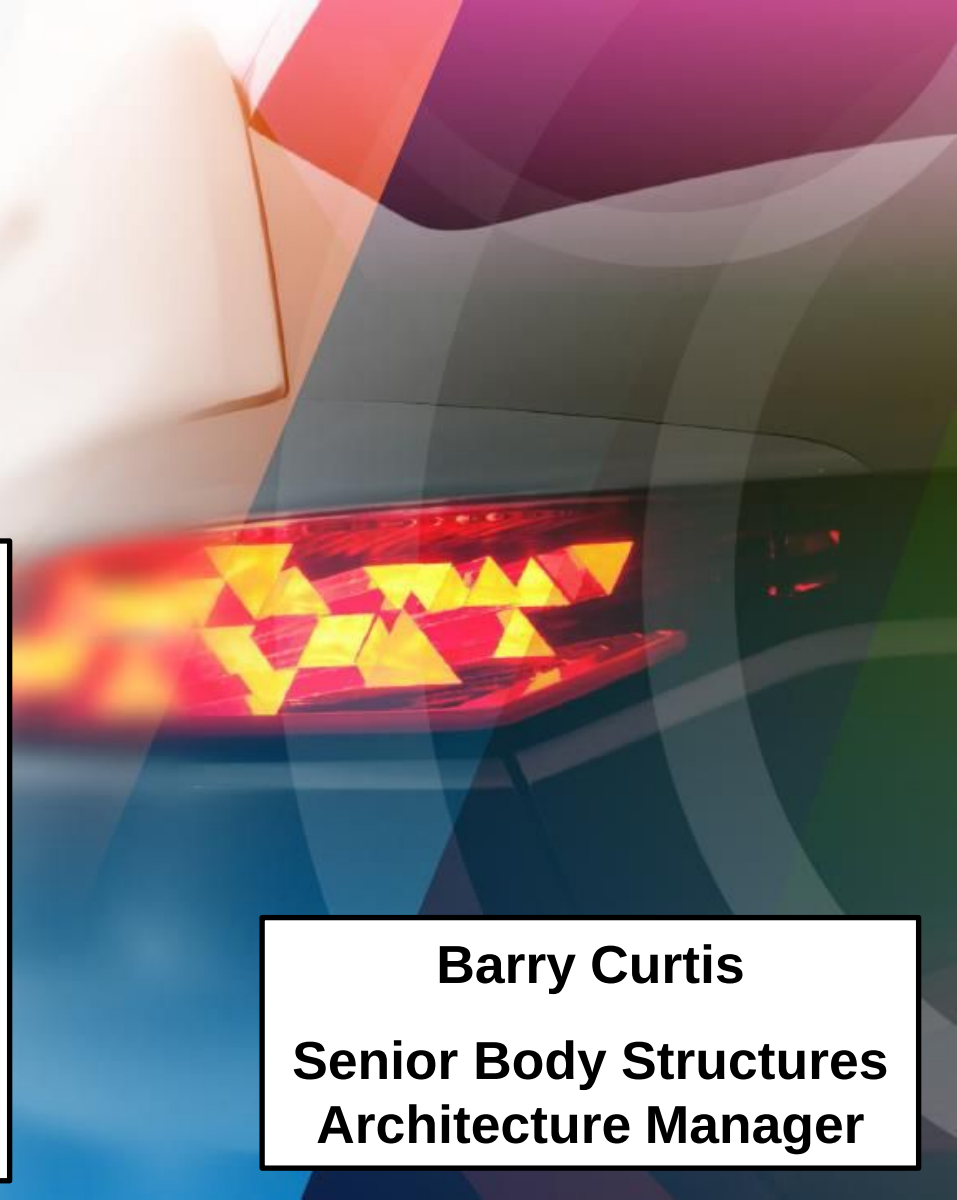
上汽集团
SAIC MOTOR
UK Technical Centre

Adhesive Placement Optimisation in BIW Design



Barry Curtis

Senior Body Structures Architecture Manager

ABOUT
SAIC MOTOR

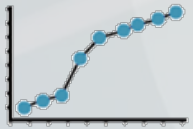
Who are SAIC?

ABOUT
SAIC MOTOR

China's LARGEST automobile company, founded in 1958 and headquarters in Shanghai

SAIC Motor's business covers the research, production and vehicle sales of both passenger cars and commercial vehicles. It also covers components including engines, gearboxes, powertrains, chassis, interior and exterior and miscellaneous electronic components, and logistics, vehicle telematics, second-hand vehicle transactions and auto finance services.

5 MILLION +
units sold worldwide

60TH

FORTUNE 500 COMPANY
in the world

SAIC
上汽集团
SAIC MOTOR

上海大众汽车 SHANGHAI VOLKSWAGEN 50%

SHANGHAI GM 51%

SAIC Motor Passenger Vehicle Company (SMPV)

SAIC Motor Technical Centre (SMTC)

SMPV Manufactur

SMTC Anting

SMTC Nanjing

SMTC UK

SAIC-CP Motor Co LTD

Pukou (Nanjing

SMTC UK
CAPABILITY

ROEWE
is for the domestic Chinese market only

Has traditional values of refinement, quality and space.

Combined with contemporary styling and world-class engineering.

MG
is a global brand, on sale in 40 countries around the world

In 2014 MG was the fastest growing brand in the UK with an incredible 361% increase in sales.

Provides modern and individual styling.

Combined with high technology, great dynamics and global engineering quality.

MG GS
Developed by SAIC Motor UK and China Technical Centres

Launched in China, 2015. European launch in June 2016.

In May 2016, the first reveal of the car will be at the London Motor Show.

