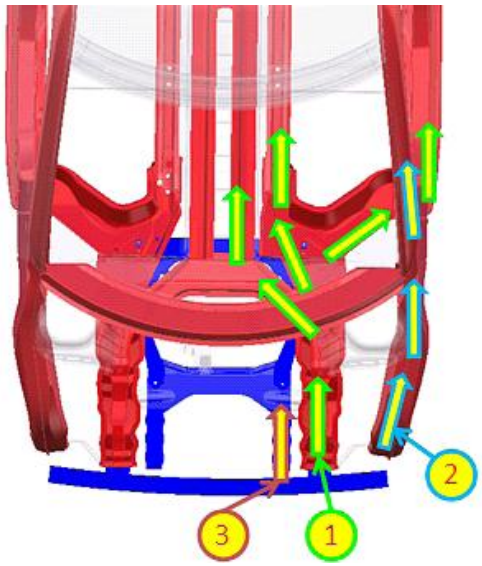
#5 – Enables 5-Star Safety Rating









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#6 – Reduces Life Cycle Emissions

Benchmark V ICEg	**1,479**	**32,655**	**34,134**
FSV BEV USA grid	**1,328**	**13,844**	**15,172**
FSV BEV Europe grid	**1,328**	**9,670**	**10,998**

FSV vs. Benchmark – USA Grid - 56% CO_2e reduction

FSV vs. Benchmark – Europe Grid - 68% CO_2e reduction

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#7 – No Cost Penalty

	Cost (US$)
Body Structure Manufacturing Costs	$775
Body Structure Assembly Costs	$340
Total Body Structure Manufacturing & Assembly	**$1,115**

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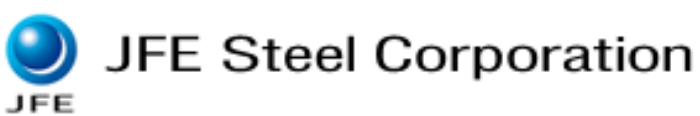
Acknowledgements

We'd like to thank our members:

Our partners and contractors:



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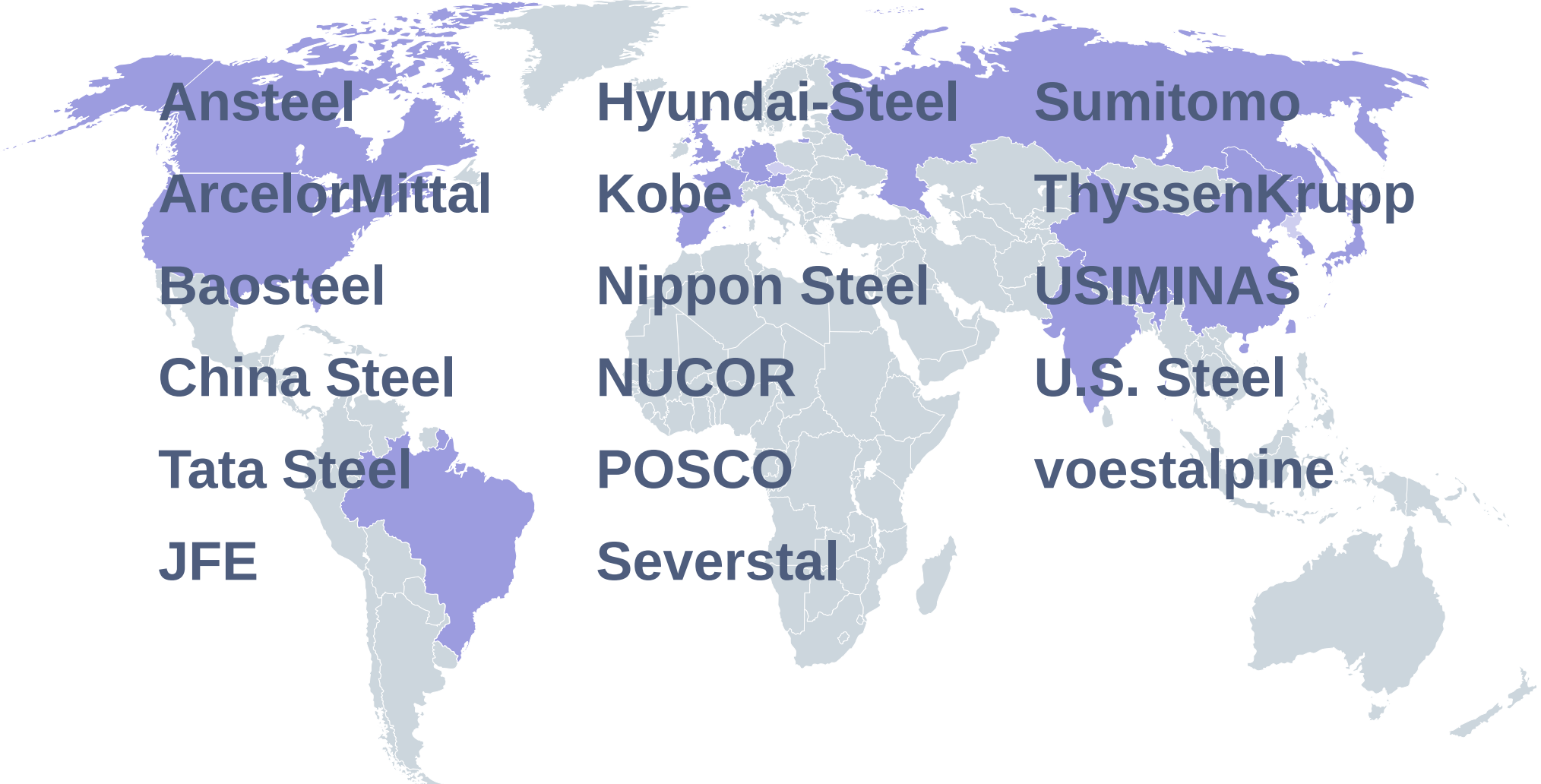
Thank you for your attention

Strong, Safe, Sustainable

WorldAutoSteel

Automotive Group of the World Steel Association

MEMBER COMPANIES:



- Ansteel
- ArcelorMittal
- Baosteel
- China Steel
- Tata Steel
- JFE
- Hyundai-Steel
- Kobe
- Nippon Steel
- NUCOR
- POSCO
- Severstal
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- ThyssenKrupp
- USIMINAS
- U.S. Steel
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