

Great Designs in

STEEL 2014!!

2014 Chevrolet Spark & Spark EV



CHEVROLET

Ickhee Han
Body Engineering
GM Korea





Vehicle Introduction of Spark, Spark EV

Do you remember the name of the Autobot in the movie “Transformers?”

“Skids”

He is the “Chevrolet Spark!”





Vehicle Introduction of Spark, Spark EV

❑ Spark

- City car (A-segment super-mini)
- 5 door hatchback
- Wheelbase 2,370 mm
- Length 3,720 mm
- Width 1,630 mm
- Curb Weight 1,042 kg



❑ Spark EV

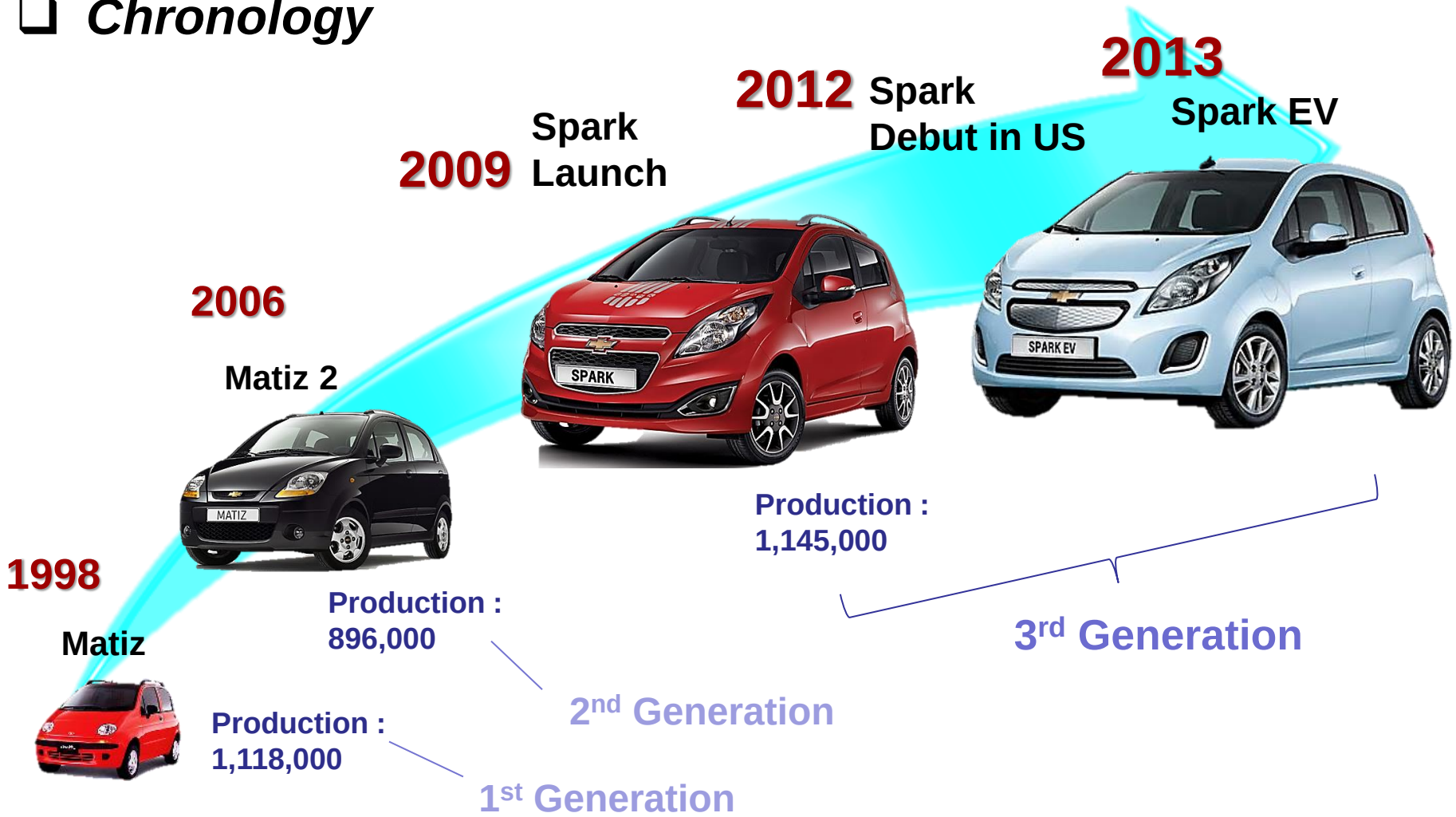
- All electric version of Spark
- Modified architecture from Spark : Slightly longer and wider
- Increased vehicle mass by 310 kg due to battery unit
- Upper and rear structure enhanced





Vehicle Introduction of Spark, Spark EV

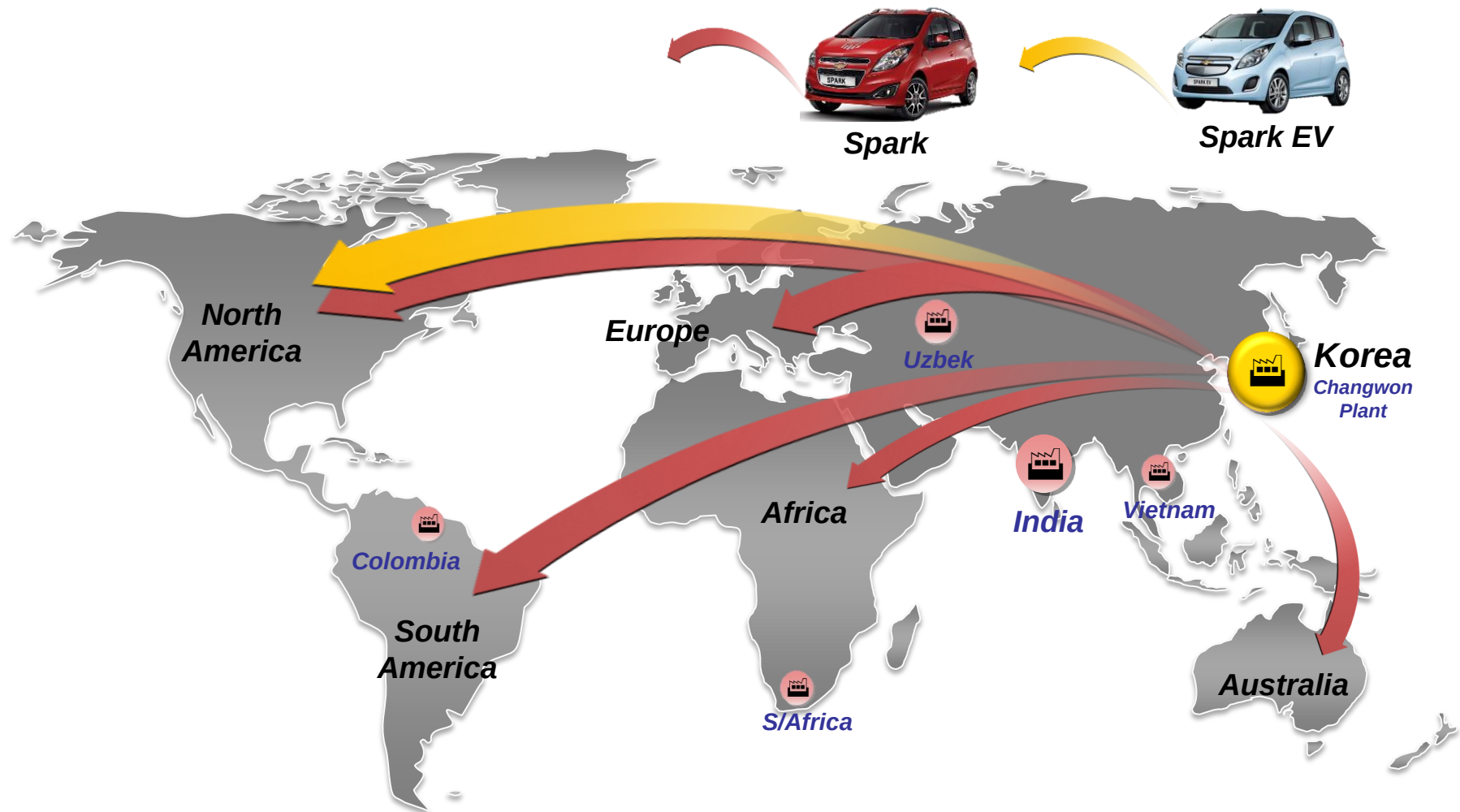
Chronology





Vehicle Introduction of Spark, Spark EV

❑ *Manufacturing Footprint & Sales Market*





Chevrolet Spark

- Chevrolet's first mini-car for the US and Canadian markets
- Aimed at urban customers who want a stylish and practical vehicle that is easy to drive and own
- Highest-selling among super-minis in US



***A Globe-Trotting
City Car
That Packs
A Lot of Punch***



Chevrolet Spark





Awards & Accolades of Chevrolet Spark

AWARDS

- One of *Kelley Blue Book's* 10 Coolest Cars under \$18,000.
- The Hispanic Motor Press Association selected the 2013 Chevrolet Spark as Subcompact of the Year.
- The Chevrolet Spark earned the 2013 Automotive Science Group's (ASG) "Best Economic Performance" Award for best value among all compact cars sold in the US market.
- Editors at *Ward's Auto* named the 2013 Chevrolet Spark mini car among its 10 Best Interiors of 2013 from a field of 46 new or refreshed nominees.
- 2013 Spark was recognized as one of the "Best 5 All-Around Performance" compact vehicles by Automotive Science Group.
- 2012 Chevrolet Spark's MyLink infotainment system voted Editor's Pick by WIRED's Automotive Edition.





Chevrolet Spark EV

- 100% pure electric fun, advanced technology that enables gas-free driving
- City-sized fun that's easy to love
- Technology and infotainment

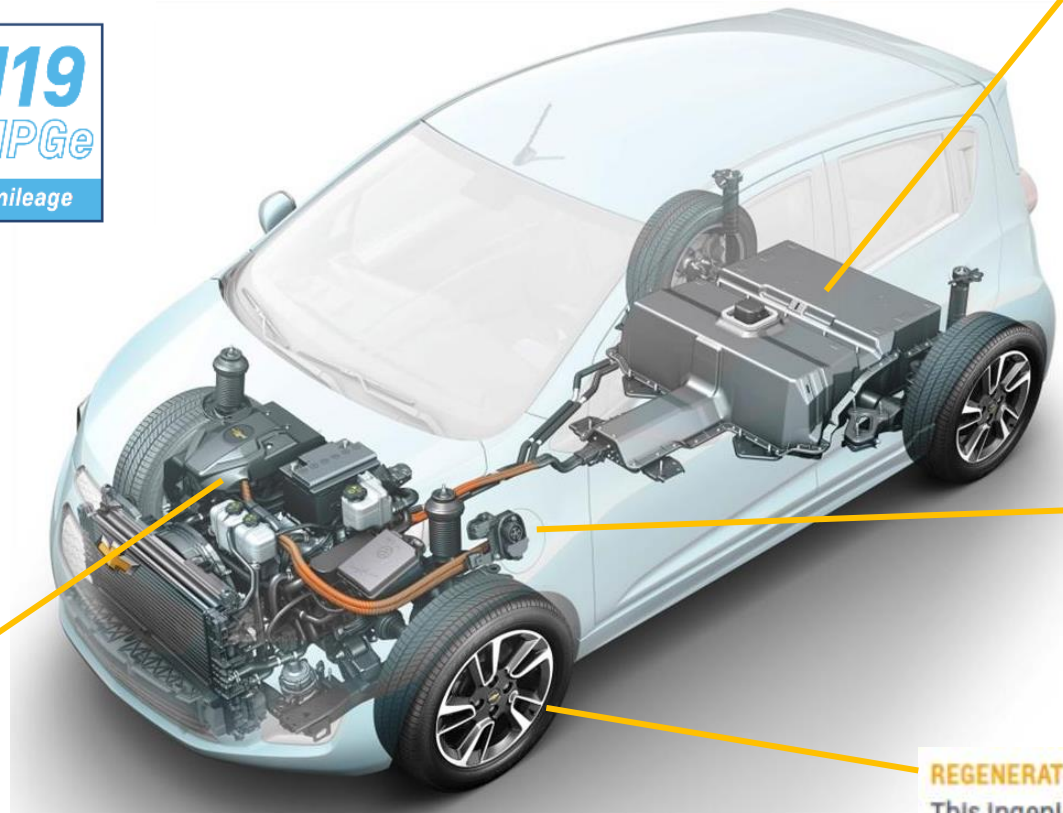




Chevrolet Spark EV

POWER & PERFORMANCE

90	82	119
mph	mile	MPGe
top speed	range	mileage



ELECTRIC PROPULSION SYSTEM In Spark EV, 400 lb.-ft. of torque goes directly to the tires and the road. Bottom line: 0 to 60 mph in 7.6 seconds.

LITHIUM-ION BATTERY
Spark EV delivers zero-emissions power and 82 miles of EV range.

CHARGING PORT
Three convenient charging options give you the power of choice.

REGENERATIVE BRAKING
This ingenious system captures energy when slowing down or braking and recycles it back into the battery. Now that's energy innovation.