MG 6
Developed by SAIC Motor UK and China Technical Centres

Shared platform with Roewe 550

Launched in China, 2009
European launch Q1 2011

MG GT
Developed by SAIC Motor UK and China Technical Centres

Shared platform with Roewe 350 & MG 5

Launched in China, 2014

MG 5
Developed by SAIC Motor UK and China Technical Centres

Shared platform with Roewe 350

Launched in China, 2012

MG 3
Developed by SAIC Motor UK and China Technical Centres

Launched in China, 2011

Launched in UK, 2013

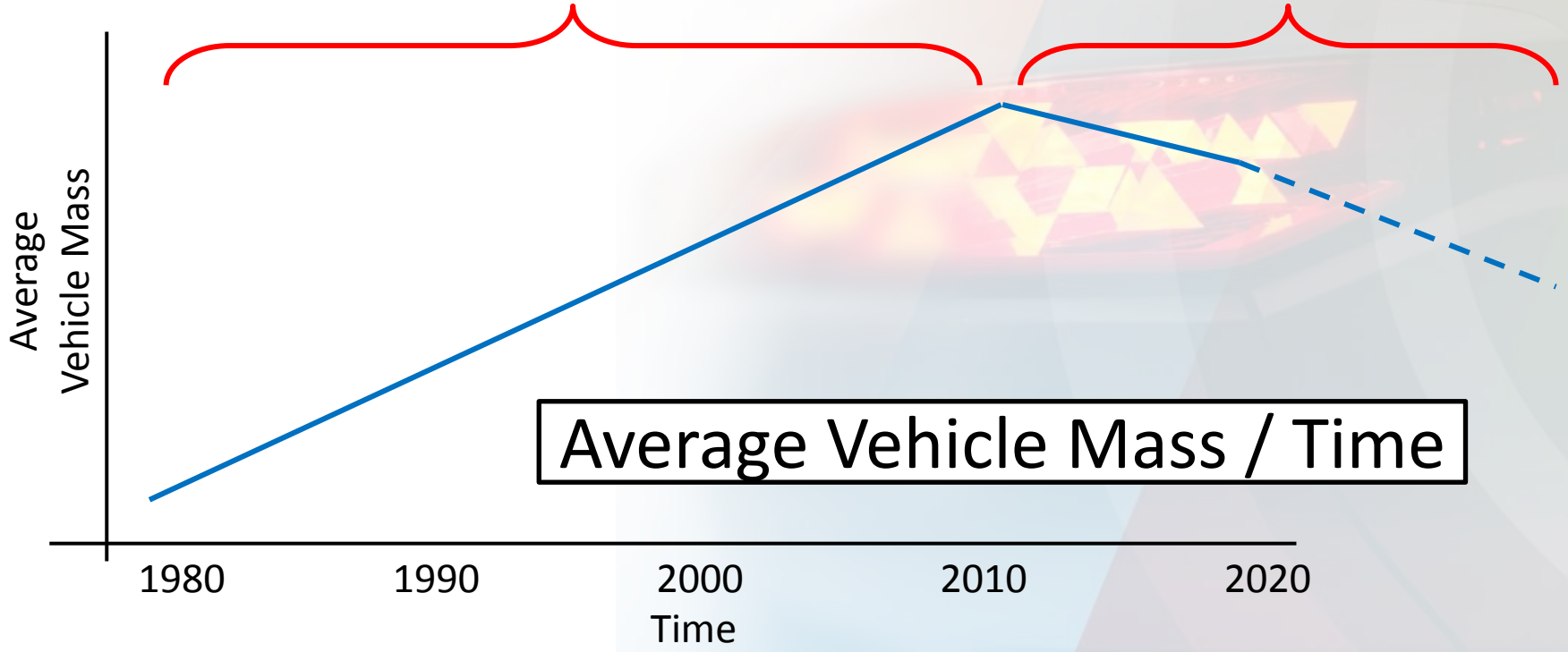
Presentation Contents

1. Vehicle Mass Trend
2. BIW Trends
3. High Strength Adhesive Trend
4. Influence of Adhesive
5. SMTC UK Adhesive Study
6. The Optimisation Model and Process
7. Baseline Run
8. Results
9. Summary

Vehicle Mass Trend

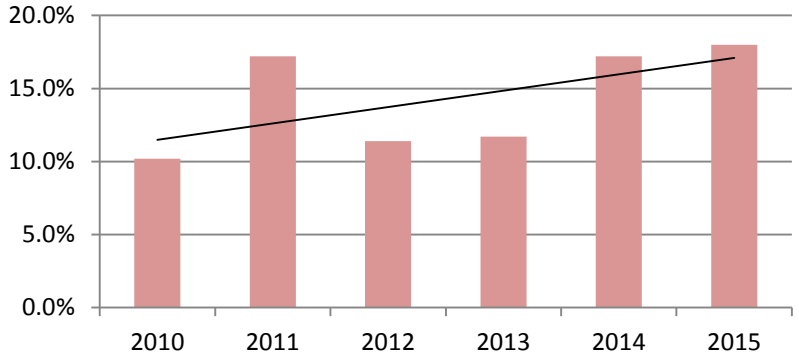
Increase in customer expectations (safety, comfort, feature) added to the vehicle weight in this period

The search for fuel economy improvements and CO2 output reduction has reversed the mass trend

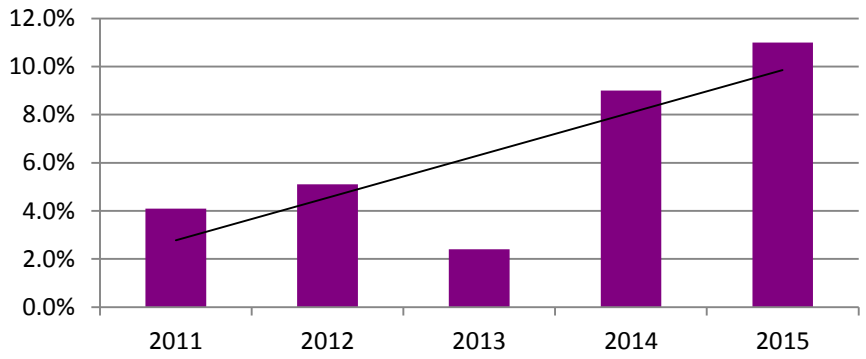


Sub £30k vehicle BIW Trends

Advanced and Ultra High Strength Steel Use / Year



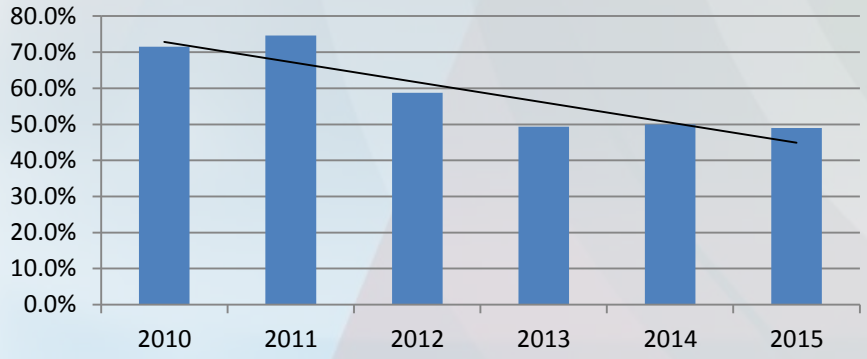
Press Hardened Steel Use / Year



Very High Strength Steels materials are being used in higher percentages

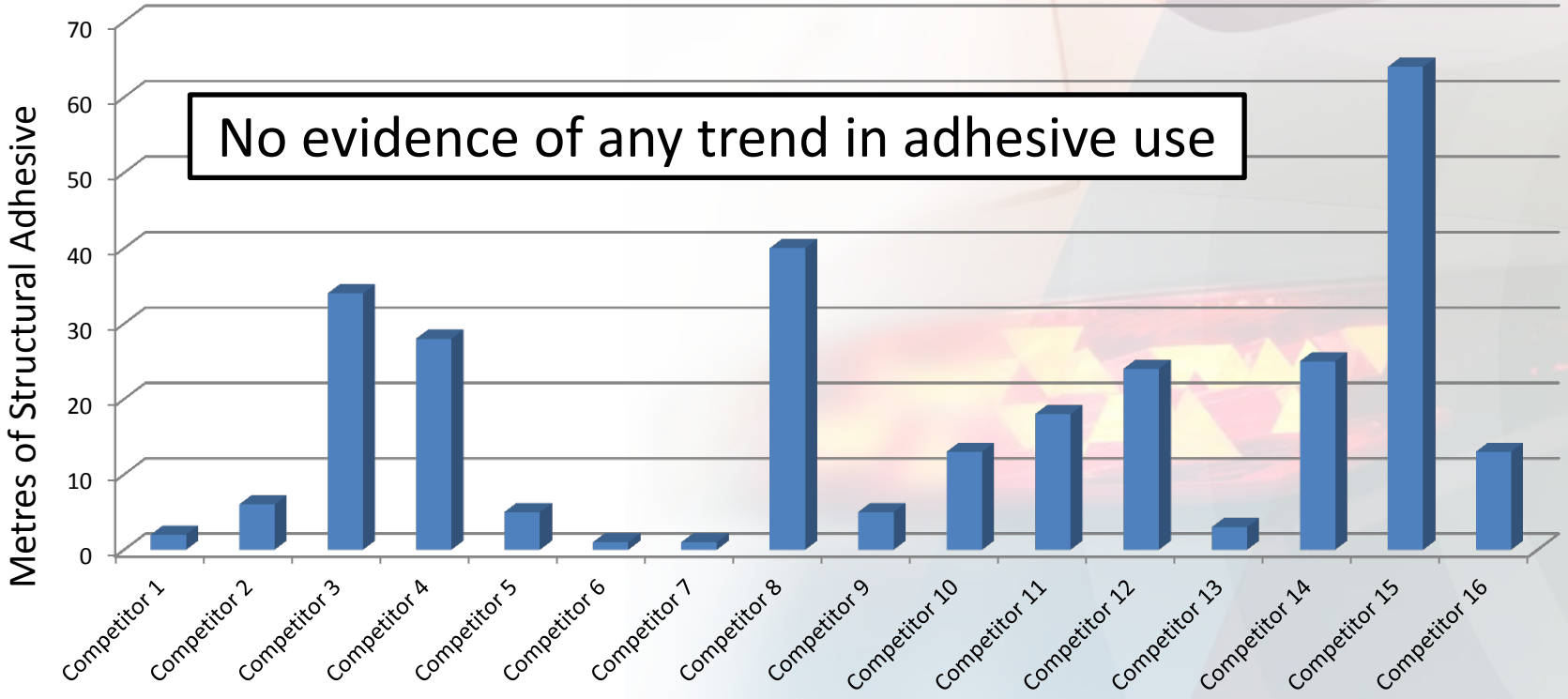
Obviously the percentage of lower strength Steel is in decline

