

The CAE led design process



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CAE led design in the Product lifecycle

■ Historical Approach

Design in CAD > Build Tools > Test parts
 > Redesign in CAD > ... etc etc ...

■ CAD led design

Design in CAD > Assess in CAE >
 Redesign in CAD > Assess in CAE > ... etc
 etc...

Build Tools > Test parts

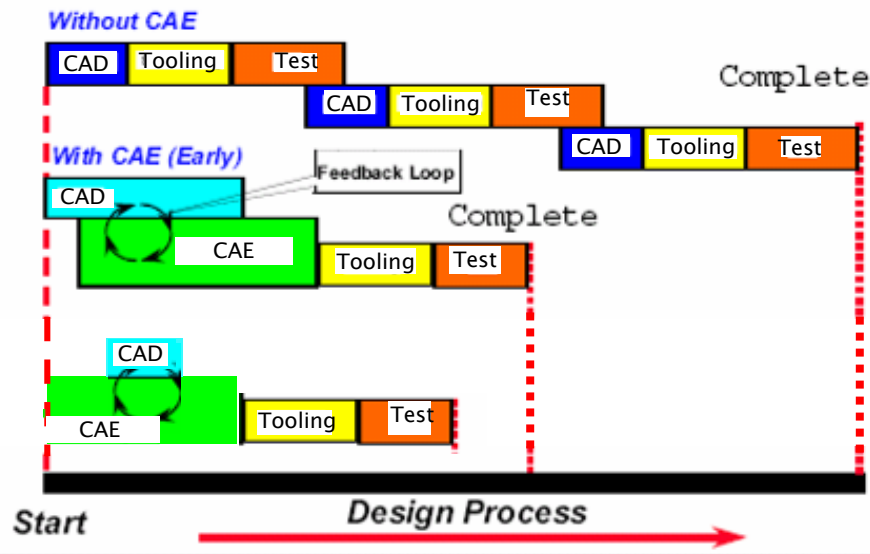
■ CAE led design

Design in CAE > Assess in CAE >
 ... etc etc...