Awards & Accolades of Chevrolet Spark EV

The 2014 Chevrolet Spark electric vehicle is the most fuel-efficient vehicle sold in the United States:

- Miles per gallon equivalent of 119 combined, 128 city and 109 highway

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Office of Transportation & Air Quality | U.S. ENVIRONMENTAL PROTECTION AGENCY

www.fueleconomy.gov

the official U.S. government source for fuel economy information

Mobile | Español | Site Map | Links | FAQ | Videos | Contacts

2014 Most Fuel Efficient Cars (including electric vehicles)

EPA Class	Vehicle Description		Fuel Economy Combined
Two-Seaters		smart fortwo electric drive Convertible" A-1, 55kw DCPM, Electric Vehicle	107*
		smart fortwo electric drive coupe A-1, 55kw DCPM, Electric Vehicle	107*
Minicompacts		Fiat 500e A-1, 82 kW AC Induction, Electric Vehicle	116*
Subcompacts		Chevrolet Spark EV A-1, 104 kW ACPM, Electric Vehicle<	119*
Compacts		Ford Focus Electric Automatic (CVT), 107 kW AC Induction, Electric Vehicle	105*
Midsized		Nissan Leaf A-1, 80 kW DCPM, Electric Vehicle	114*





Functional Performance of Spark

- ❑ Named **IIHS 2014 “Top Safety Pick”** *first and only* in mini-car segment
 - Achieved **“Good”** scores in the moderate overlap front, side, roof strength, and head restraints tests
 - Scored an **“Acceptable”** in IIHS's new **Small Overlap Test**
- ❑ **Euro NCAP “4 stars”** in 2009
- ❑ **Korean NCAP “1st grade”** in 2010

2014 TOP SAFETY PICK

2014 Chevrolet Spark

Minicar

CRASHWORTHINESS

Small overlap front

Moderate overlap front

Side

Roof strength

Head restraints & seats

A

G

G

G

G

FRONT CRASH PREVENTION

NOT AVAILABLE



2014 Chevrolet Spark

[PRINT FULL REPORT FOR THIS VEHICLE](#)



Chevrolet Spark

Chevrolet Spark 1.0 base grade, LHD

TEST 2009

★★★★☆

ADULT OCCUPANT

81%

CHILD OCCUPANT

78%

PEDESTRIAN

43%

SAFETY ASSIST

43%



(Spark 2010)

Full Frontal Crash	Frontal Moderate Offset Crash	Side Crash	Side Pole	Passenger	Pedestrian	Roll Over	Braking	
							Dry	Wet
5/5	5/5	5/5	-	4/5	4/5	-	45.7	50.7





Functional Performance of Spark

Consumer Metric Performance	Official Status	Key Competitor Status	
	'14 Spark	'14 Scion IQ	'14 Fiat 500
US-NCAP - Frontal (Driver / Passenger)	4 / 4	4 / 3	4 / 3
US-NCAP - Side (Front / Rear)	5 / 5	4 / 3	5 / 5
US-NCAP Overall rating	4	4	4
IIHS Roof Strength SWR	Good	Good	Good
IIHS Ratings (Front / Side / Rear)	G / G / G	G / G / A	G / G / G
IIHS Small Overlap Front	Acceptable	Not tested	Poor
IIHS Overall Score	2014 TSP	-	-

* Data quoted from
www.safercar.org, www.iihs.org





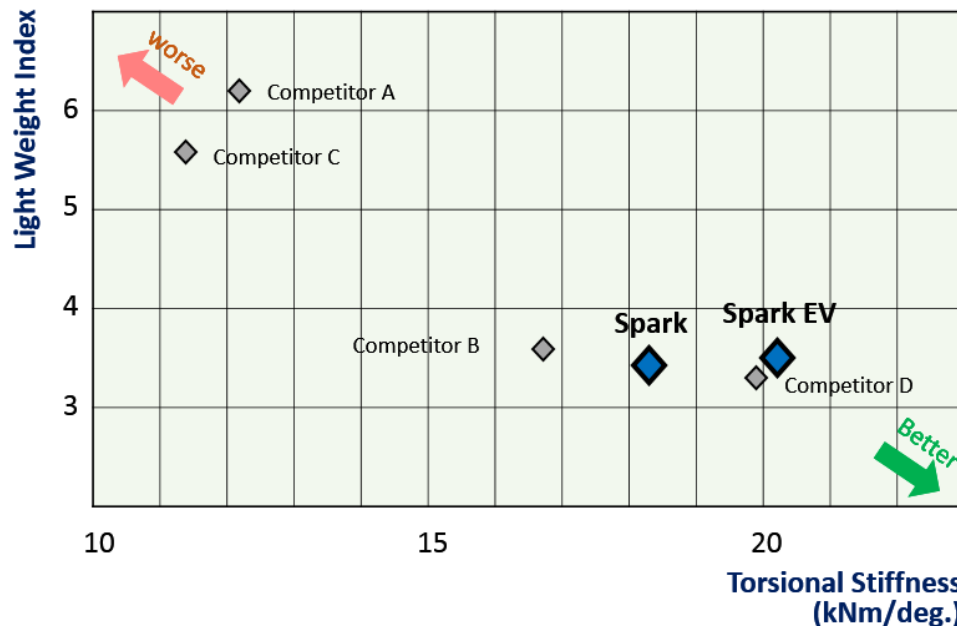
Functional Performance of Spark, Spark EV

BIW Stiffness & Lightweight Index

- Competitive level of body stiffness among mini vehicles

Torsional Stiffness = Spark : 18.3 kNm/deg
= Spark EV : 20.1 kNm/deg

Light weight index = Spark : 3.42
= Spark EV : 3.55



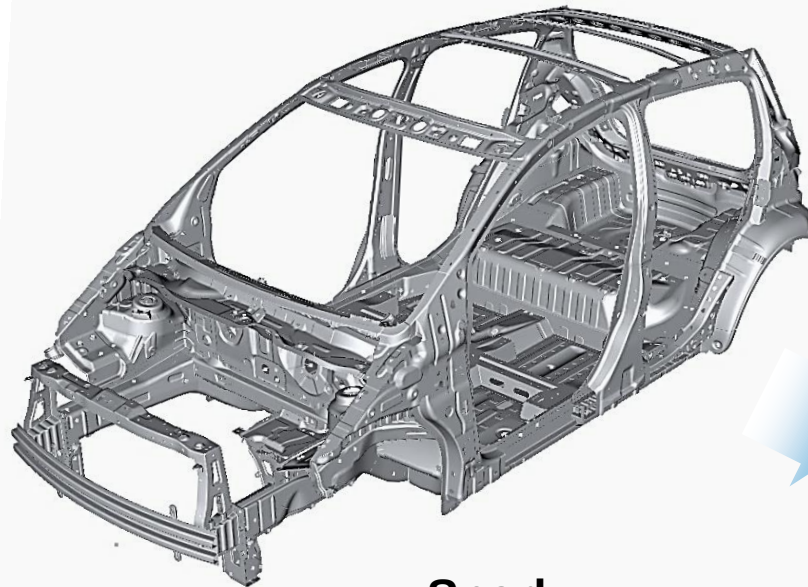
Lightweight index



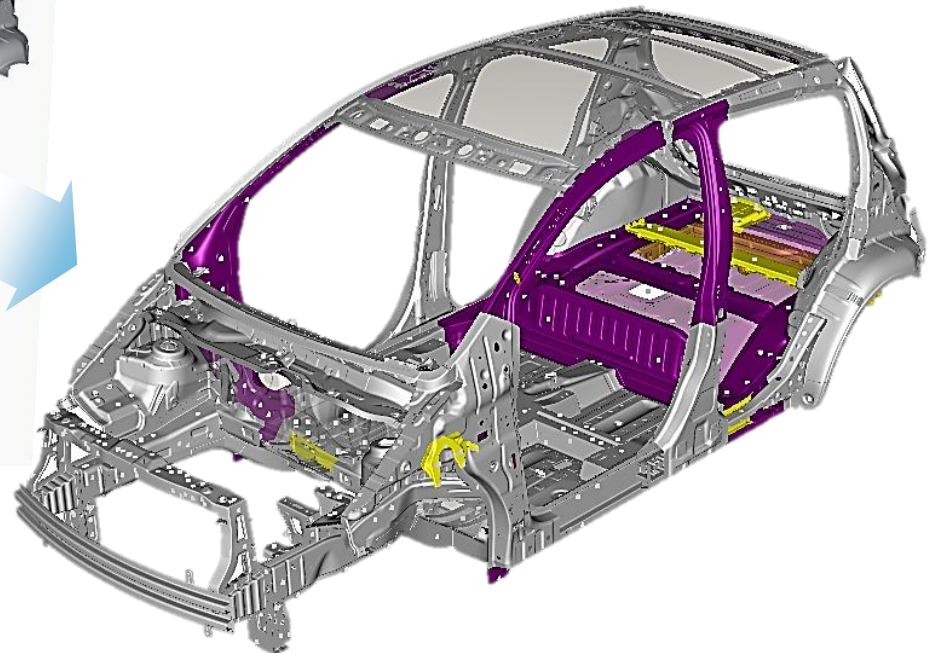
m_k Body weight
227 kg
 C_t Torsional rigidity
18,000 Nm/°
 A Contact area
3.6 m²
$$L = \frac{m_k}{C_t \cdot A} = 3.5$$