Mild and High Strength Steel Use / Year



Data from ECB

High Strength Adhesive

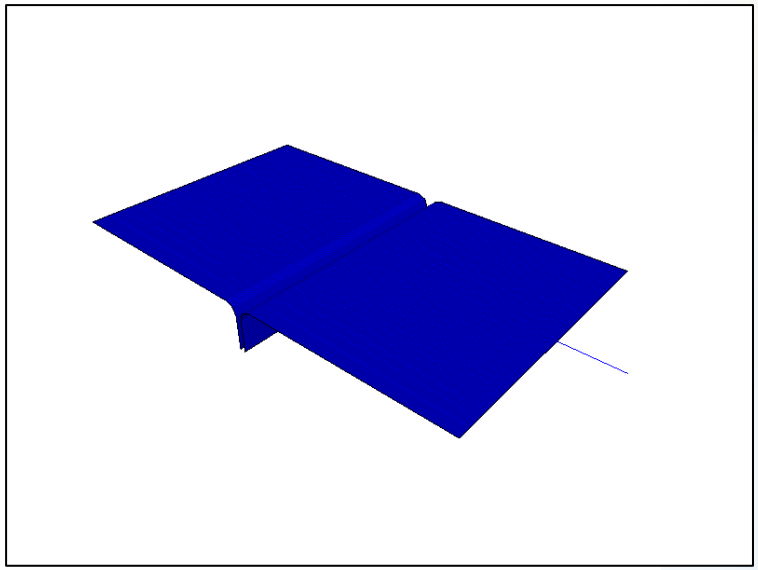


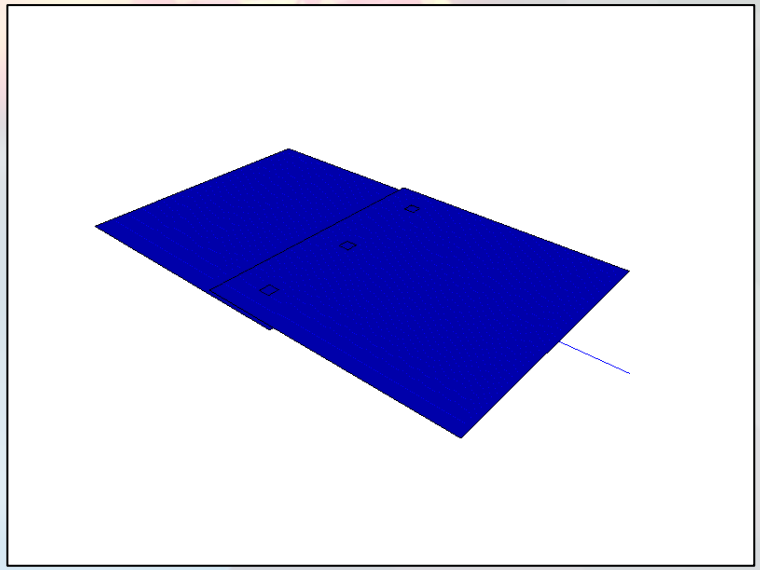
Lowest Cost — Vehicles Arranged by Estimated Retail Price — Highest Cost

Data from ECB 2013 – 2015 (Steel BIW only)

Influence of Adhesive

- Adding adhesive to a spot welded joint makes it:
  - 4 times stiffer in peel
  - 5 times stiffer in shear
  - 1.5 times stiffer in vertical torsion
  - 2.2 times stiffer in horizontal torsion
- This means it's difficult for an engineer to predict what the effect on each joint will be





SMTC Study

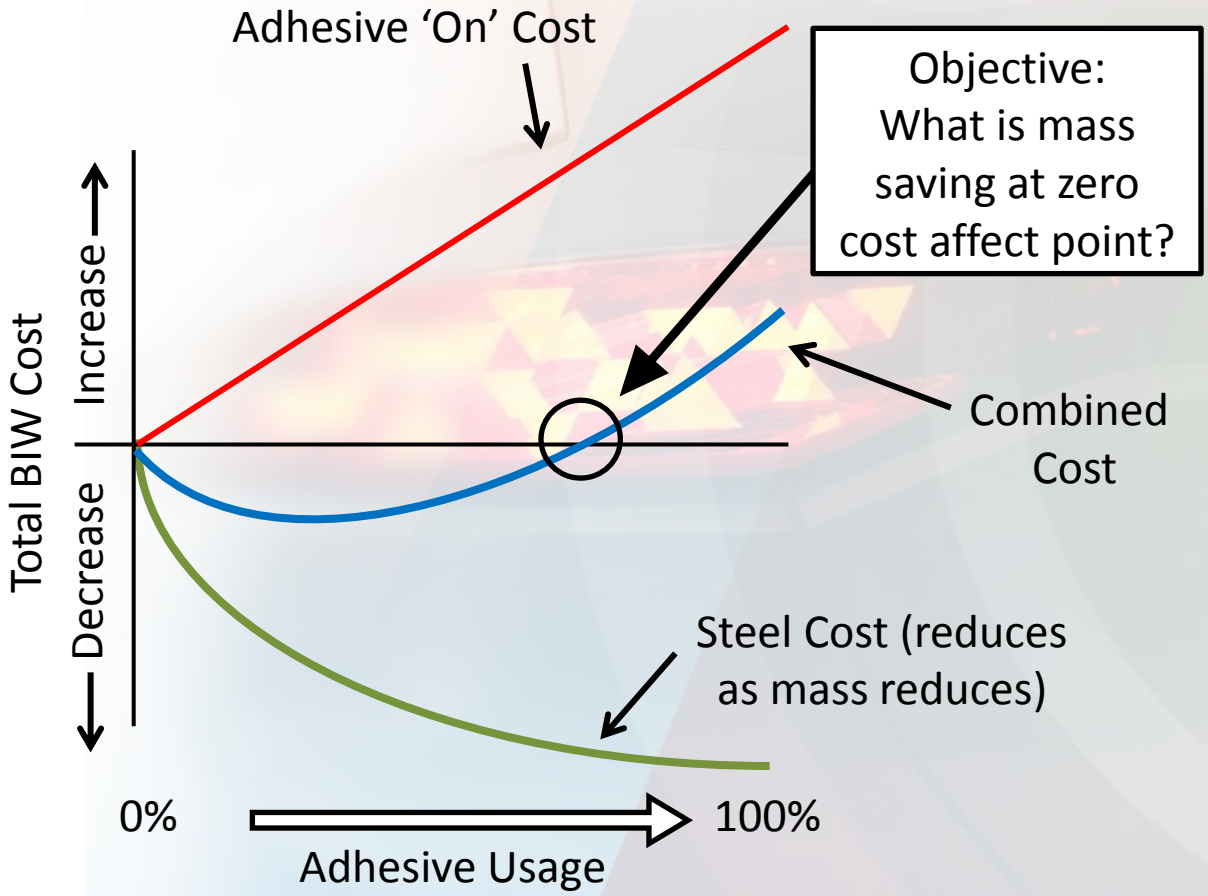
- **Assumption**: using high strength adhesive in the BIW weld flanges will allow a down gauging of some BIW parts allowing a weight reduction without affecting vehicle performance

- **Problem**: the increase in cost from using adhesive in 100% of weld flanges is likely to be prohibitive

- **Study Proposal**: An optimisation study to evaluate where and at what quantity in the BIW structure we can add adhesive to allow a weight reduction without an increase of BIW cost