Produce CAD > Assess in CAE >

Build Tools > Test parts

Feedback Look Identifies Problems Early

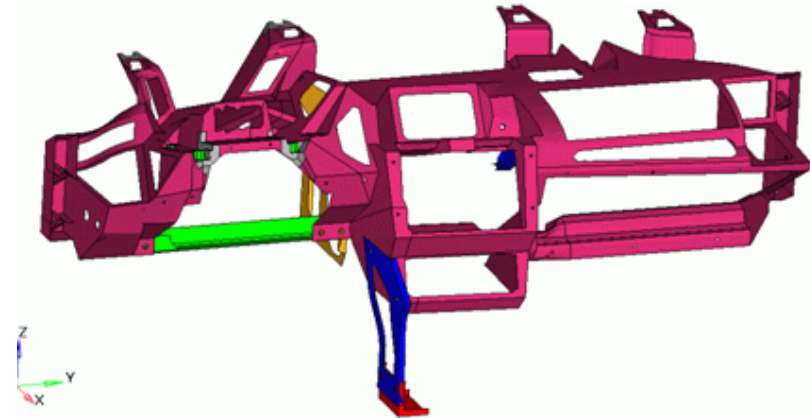


Purpose

To support BD/AE in securing new business

Scope

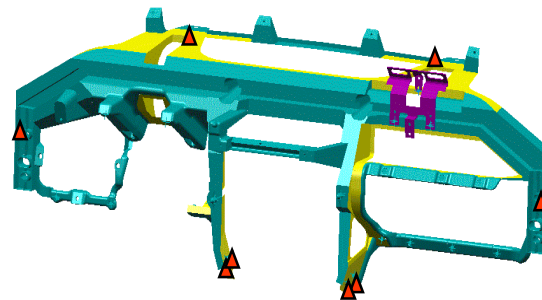
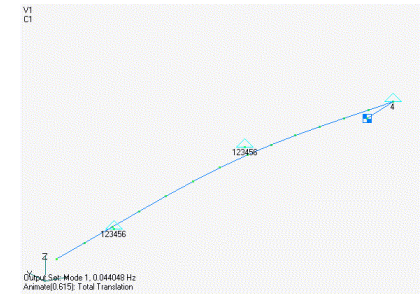
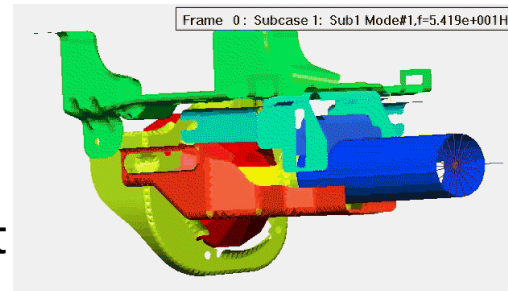
- LINEAR
 - NVH
 - Main Driver
 - Carry over column/PAB etc?
 - Basic Attachments possibilities known
 - Basic package known
 - Easy to compare Mag to Alu/Steel Etc.
 - Static Stiffness
 - Attachment points – Airbags, columns etc
 - FEC Latch loads
 - Global Torsion
 - FEC contribution to global vehicle torsion
- NON-LINEAR
 - Crash
 - Generic assessments sometimes requested
 - Unknown inputs (forces/displacements)



Concept Development – LINEAR – INPUTS

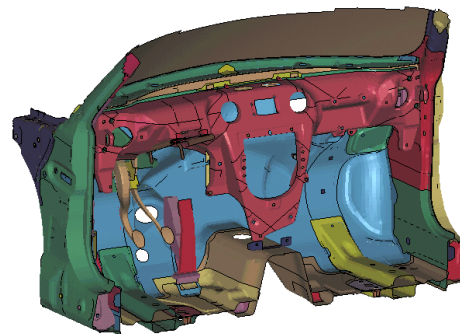
Inputs

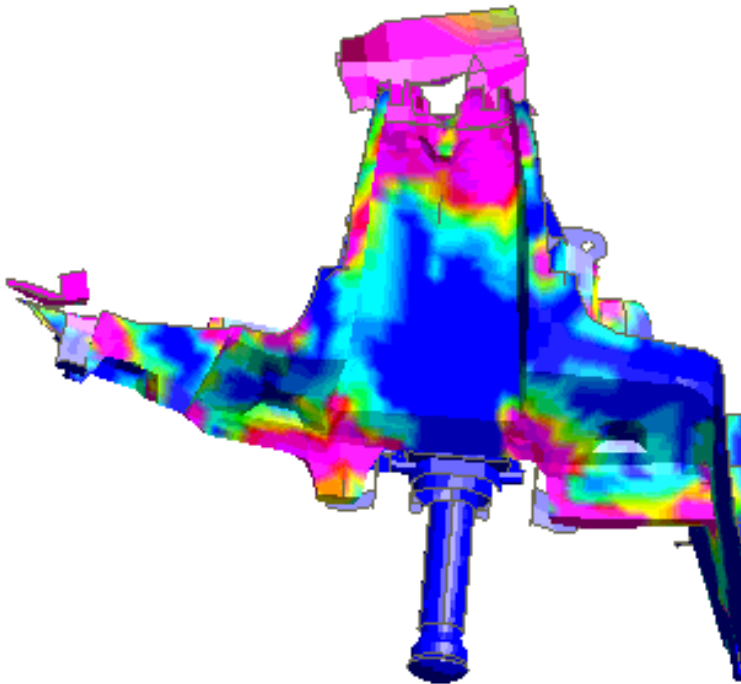
- Existing geometry?
- Column for NVH assessment
 - Meshed model
 - Generic ‘tuned’ column
- Boundary Conditions
 - Rigid bedplate
 - Generic Stiffness attachments
 - Clipped BIW
 - Superelement