□ *BIW Variants*

 Parts modified
 Parts added



Spark



Spark EV



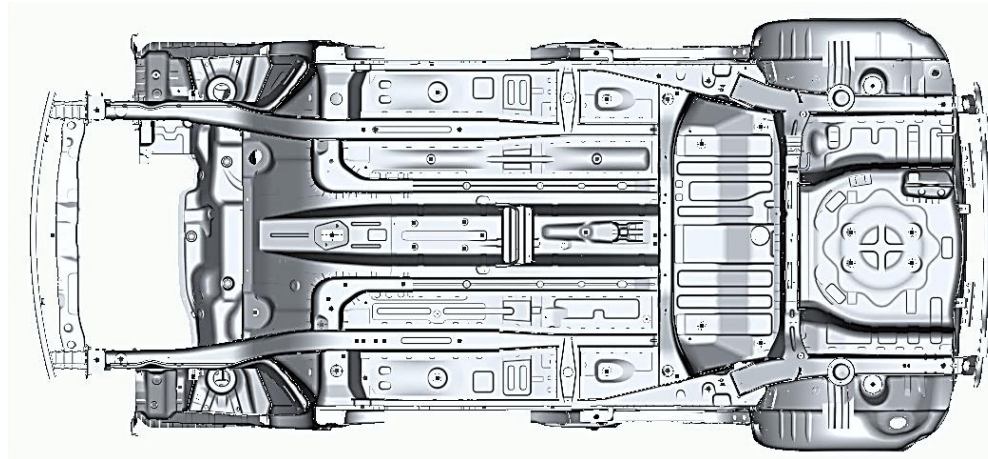


Body-in-White Design Concept

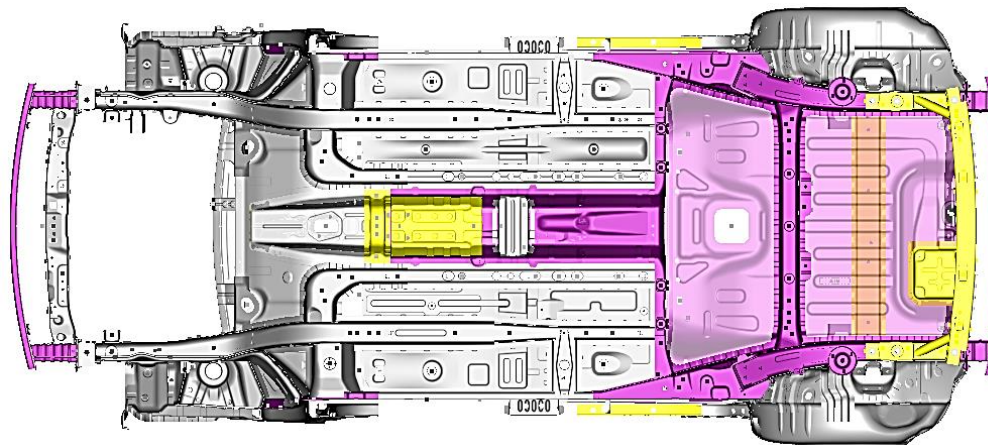
□ *BIW Variants - Underbody*

 Parts modified
 Parts added

Spark



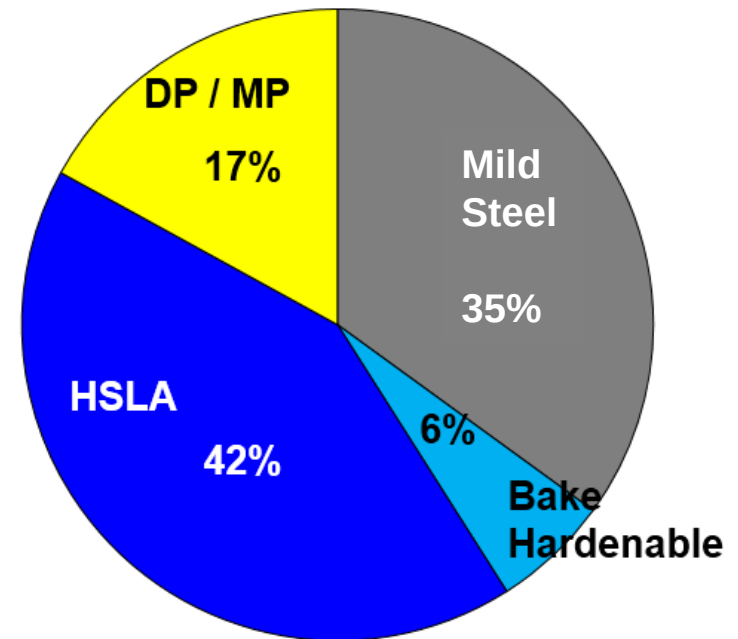
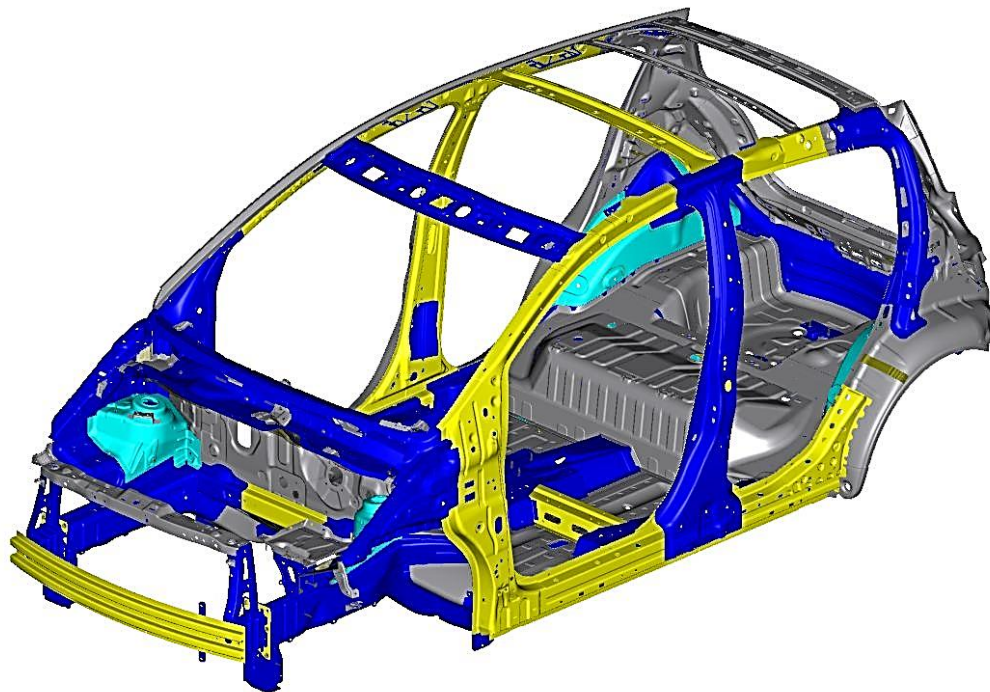
Spark EV





Sheet Metal Material Selection

□ Spark



High-Strength Steel

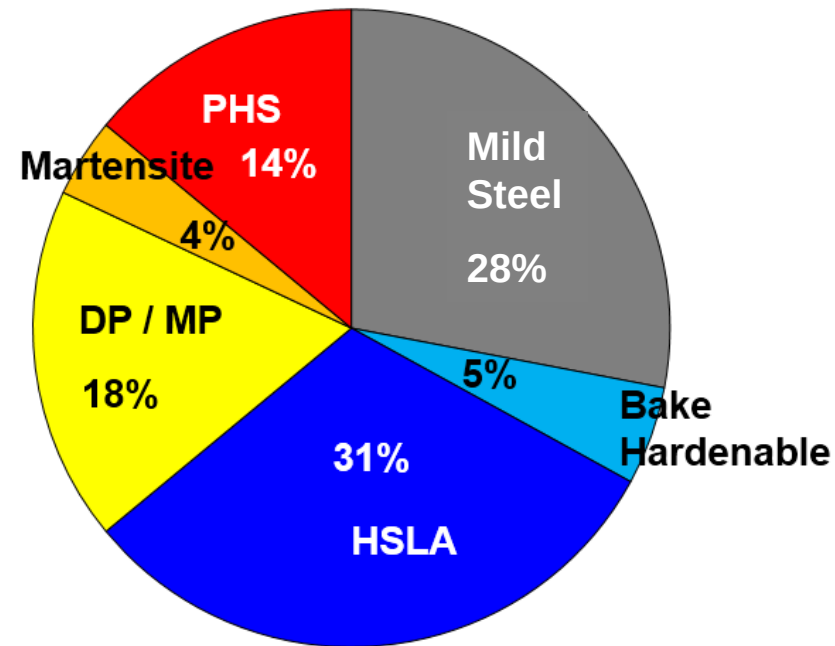
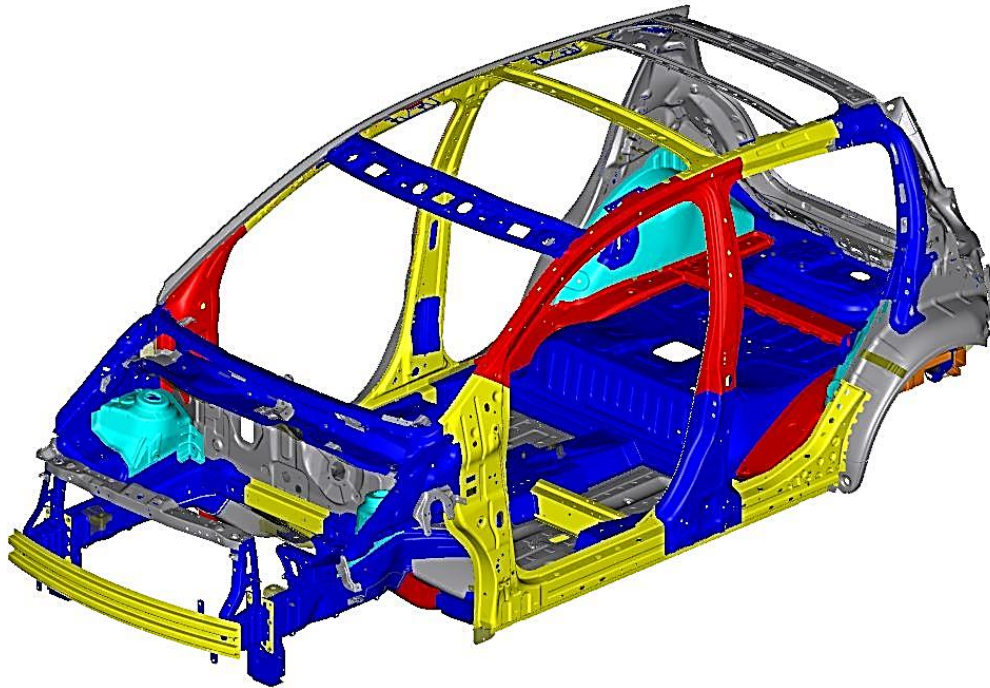
65% of Body Mass