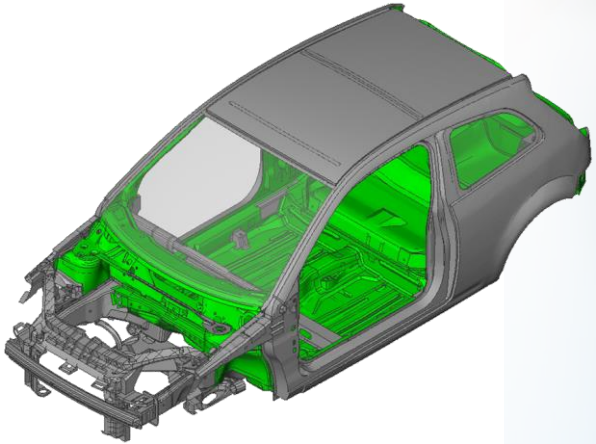
Study Process

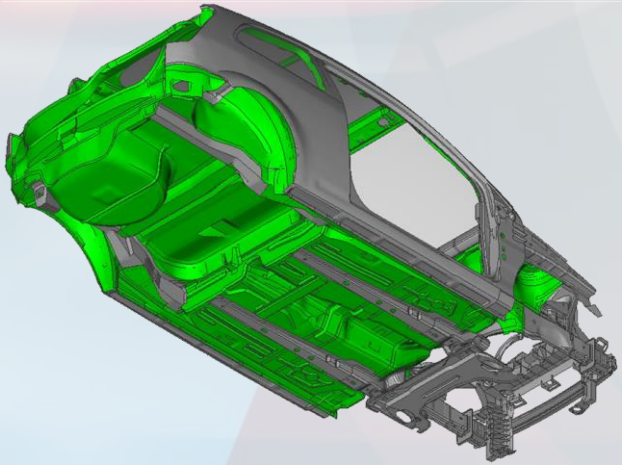
1. Perform a number of optimisations at various distinct adhesive percentage use cases
2. For each optimisation plot the adhesive cost, steel cost and combined cost against the adhesive percentage
3. The point at which the combined cost crosses over the neutral cost axis shows the optimum adhesive use for no cost affect
4. Determine the weight reduction available at this point



Optimisation Model and Objective

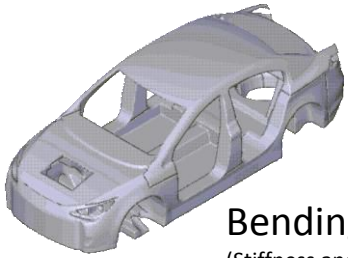
- The CAE optimisation was undertaken using a proven known 3 door CAE model
- The objective is to minimise mass by down gauging panel thicknesses whilst maintaining vehicle performance through the addition of high strength adhesive
- The optimiser is only able to alter the green panels pictured below; the grey parts have been excluded from the optimisation as the gauge is determined by the panel geometry (skin panels) or by an over riding function (crash performance)
- Discrete thickness values limit the panel thickness change to panel gauges already present in the vehicle (between 0.65 and 5.0mm)



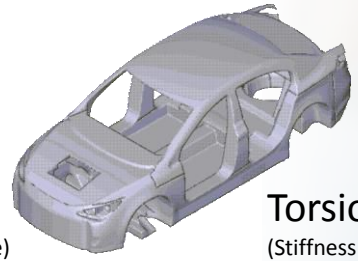


Constraints and Load Cases

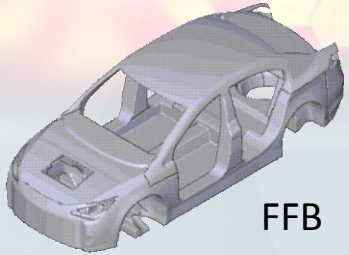
- Performance constrained as follows:
  - 1st mode is constrained as a lower bound.
  - For all other load cases the global strain energy is constrained as an upper bound.
- The optimiser will add set amounts of adhesive to constrain the performance but reduce the mass of the system
- Load Cases (picture taken from another project) shown below
- Linierized crash loads are used where applicable



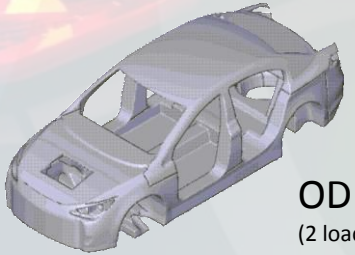
Bending
(Stiffness and 1st Mode)



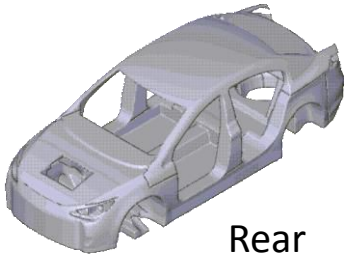
Torsion
(Stiffness and 1st Mode)



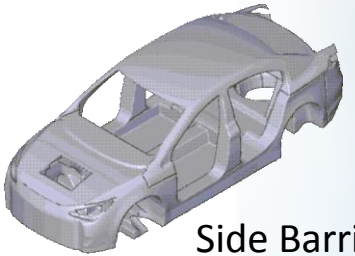
FFB



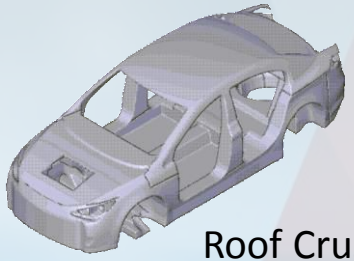
ODB
(2 load cases)



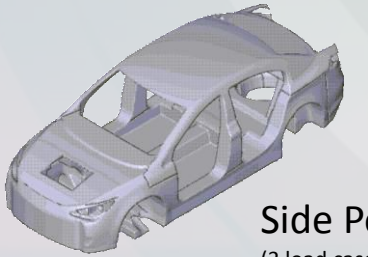
Rear



Side Barrier



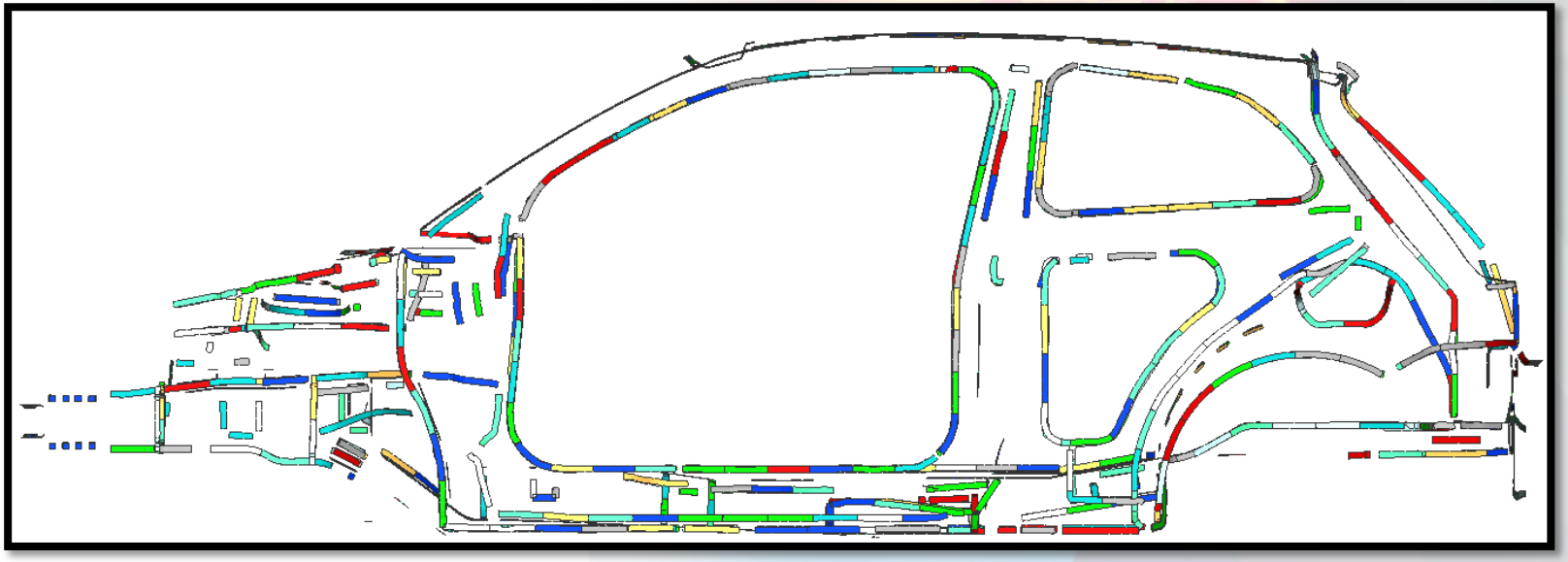
Roof Crush



Side Pole
(3 load cases)

Adhesive setup

- Solid adhesive elements defined at all BIW panel joints.
- Topology optimisation used to remove adhesive not required to achieve target performance.
- The adhesive was split into 100mm design regions and the optimiser forced to only select full regions
  - Prevented the optimiser spacing the adhesive between the spotwelds



Baseline Performance Analysis

Baseline runs to see performance uplift with 100% adhesive use.
No optimisation.