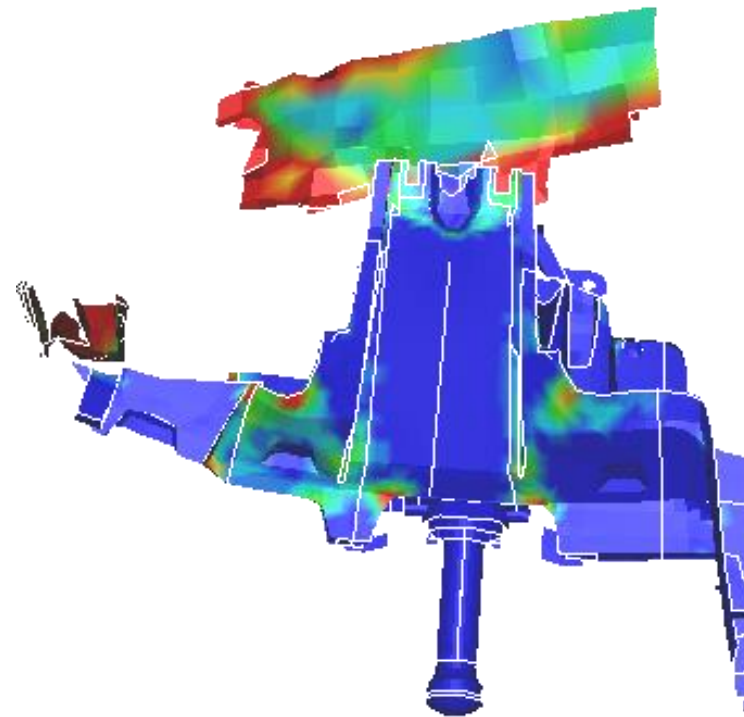
- A-pillar = 10kN/mm
- Cowl = 1kN/mm
- Tunnel = 1kN/mm

Rotational stiffnesses (single fixes only)
 • A-pillar = 500kNm/deg

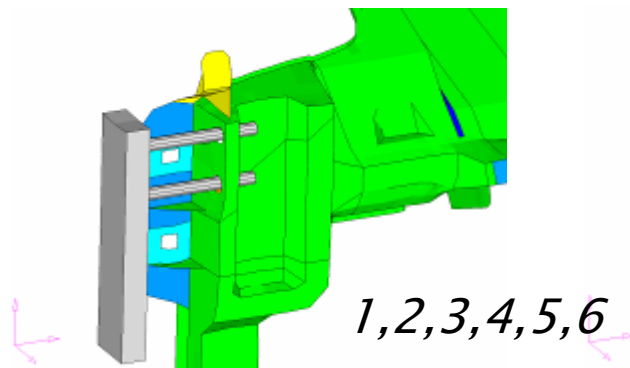




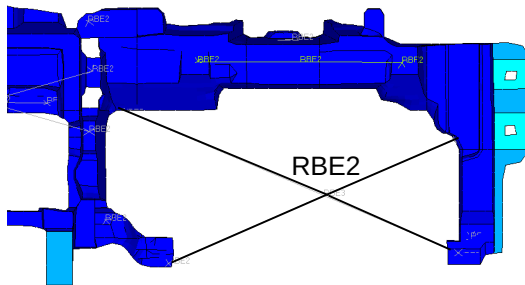
Non Representative Boundary Conditions



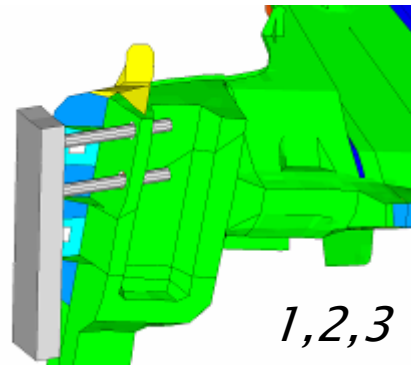
Representative Boundary Conditions



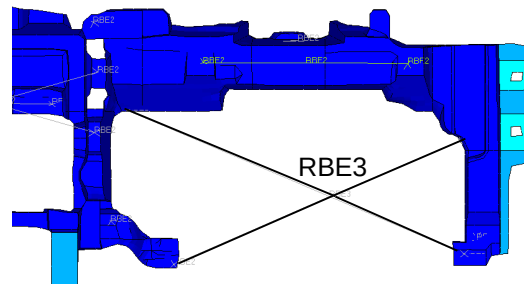
Rigid links (RBE2)