Sheet Metal Material Selection

□ Spark EV

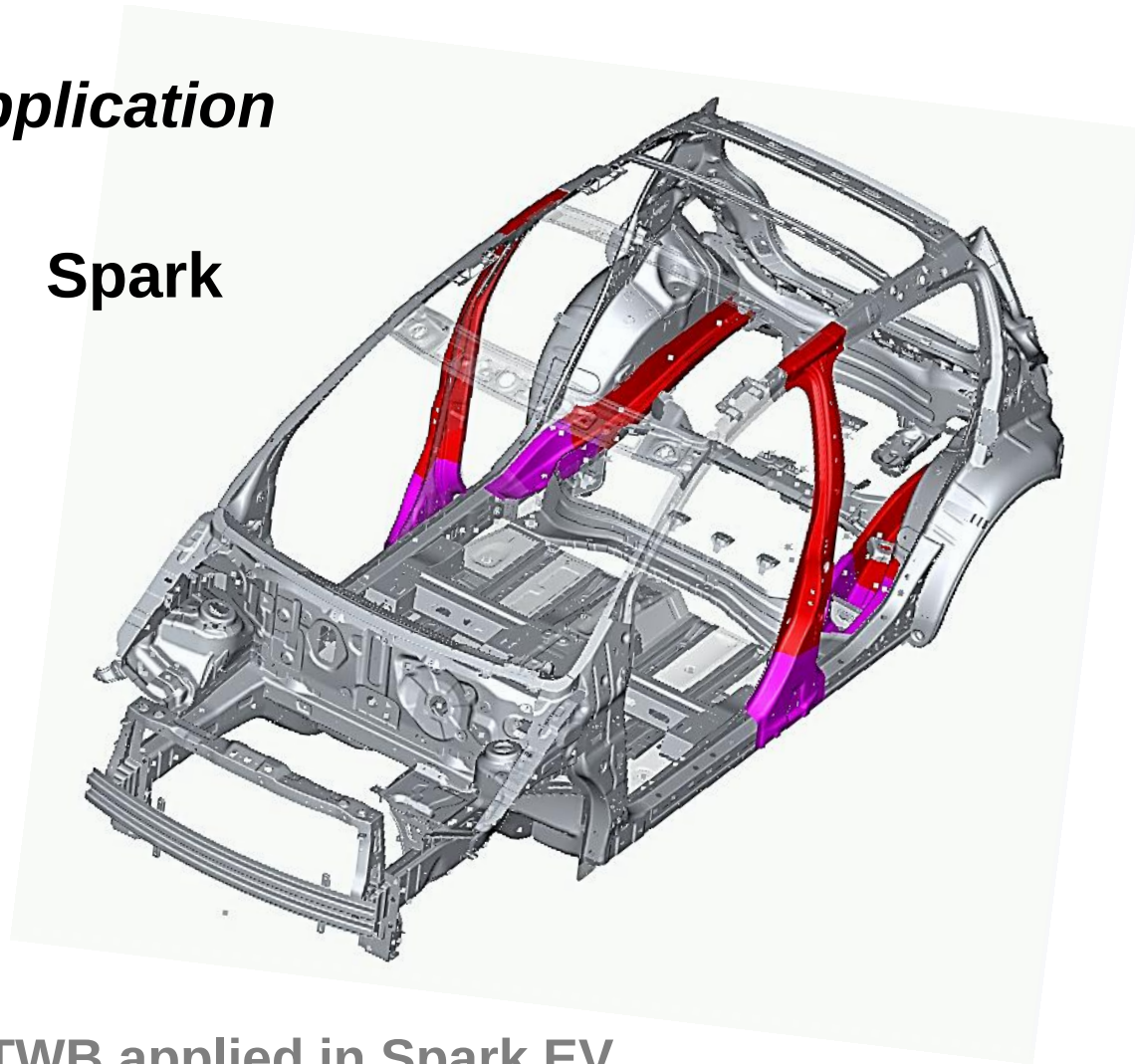


High-Strength Steel

72% of Body Mass

□ *TWB Application*

Spark

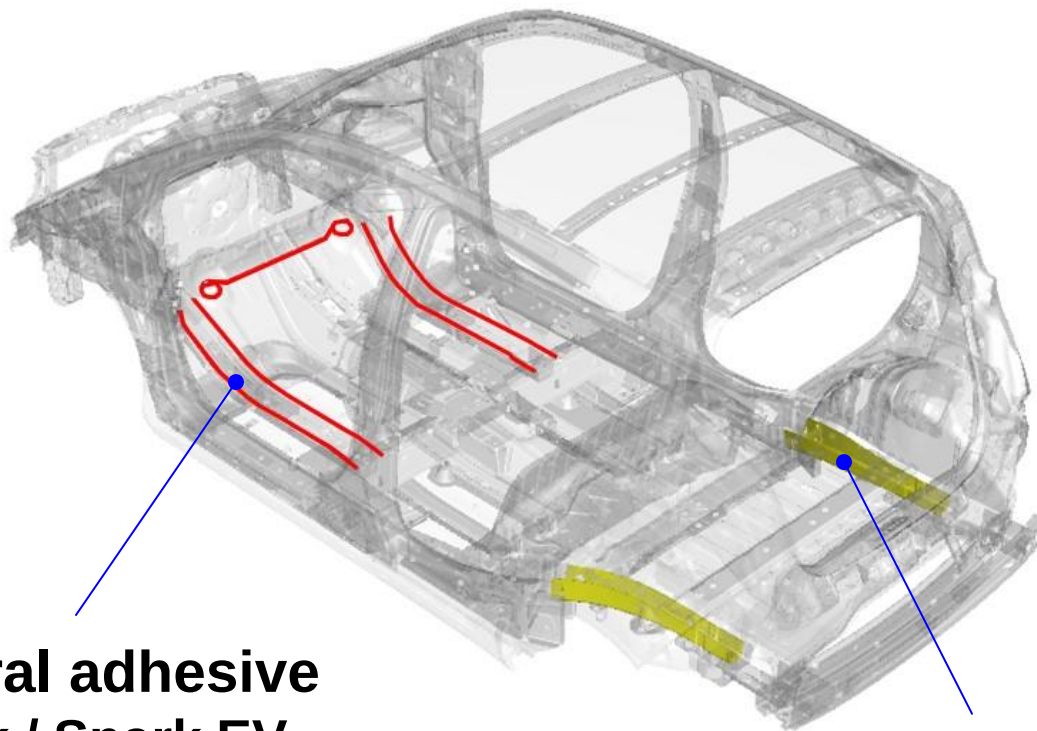


*** No TWB applied in Spark EV**





Structural Adhesive & Foam Application



**Structural adhesive
for Spark / Spark EV**

* Total length : 4.7m

**Structural foam
for Spark EV**

* Inside of Rear Rail

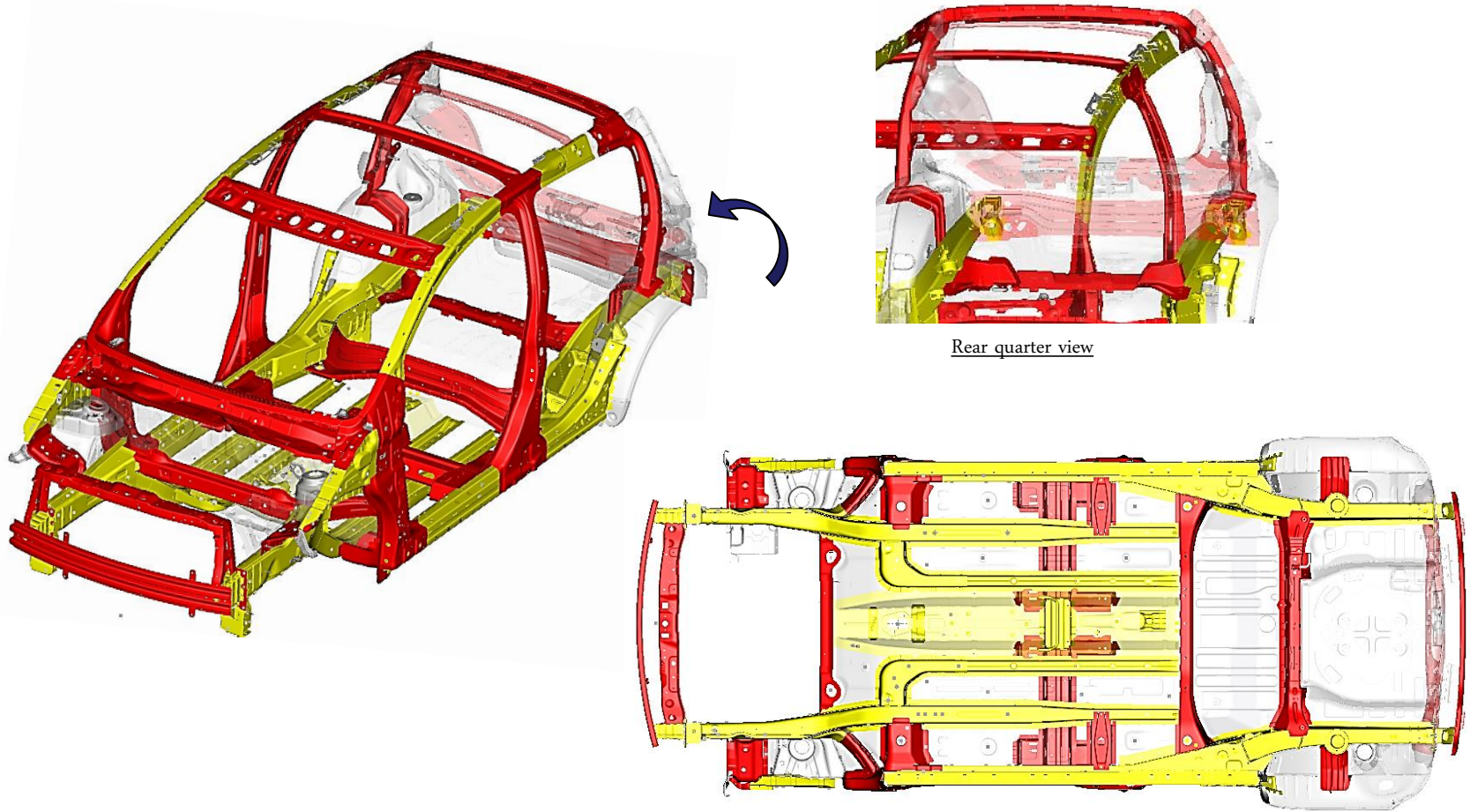


Body-in-White Design Concept

- ❑ Advanced Frame Structure
 - *Fully Connected Frame Structure with Homogenous Contour of Frames*
 - *Maximized Connections between Frames (3D joints)*
- ❑ Non Frame Parts Removed / Material Gage Minimized
- ❑ High Force Load Attachments Positioned only on Frames
- ❑ High Efficiency Design for Crash Performance



☐ *Fully Connected Frame Structure with Homogenous Frames*

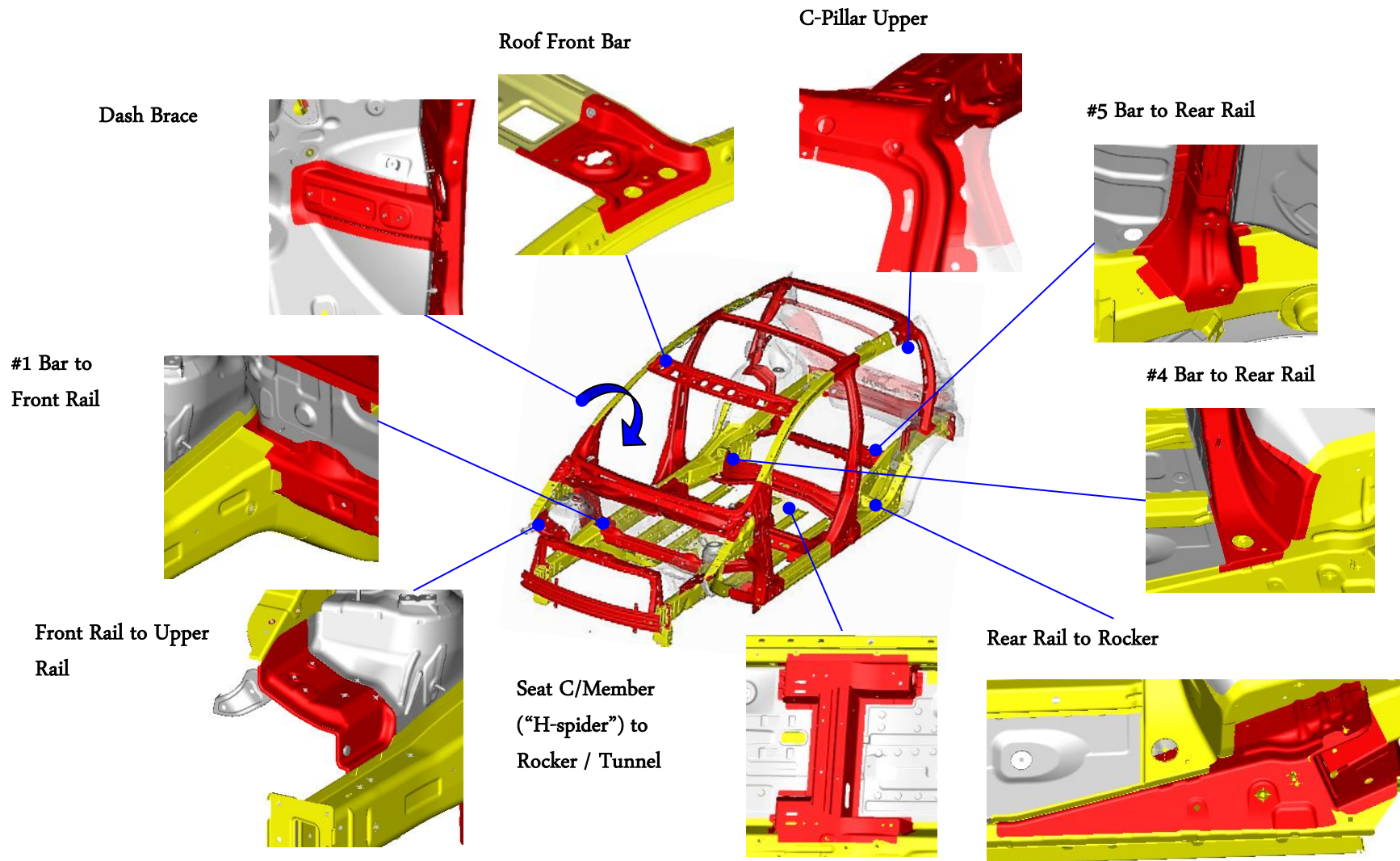


Rear quarter view



Advanced Frame Structure

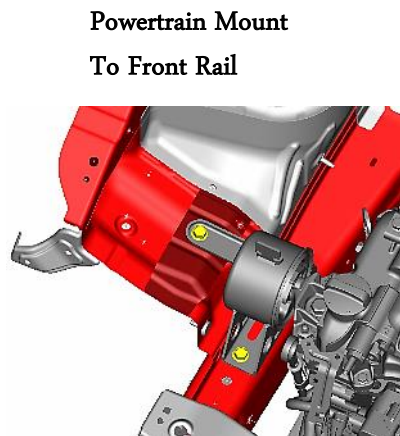
☐ *Maximized Connection between Frames (3-Dimensional Joints)*



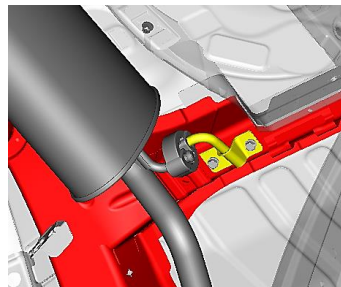


Advanced Frame Structure

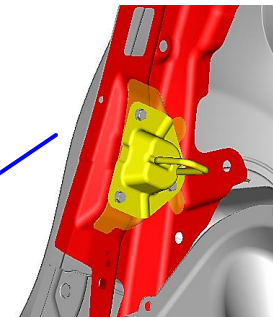
High Force Load Attachments only on Frames



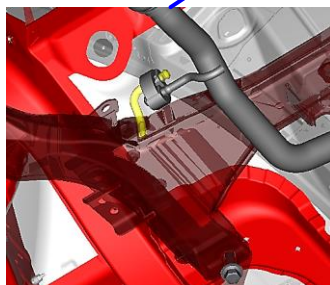
Exhaust Pipe
to #4 Bar



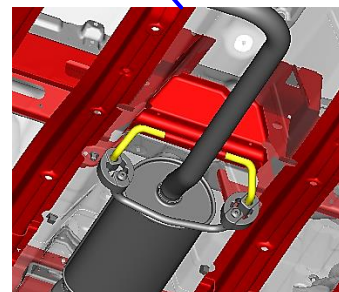
Rear Seat Back
Striker on C-Pillar Reinf.



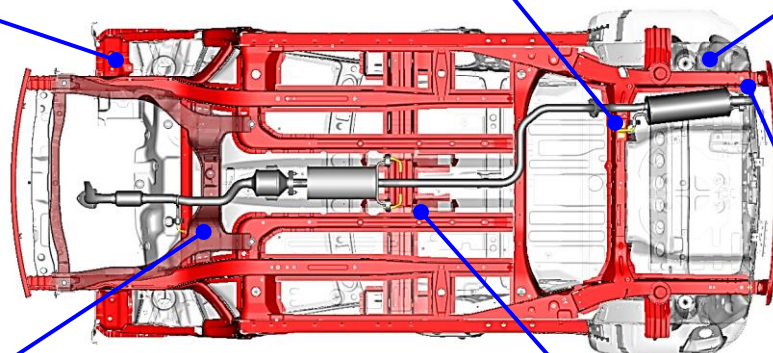
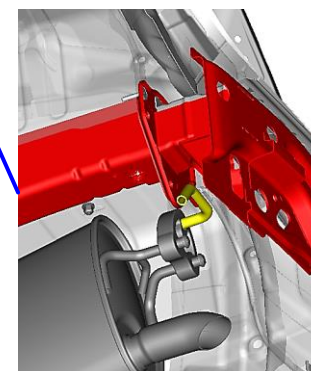
Exhaust Pipe
to Cradle