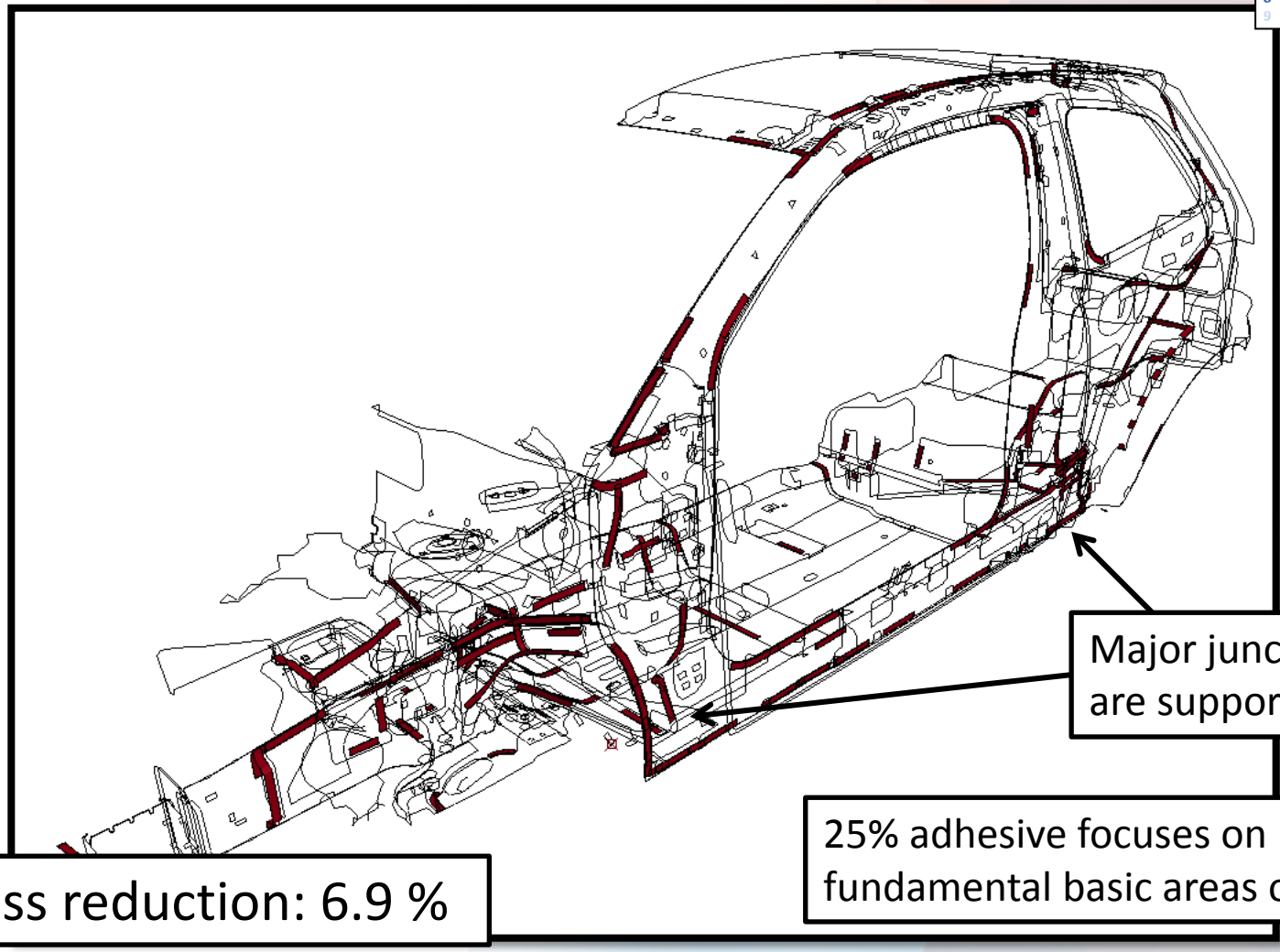
- Baseline - spot-welds only.
  - 1st Mode : 42 Hertz
  - Torsion : 18,100 Nm/deg
  - Bending : 6.4 kN/mm

- With spot-welds and 100% adhesive.
  - 1st Mode : 45 Hertz (+3 Hertz)
  - Torsion : 21,901 Nm/deg (+21%)
  - Bending : 7.1 kN/mm (+10%)