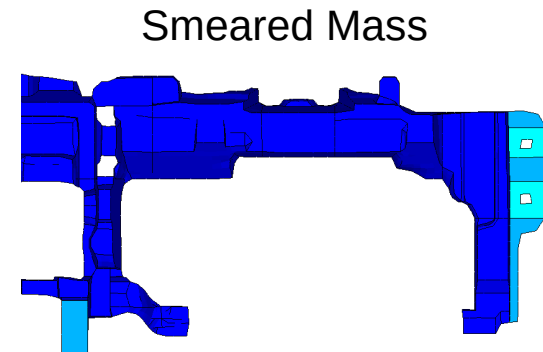
Over stiff assumption
as rigidly links
attachment points



Deformable links (RBE3)



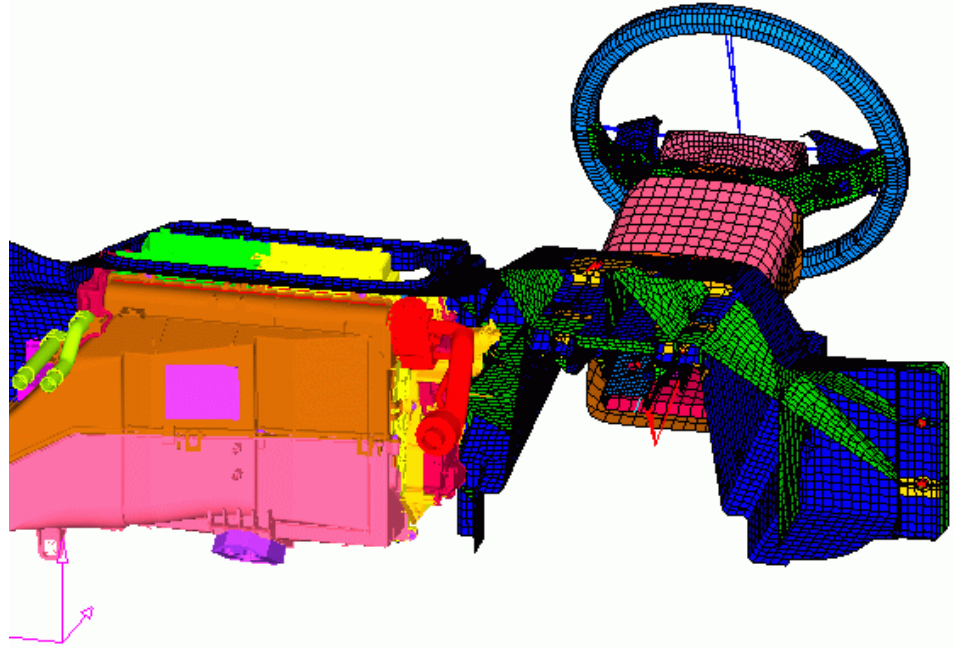
Under stiff assumption
as links don't add any
stiffness resulting from
additional components



Under stiff as RBE3
method and smeared
mass method only
approximates cog
positions of additional
components

- Package

- HVAC, PAB, COOLING PACK
 - Mesh
 - CAD
 - 'BlackBox'