Exhaust
Pipe to
Tunnel
Bridge



Exhaust Pipe
to Rear Rail



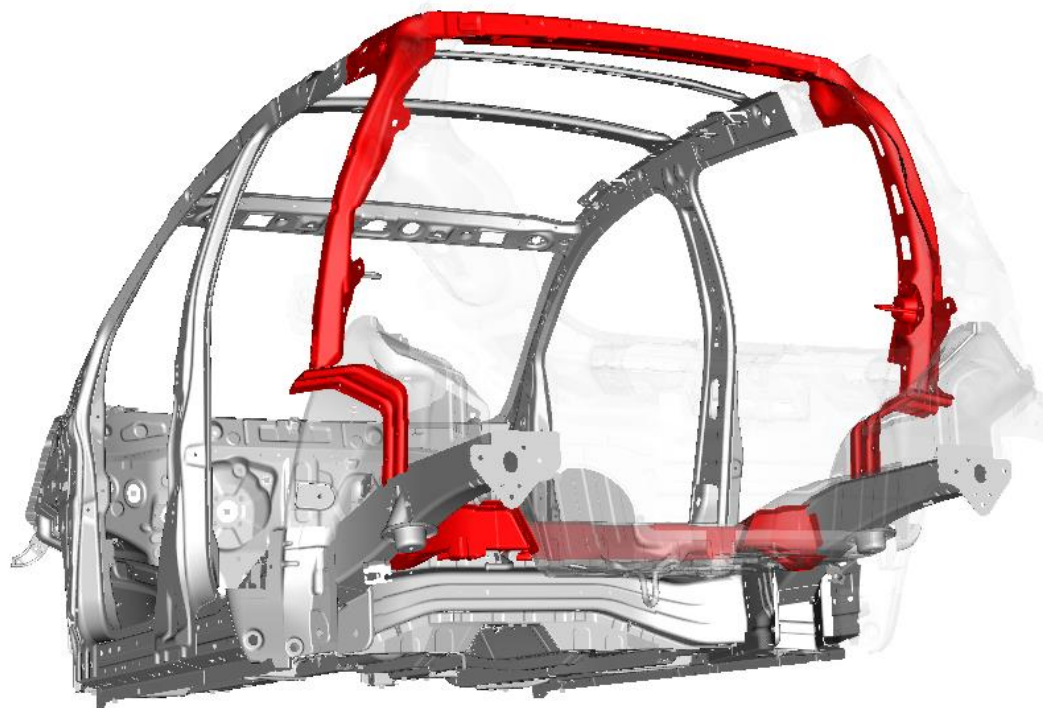


Global Stiffness Performance – Rear End Torsion

❑ *Entire Ring - Rear Body*

Rear Roof Frame → C-Pillar Reinf. → Rear Wheelhouse Brace

→ Rear Floor Center Cross Member





Crash Performance - Frontal Offset Crash



* Data & video source
: www.iihs.org

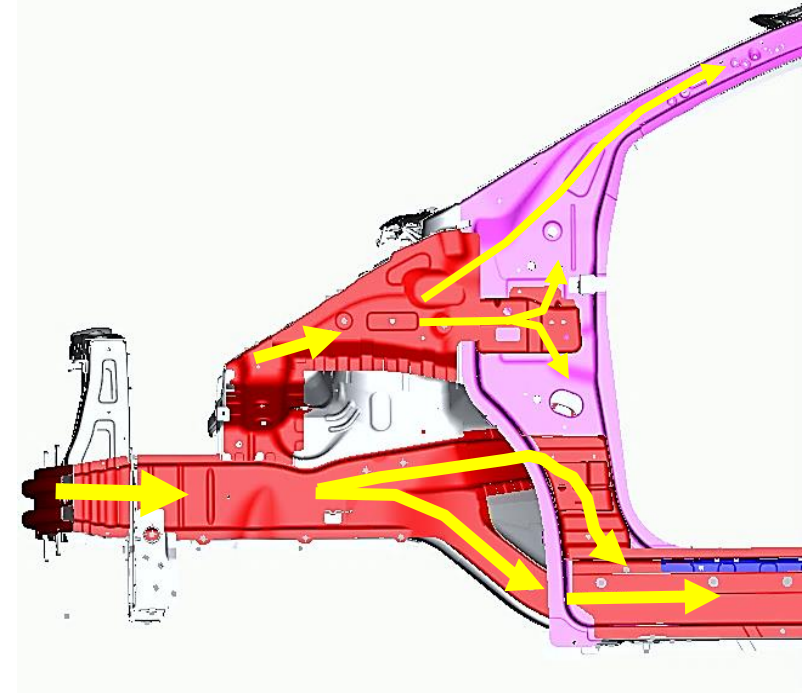
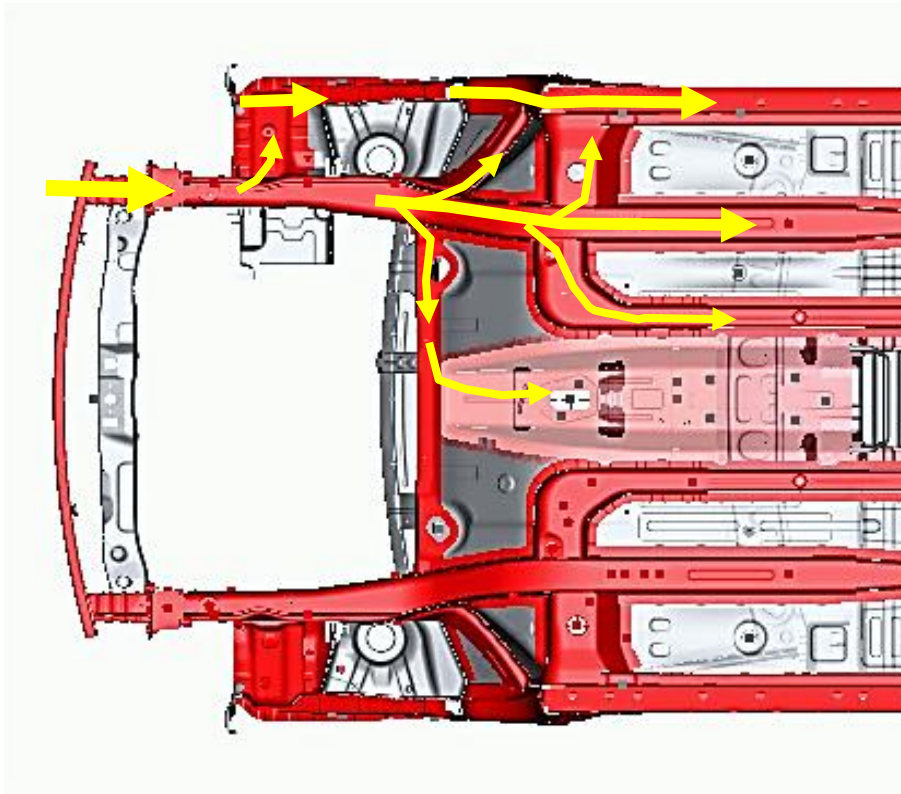
Test details

Technical measurements

Applies to 2013-14 models

Overall evaluation	G
Structure and safety cage	G
Injury measures	
Head/neck	A
Chest	G
Leg/foot, left	G
Leg/foot, right	G
Restraints and dummy kinematics	G

□ Load Path – Frontal Crash

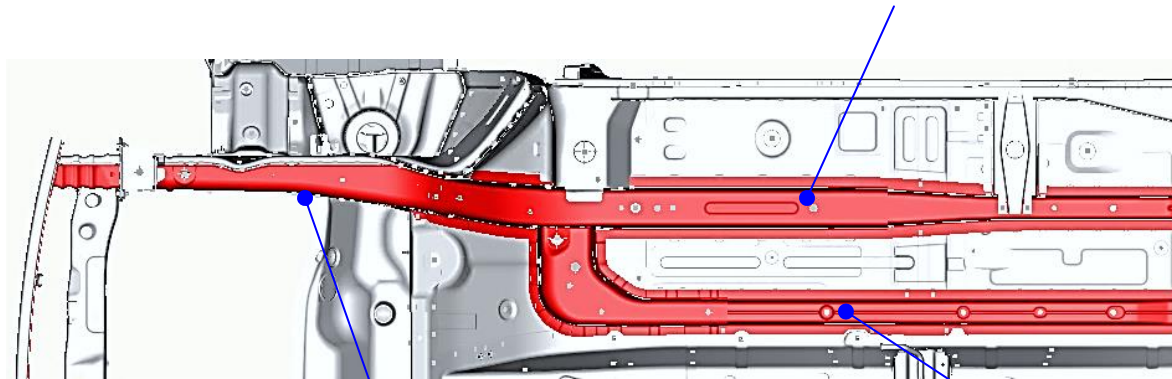




BIW Design Concept – Frontal Crash

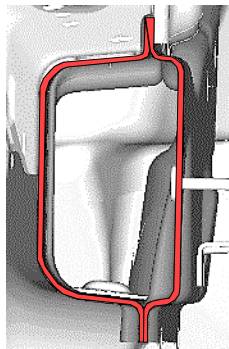
□ *Front Rail Construction*

Straight Front Rail Extension reaches to Rear Floor

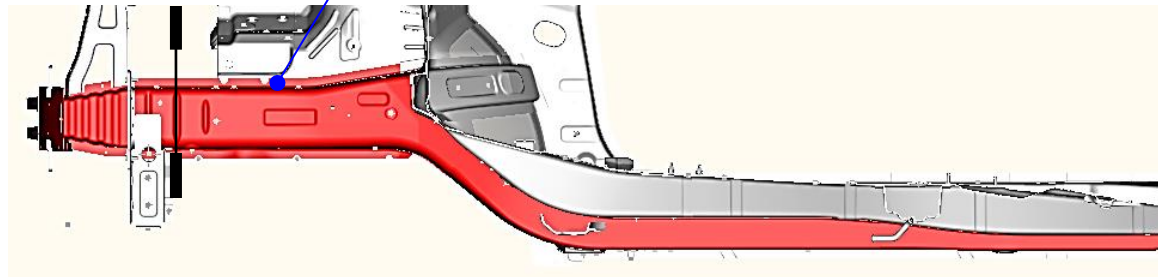


Straight contour of Front Rail with minimized internal Reinforcement

Straight Tunnel Side Rail reaches to Rear Floor



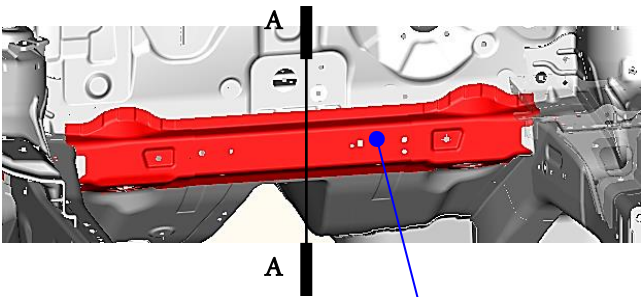
Section



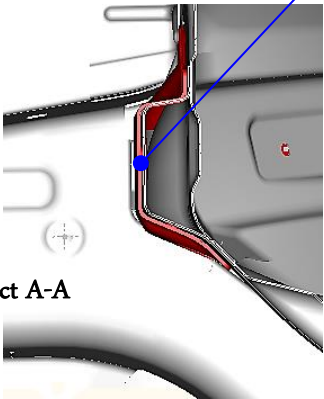


BIW Design Concept – Frontal Crash & SOF

Dash Cross Member

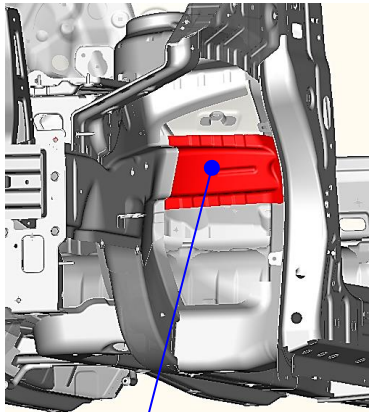
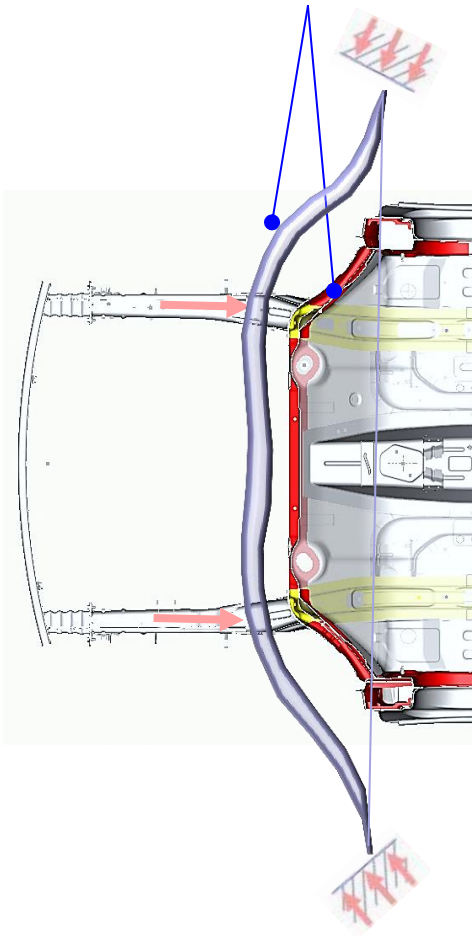