上汽集团
SAIC MOTOR
UK Technical Centre

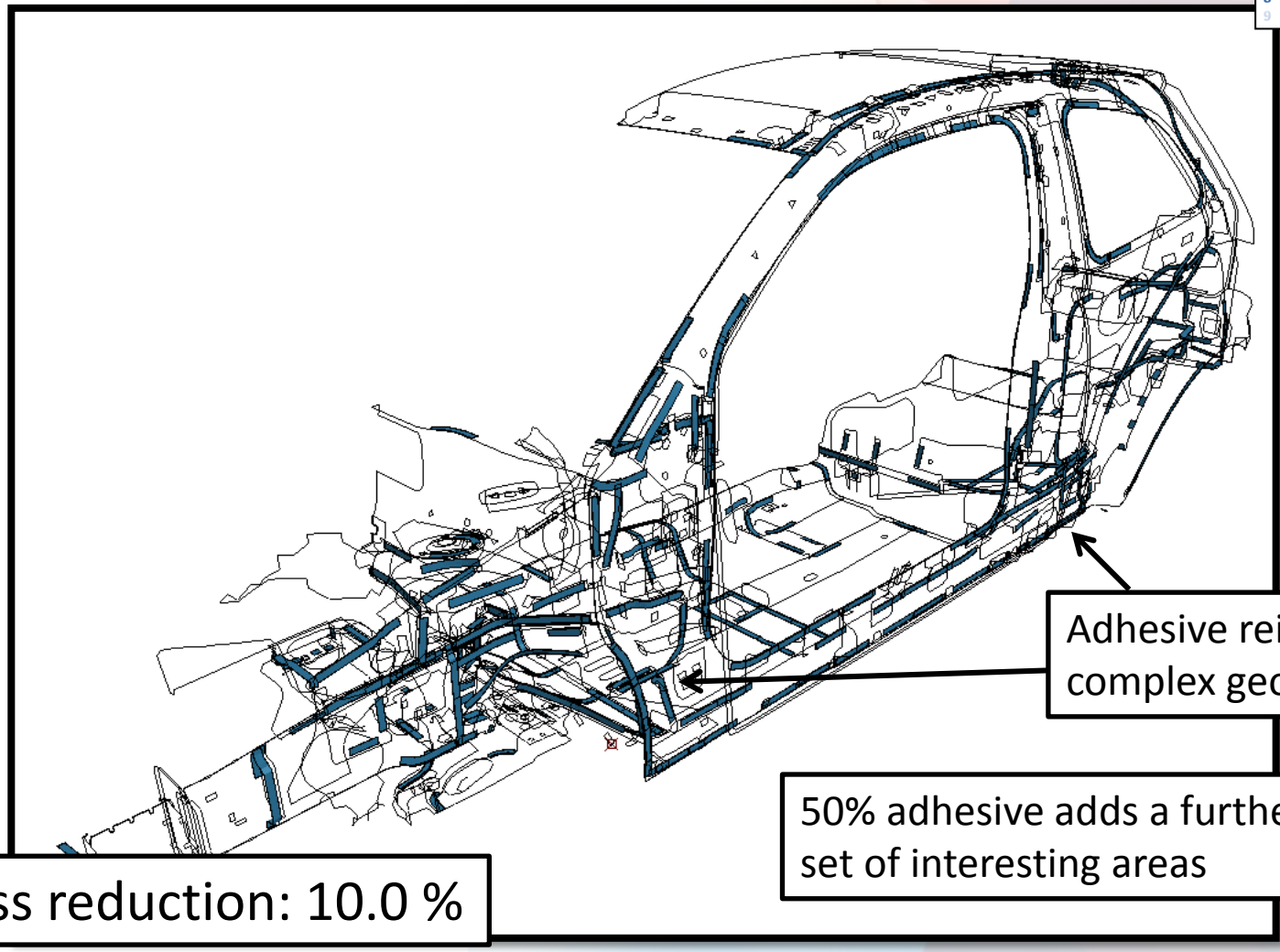
Optimisation Results

25% Coverage



BIW Mass reduction: 6.9 %

50% Coverage



Adhesive reinforces complex geometry

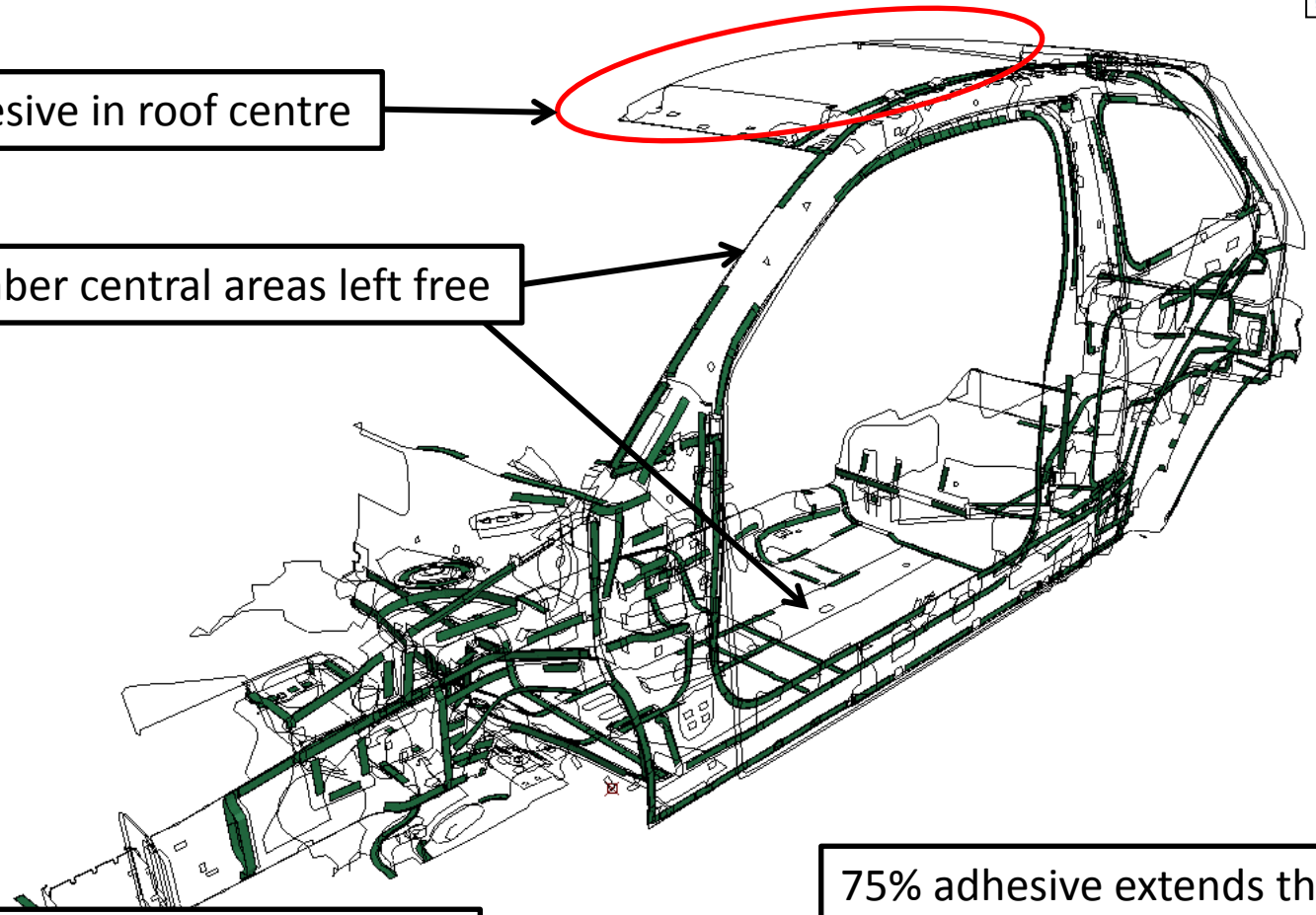
50% adhesive adds a further set of interesting areas

BIW Mass reduction: 10.0 %

75% Coverage

No adhesive in roof centre

Long member central areas left free

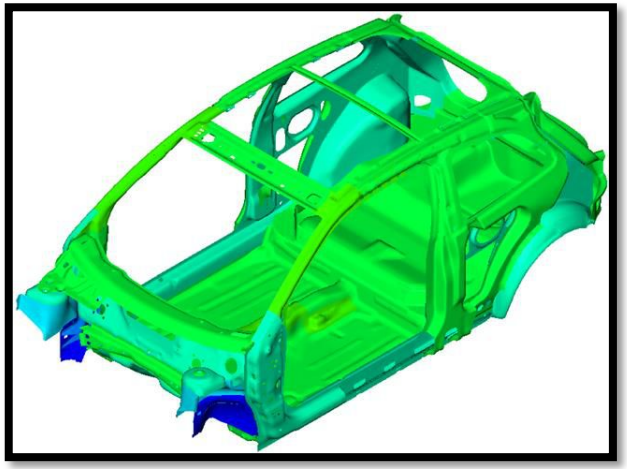


75% adhesive extends the previous set but doesn't add many new ones.