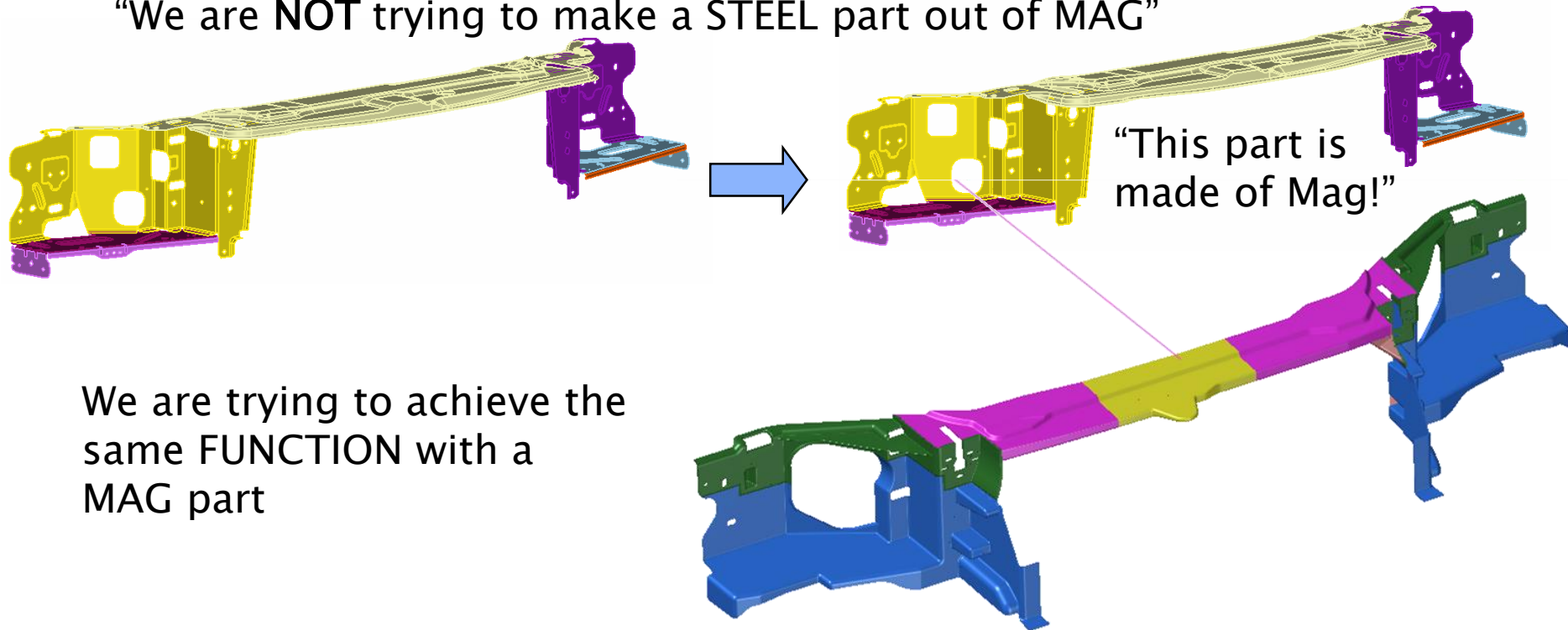


- Targets

- nvh of column on beam ~ 85% of column on bedplate
- X N/mm – latch stiffness etc

Requirements

“We are NOT trying to make a STEEL part out of MAG”