Straight &
rectangular
section

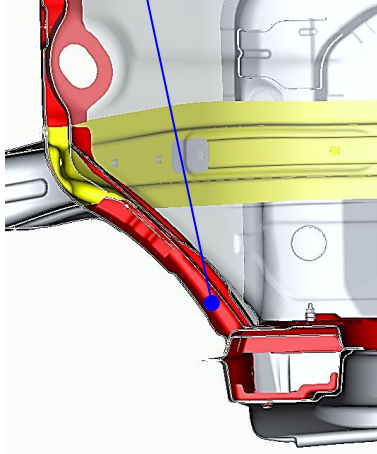


Sect A-A

“Bow” Cross Member construction



Connection between
Rail rear face to Front Hinge Pillar

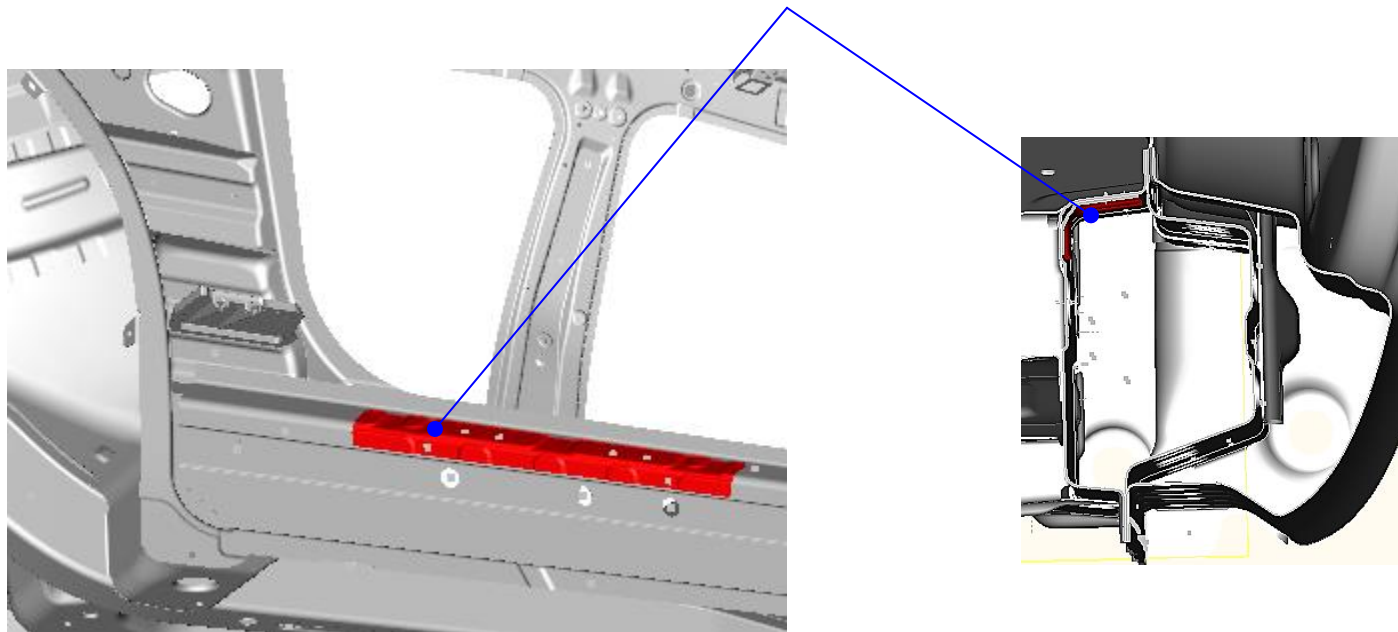




BIW Design Concept – Frontal Crash & SOF

❑ *Rocker Front Construction*

- Corner Doubler in Rocker Inner





Crash Performance – Side Impact



* Data & video source : www.iihs.org

Test details

Technical measurements

Applies to 2013-14 models

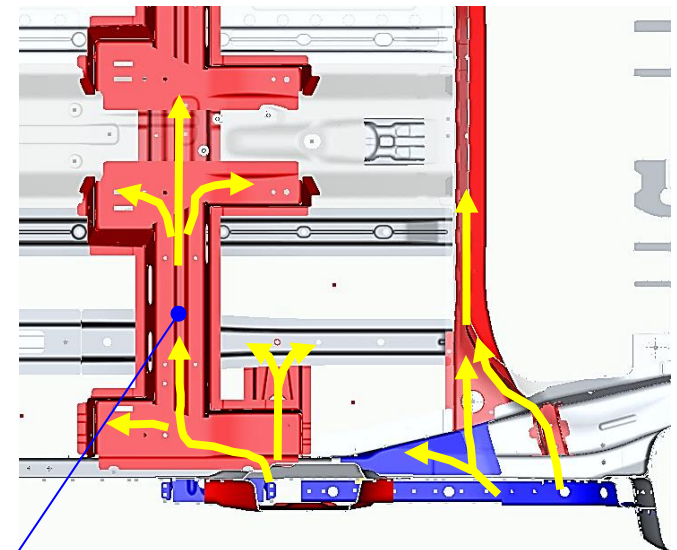
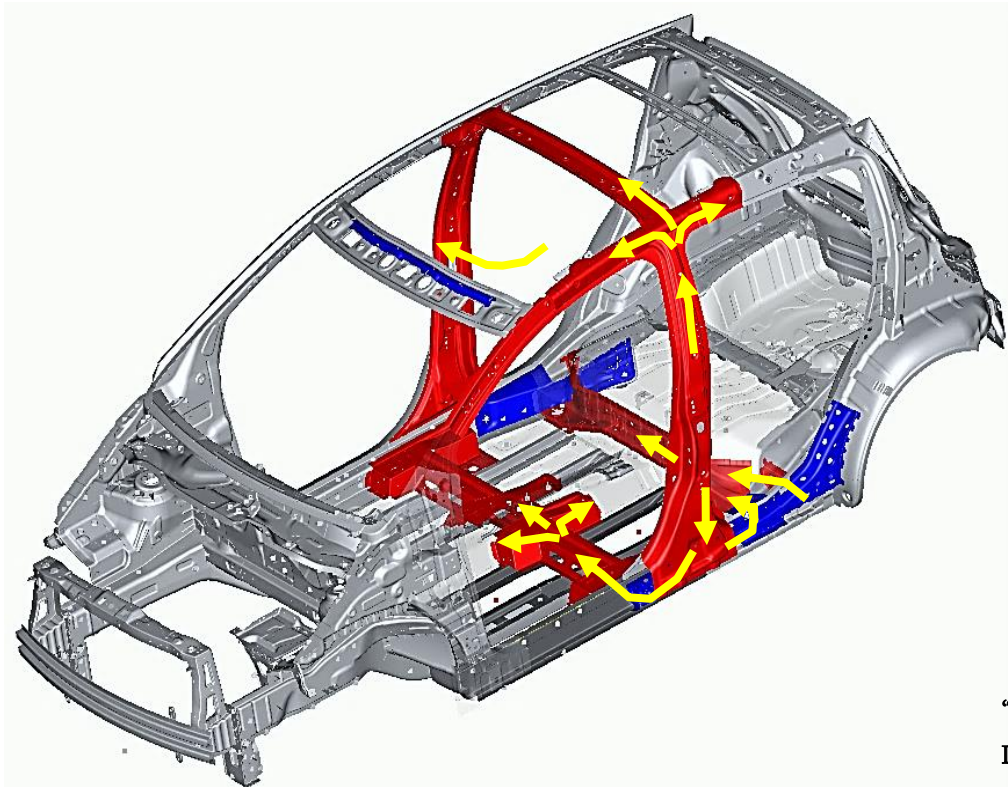
Overall evaluation	G
Structure and safety cage	A
Driver injury measures	
Head/neck	G
Torso	G
Pelvis/leg	G
Head protection	G
Rear passenger injury measures	
Head/neck	G
Torso	G
Pelvis/leg	G
Head protection	G





Crash Performance – Side Impact

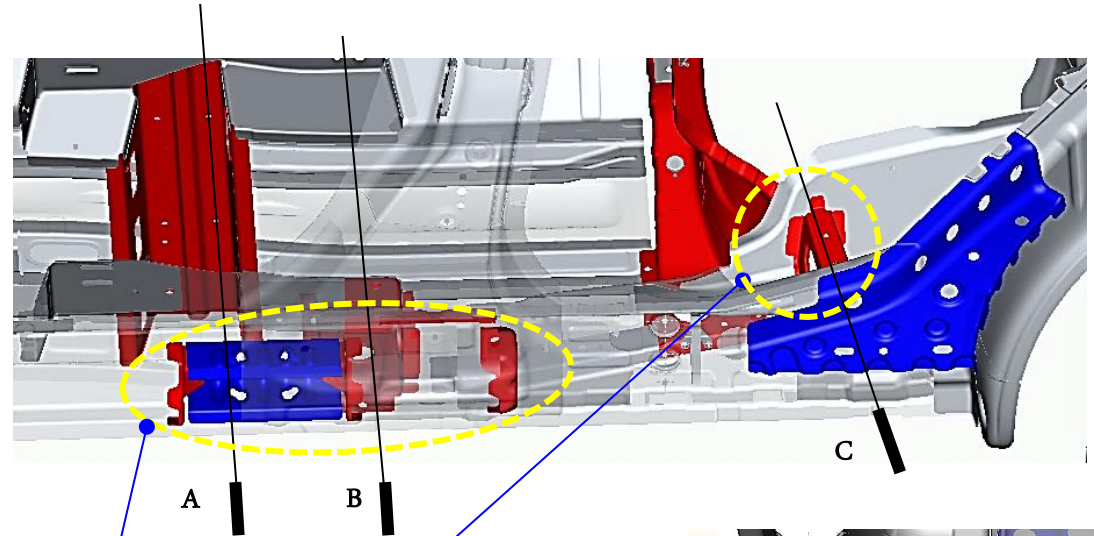
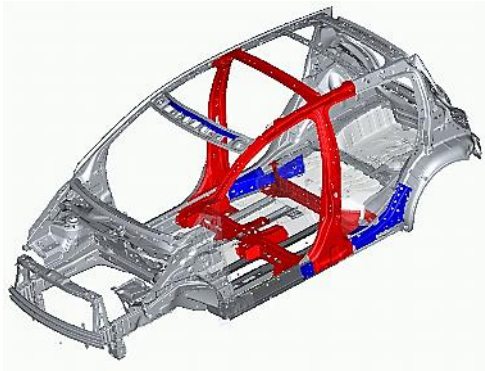
❑ Load Path – Side Crash



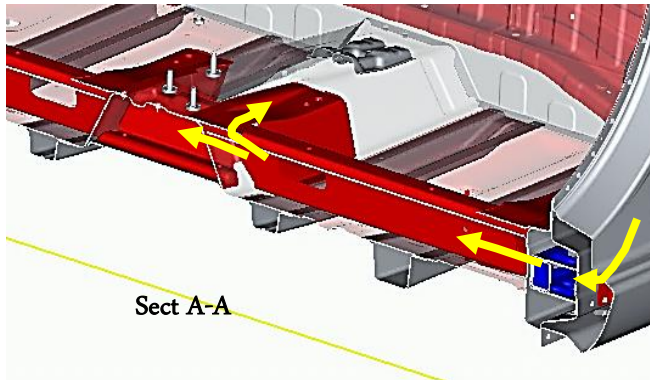
“H-Spider” Material
DP1000



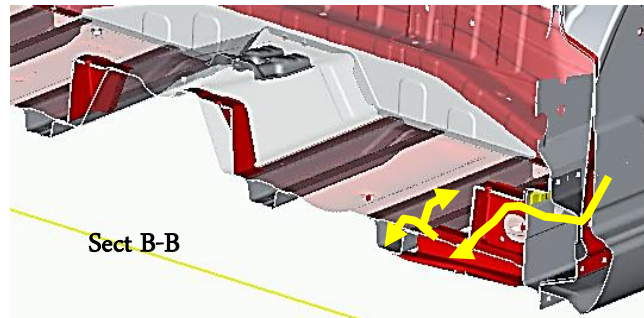
Crash Performance – Side Impact



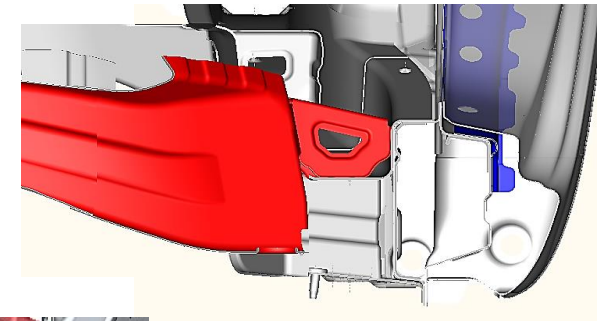
Diaphragm &
Block Bracket
aligned with Cross
Members



Sect A-A



Sect B-B



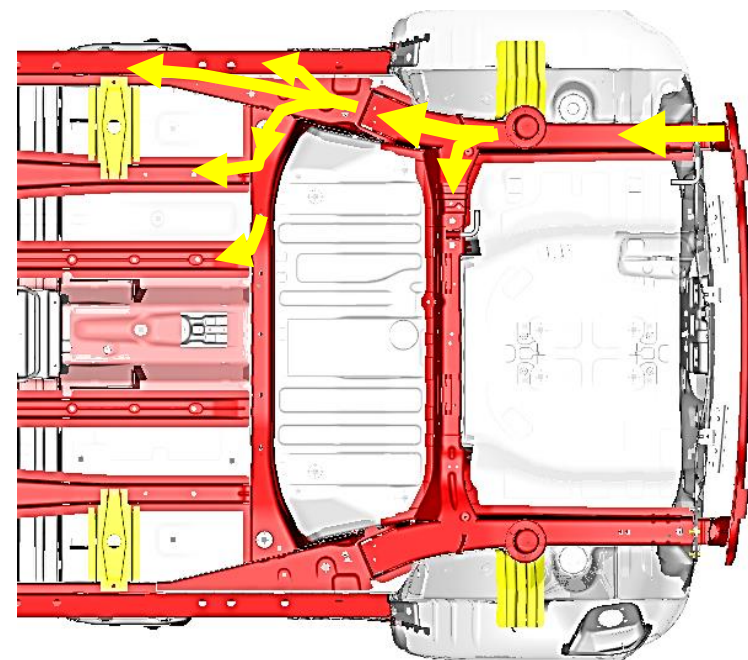
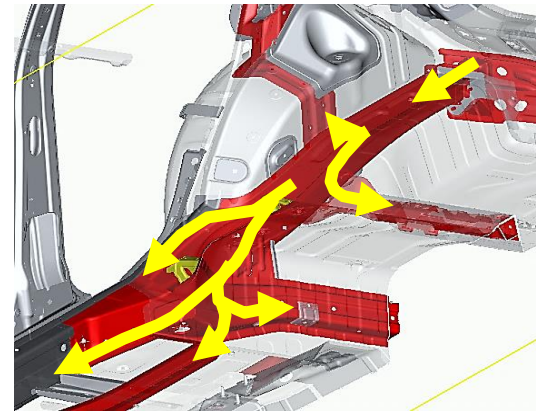
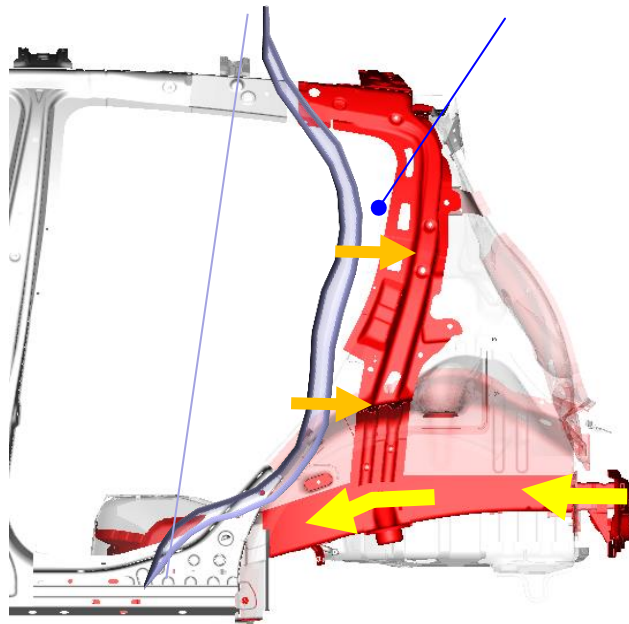
Sect C-C