BIW Mass reduction: 10.7 %

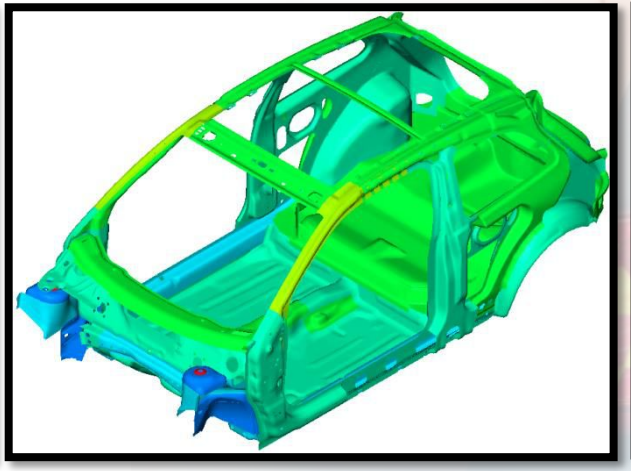
Down Gauge Comparison

25% Adhesive



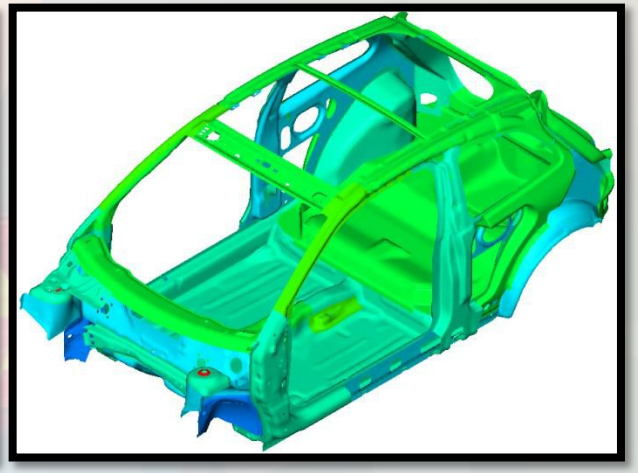
6.9 % Reduction

50% Adhesive

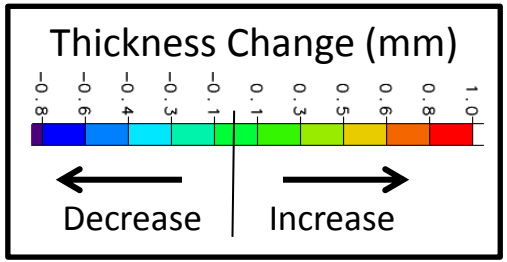


10.0 % Reduction

75% Adhesive



10.7 % Reduction

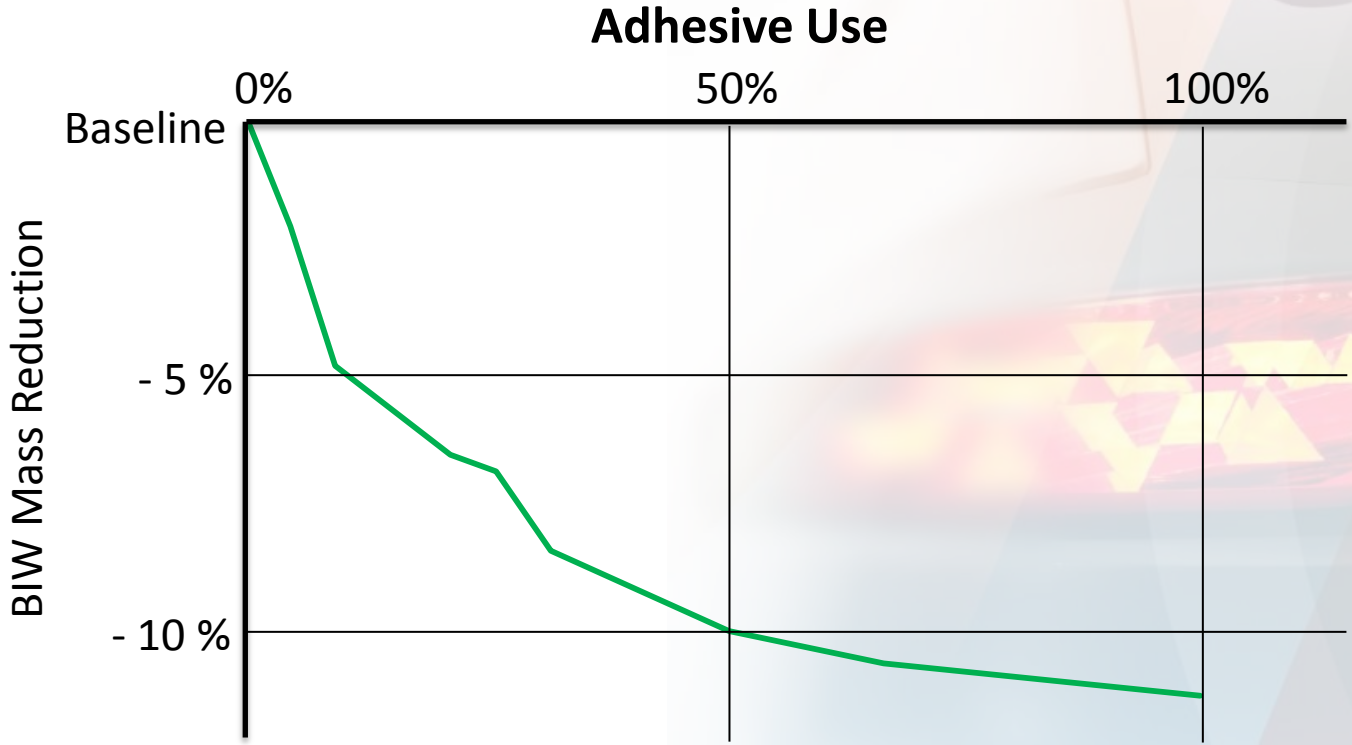


All Optimisation Results

- 8 studies carried out in total
- Results show useful and interesting trends which allow us to start plotting comparisons.

Adhesive (%)	Mass reduction due to adhesive (%)
0	0
5	2.0
10	4.8
20	6.6
25	6.9
30	8.5
50	10.0
75	10.7
100	11.3