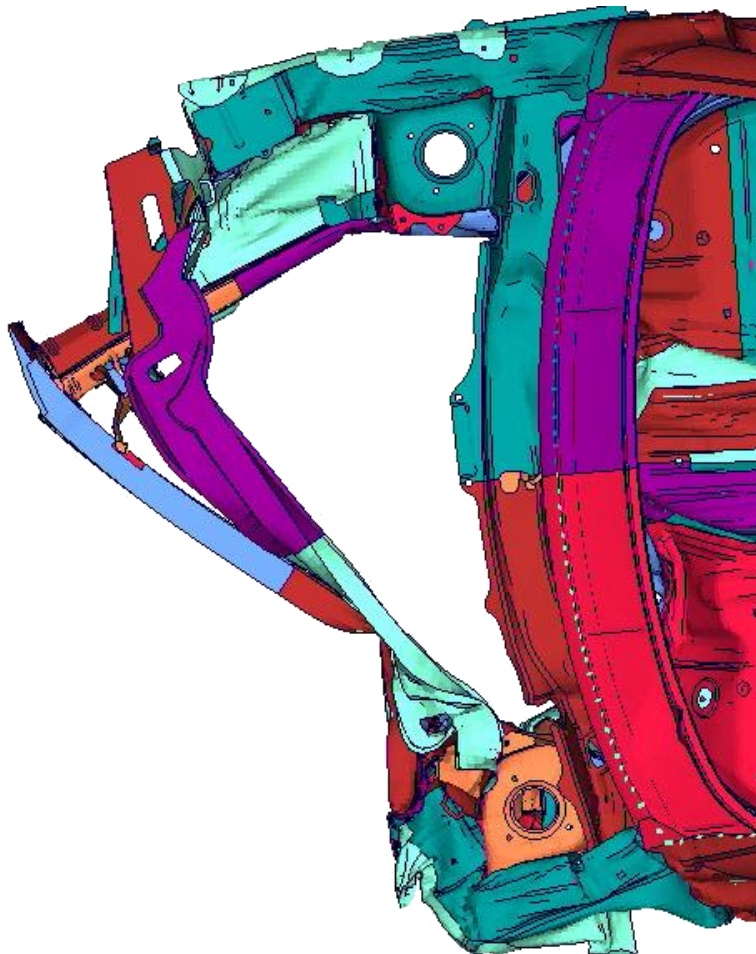


We are trying to achieve the same FUNCTION with a MAG part

benchmark current designs

HOWEVER this can lead to false targets – Function, Function, Function

Requirements

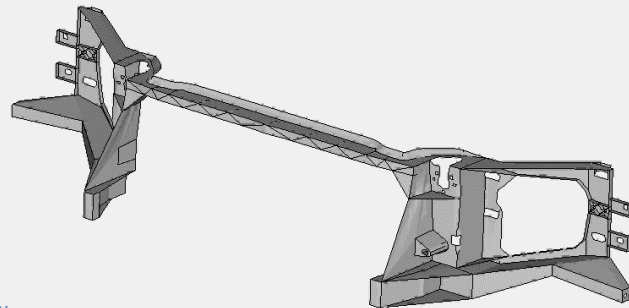


Contour (Analysis system)
 Effective plastic strain (Scalar value, Max)
 6.000E-02
 5.333E-02
 4.667E-02
 4.000E-02
 3.333E-02
 2.667E-02
 2.000E-02
 1.333E-02
 6.667E-03
 0.000E+00
 No result
 Max = 6.000E-02
 Min = 0.000E+00

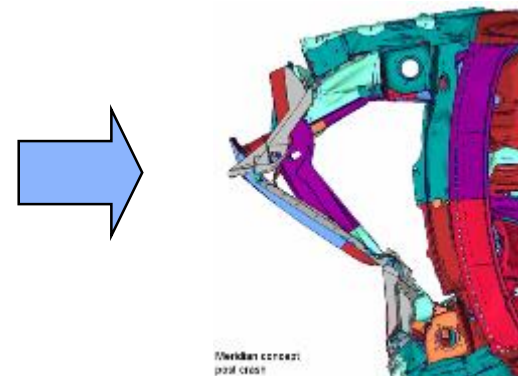
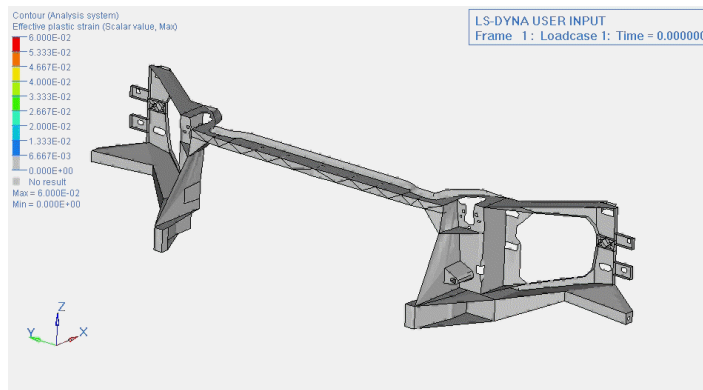