BIW Design Concept – Rear Crash, 88KPH

Load Path – Rear Crash

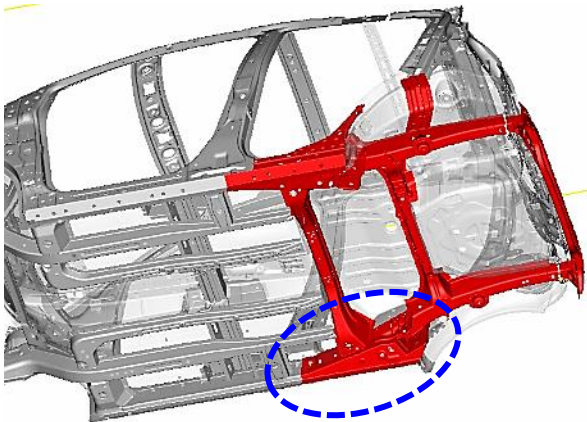
“Bow” construction
helping secure
rear cabin zone



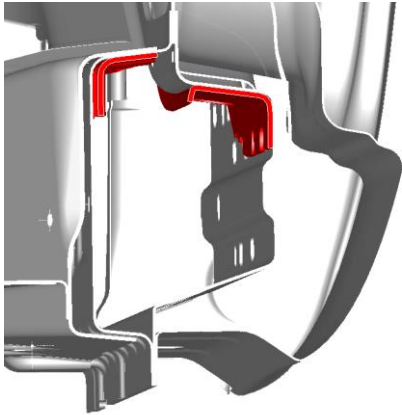
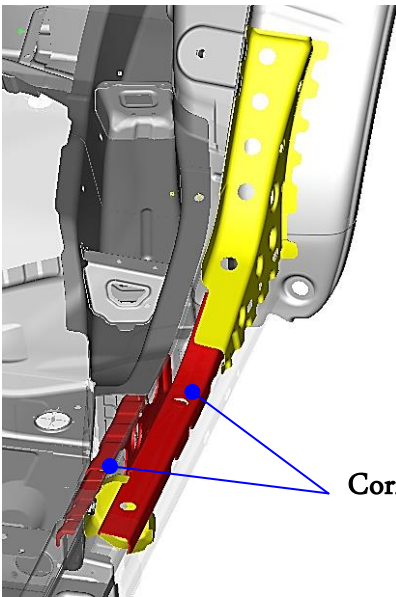
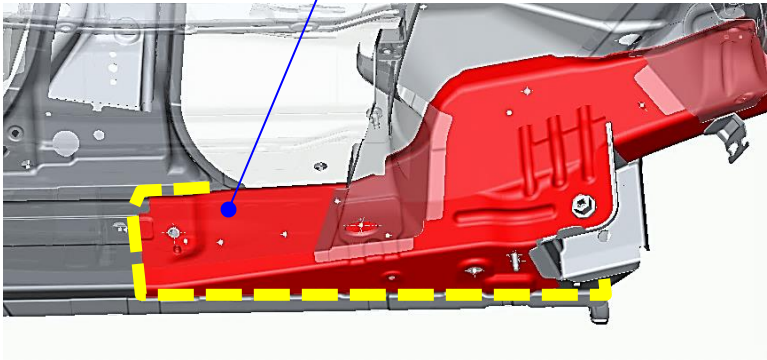


BIW Design Concept – Rear Crash, 88KPH

 Rear Rail to Rocker



Maximized joint of Rear Rail to
Rocker

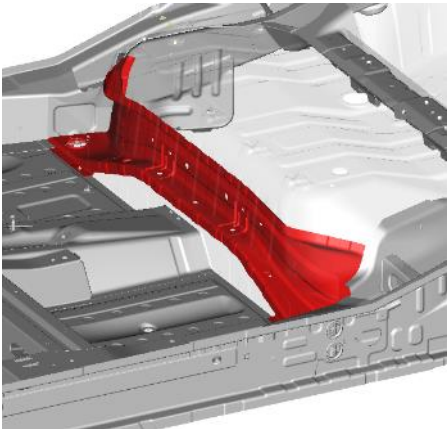


Corner Doublers

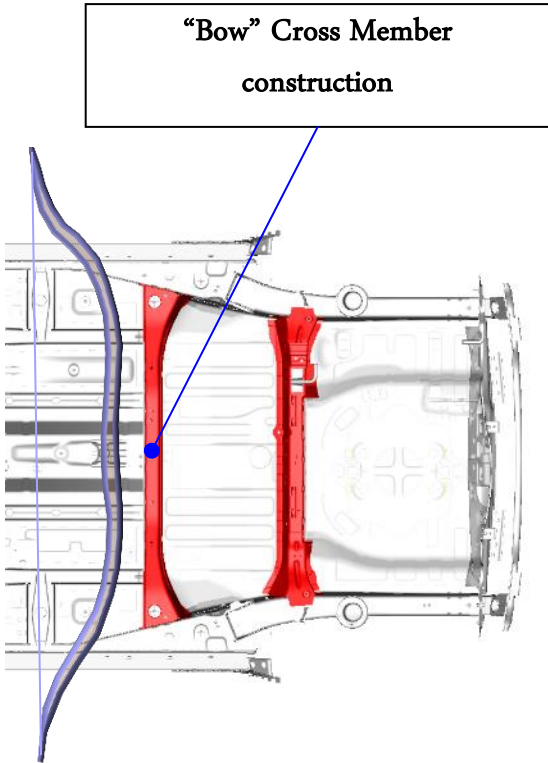
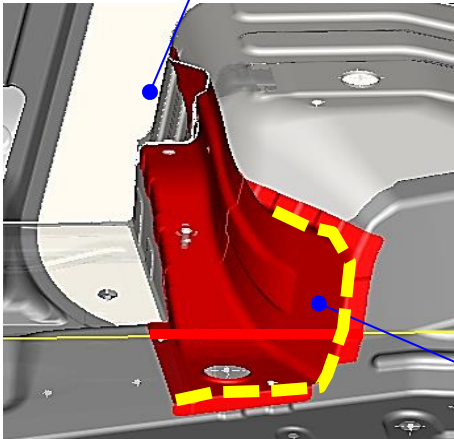


BIW Design Concept – Rear Crash, 88KPH

Rear Floor Front / Center Cross Member

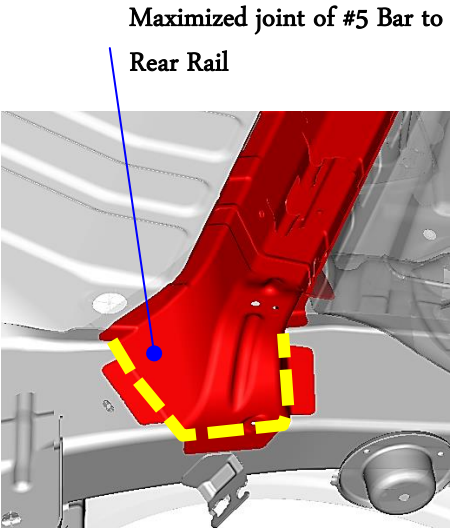


Square section
#4 Bar

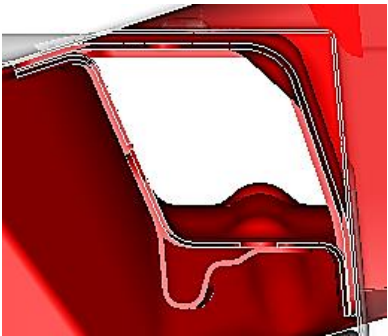


“Bow” Cross Member
construction

Maximized joint of #4 Bar to
Rear Rail



Maximized joint of #5 Bar to
Rear Rail



Closed section
#5 Bar

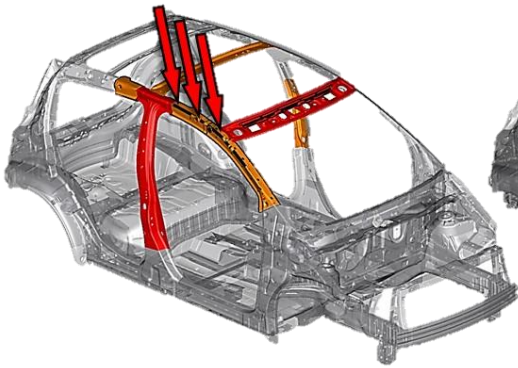


Performance - IIHS Roof 4x Strength



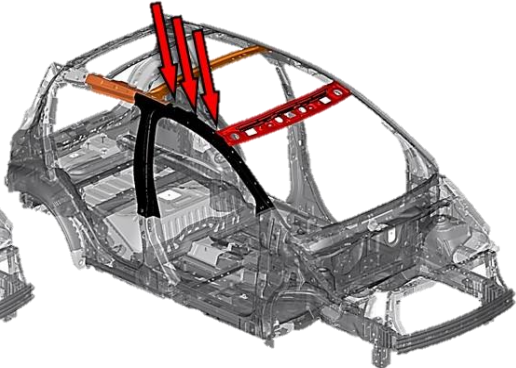
Spark

Peak Force
4,615 Kg



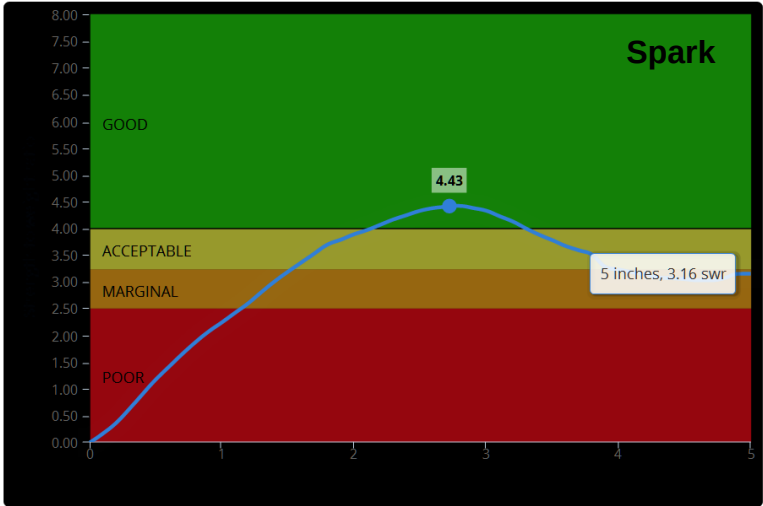
Spark EV

Peak Force



Video & data source : www.iihs.org

	Overall Rating	Curb Weight (kg)	Peak Force (kg)	Strength-to-Weight Ratio	Source
Spark	G	1,042	4,615	4.43	IIHS test
Spark EV	Not tested				





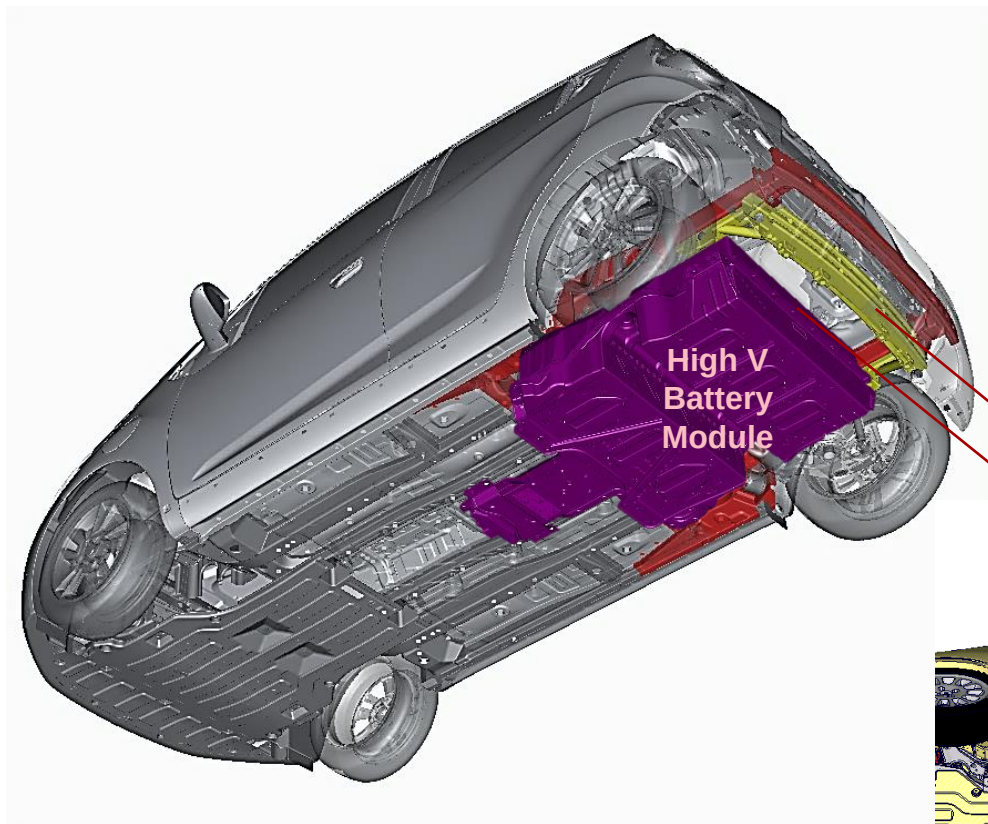
Body Design Strategy – Spark EV

- ☐ Affordable Body for Electric Vehicle
- ☐ High Structural Efficiency of EV Unique Parts
- ☐ Support Heavier Vehicle Weight (+ 310 kg)
- ☐ Protect High Voltage Parts (Battery Unit, etc.)