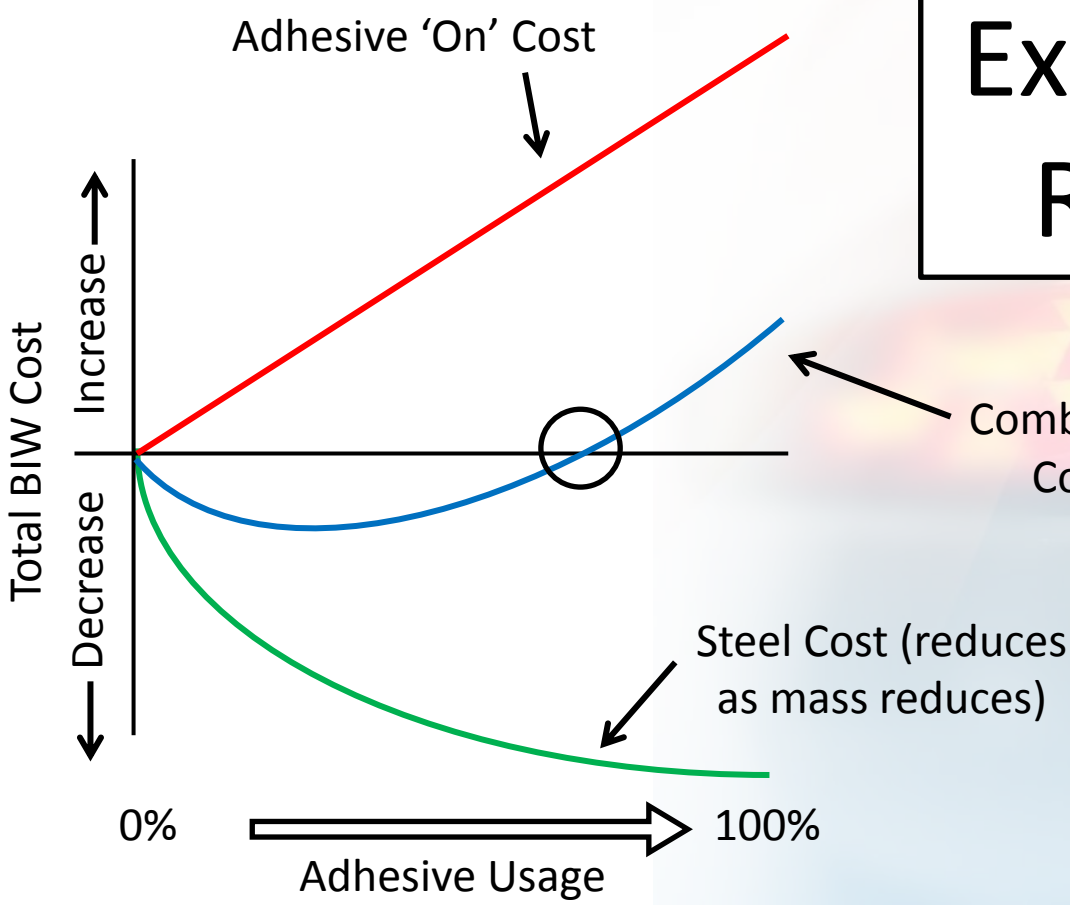
BIW System Mass Change



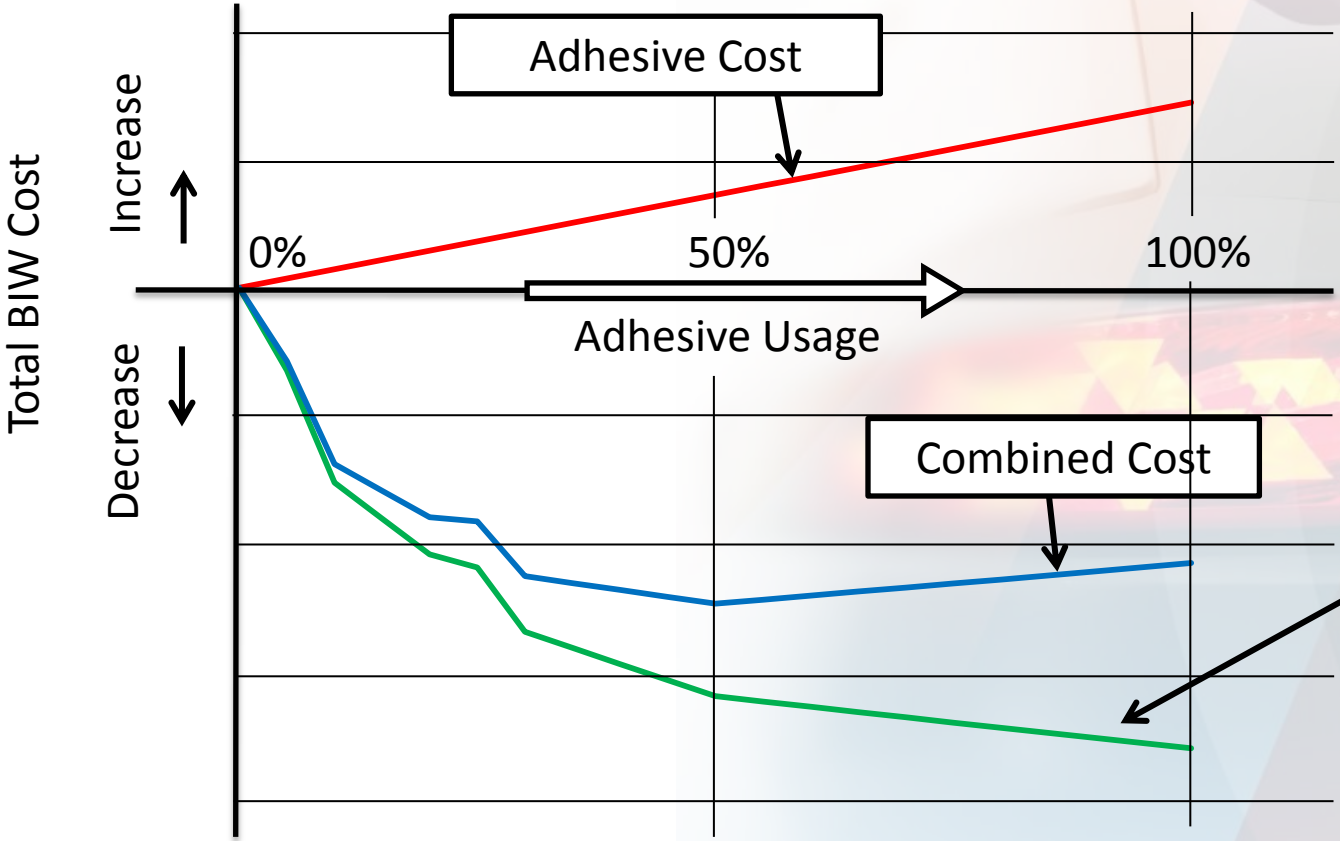
- The first 50% of adhesive removed 10 % of the BIW Mass
- The second 50% removes only a further 1.7%

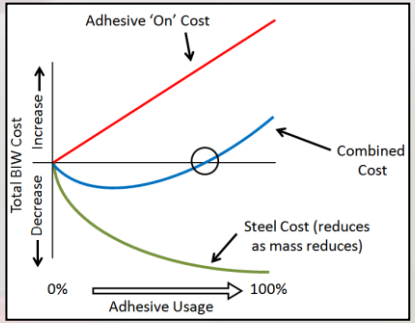
Reminder

The Expected Result

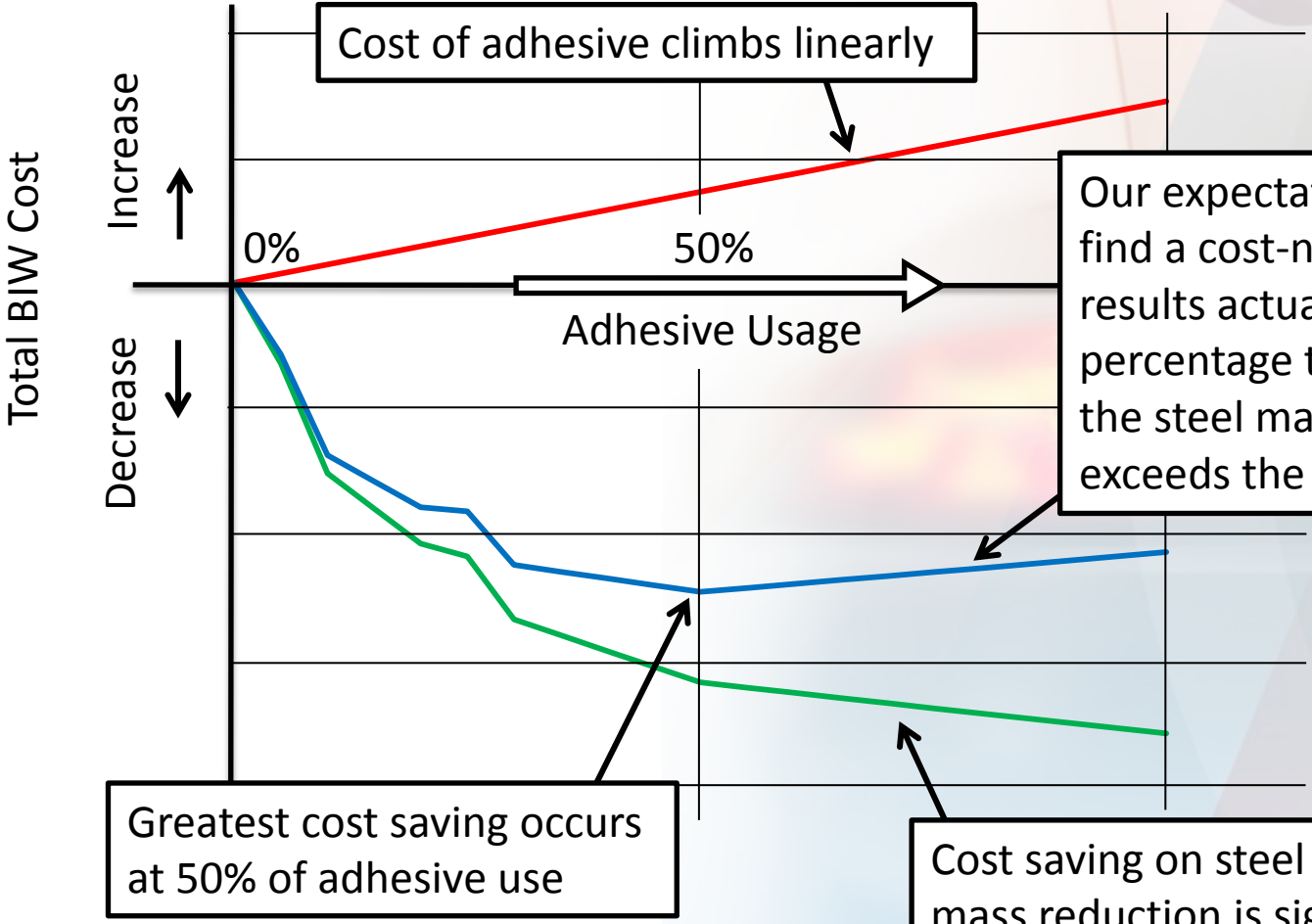


The Actual Result





Graph Explanation



To Conclude:

Summary

- Ideal areas to locate adhesive in a BIW have been established
- The influence of the adhesive use vs. cost reduction has been determined
- The optimum amount of adhesive based on the maximum material cost reduction was exactly 50% - this offered a c: 10% mass reduction to the BIW Structure
- More surprisingly this study demonstrated that even with a 100% adhesive usage the cost of the BIW was still reduced from it's no adhesive baseline

Next Steps

- Understand manufacturing constraints
- Move from the linear world into the non linear and into the real world

A Word of Caution!

- These figures are best case. It's highly likely the actual mass reduction available will reduce once the affects of other load cases, manufacturing constraints, non linear analysis etc. are included