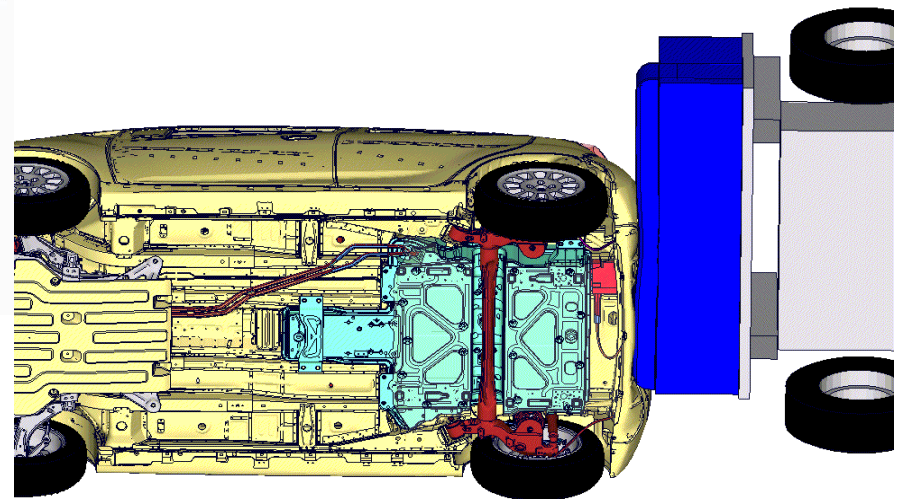


Crash Performance – Spark EV, Rear Crash, 88 kph



Crumple zone
only 196 mm

★ ★ *Protect battery
during crash*

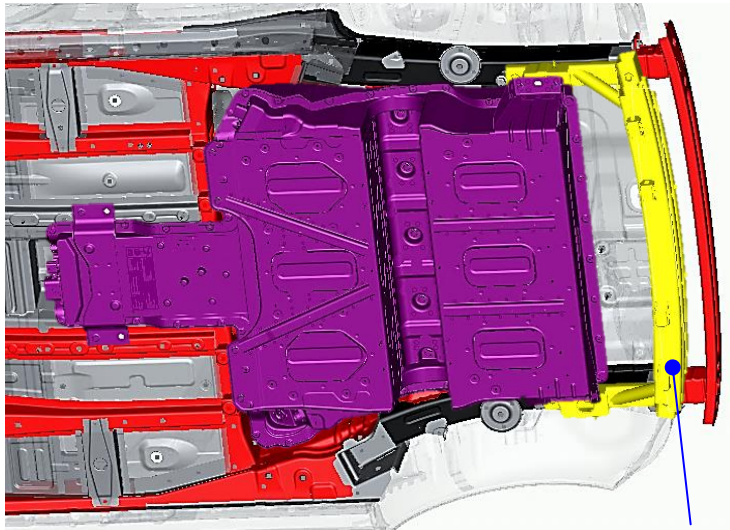


Standard Rigid and Null Corps by Karyl W - 2016 5 91 time 4 000002

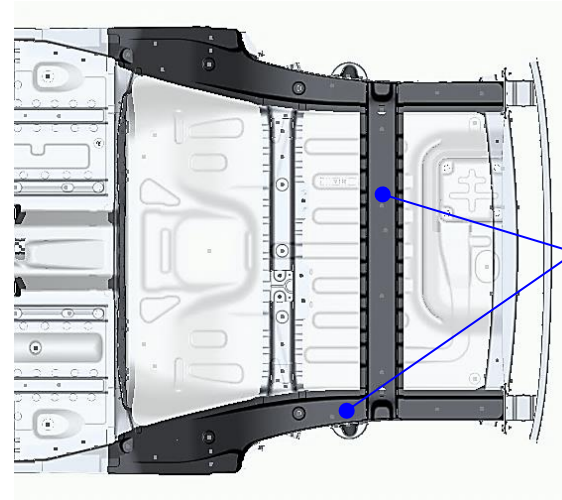
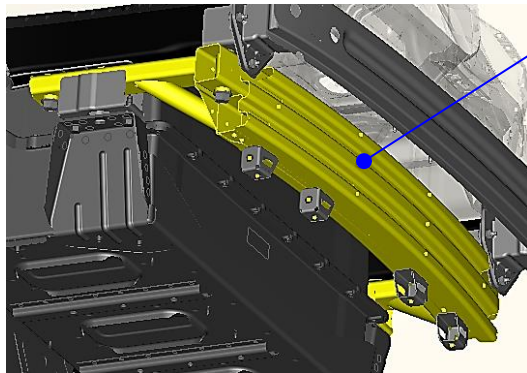




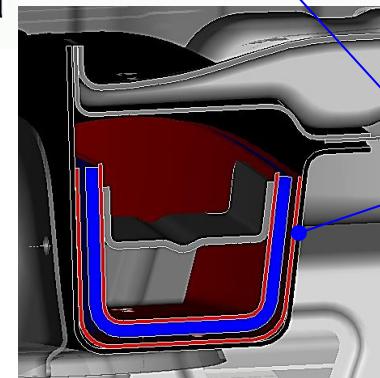
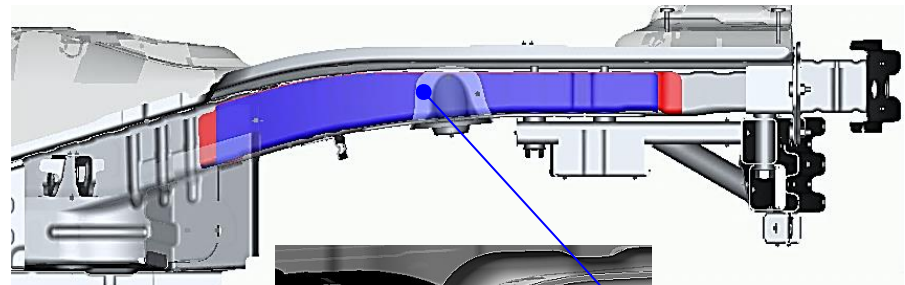
Crash Performance – Spark EV, Rear Crash, 88 kph



Bolt-on
protector bar
for battery unit
protection



PHS applied on Rear
Rail & Cross Member



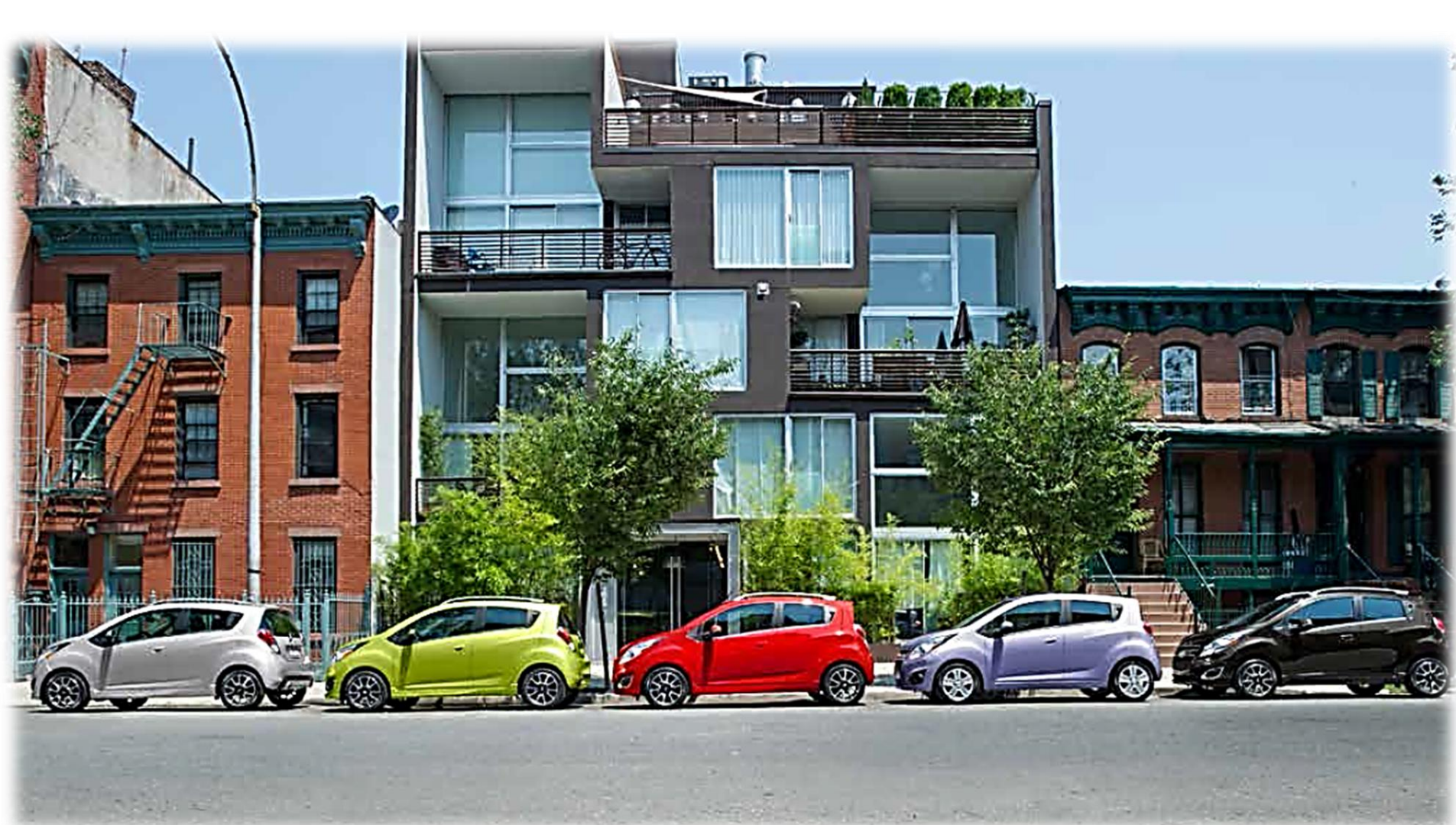
Structural foam
insert



Summary

- ❑ General Motors First Global Mini Car
- ❑ Won IIHS 2014 “Top Safety Pick”
- ❑ Achieved IIHS Small Offset Front “Acceptable” Rating
- ❑ Body Torsional Stiffness Exceeds Global Requirement
- ❑ High Strength Steel Utilization over 65%
- ❑ Optimized Body Design for Supporting Higher Mass of EV
- ❑ Enhanced PHS Application for Supporting EV Battery Unit





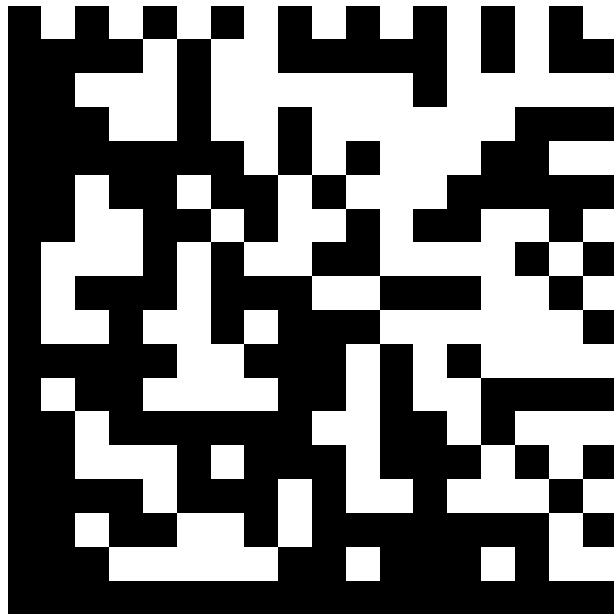
Thank you for your attention !

**Ickhee Han
GM Korea**



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