LS-DYNA USER INPUT
 Frame 1 : Loadcase 1: Time = 0.000000

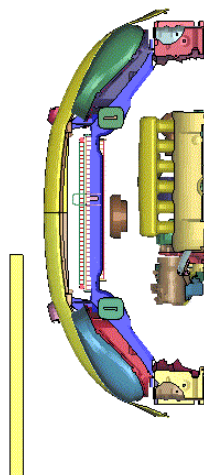
Contour (Analysis system)
 Effective plastic strain (Scalar value, Max)
 6.000E-02
 5.333E-02
 4.667E-02
 4.000E-02
 3.333E-02
 2.667E-02
 2.000E-02
 1.333E-02
 6.667E-03
 0.000E+00
 No result
 Max = 6.000E-02
 Min = 0.000E+00



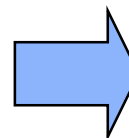
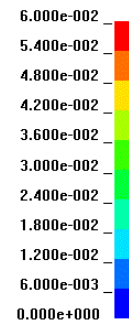
LS-DYNA USER INPUT
 Frame 1 : Loadcase 1: Time = 0.000000



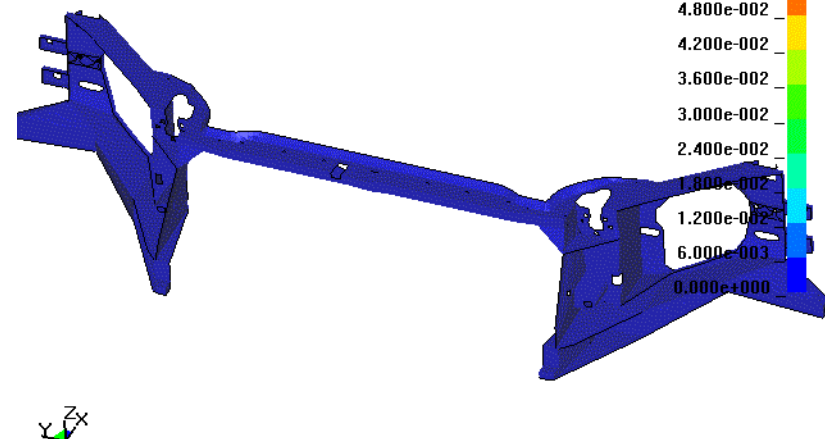
Time = 0
Contours of Effective Plastic Strain
max ipt. value
min=0, at elem# 2000023
max=0, at elem# 20000231



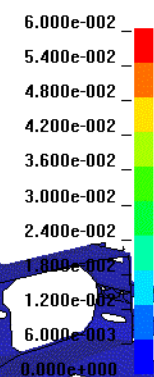
Fringe Levels



Time = 0
Contours of Effective Plastic Strain
max ipt. value
min=0, at elem# 2000023
max=0, at elem# 20000231



Fringe Levels



Requirements

Origin of Steering Column Frequency Target

- Requirement for column mode to be greater than engine idle excitation frequency
- Typically, in vehicle mode is therefore required to be greater than 30Hz

For 4 cylinder:

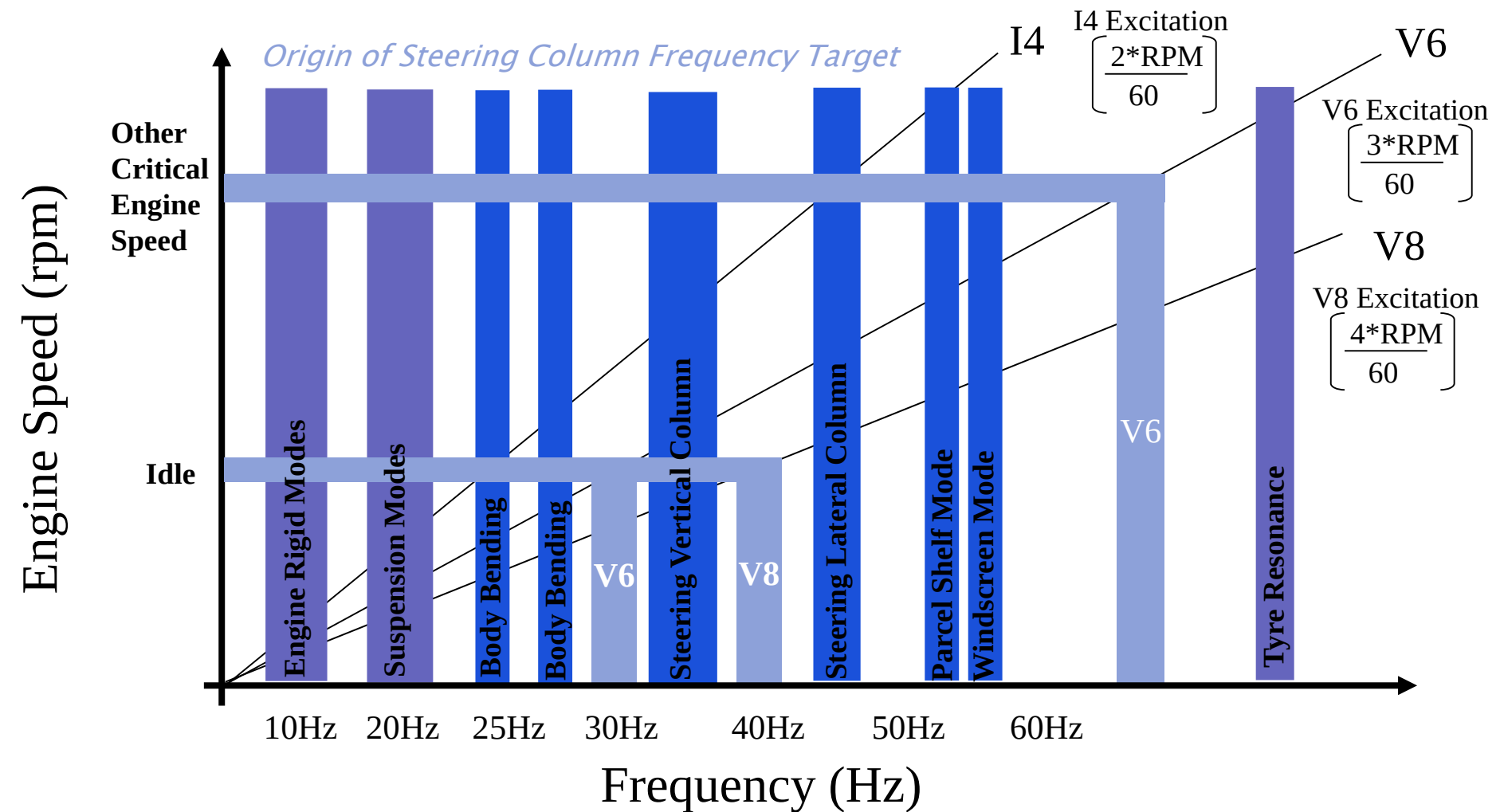
- Idle = 800rpm
- Order = 2 (i.e. firing twice per revolution)

Therefore excitation frequency =

$$frequency = order \times \frac{rpm}{60 \text{ secs}}$$

$$frequency = 2 \times \frac{800}{60}$$

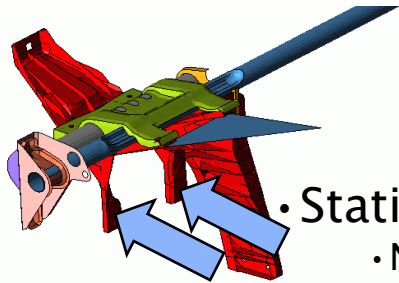
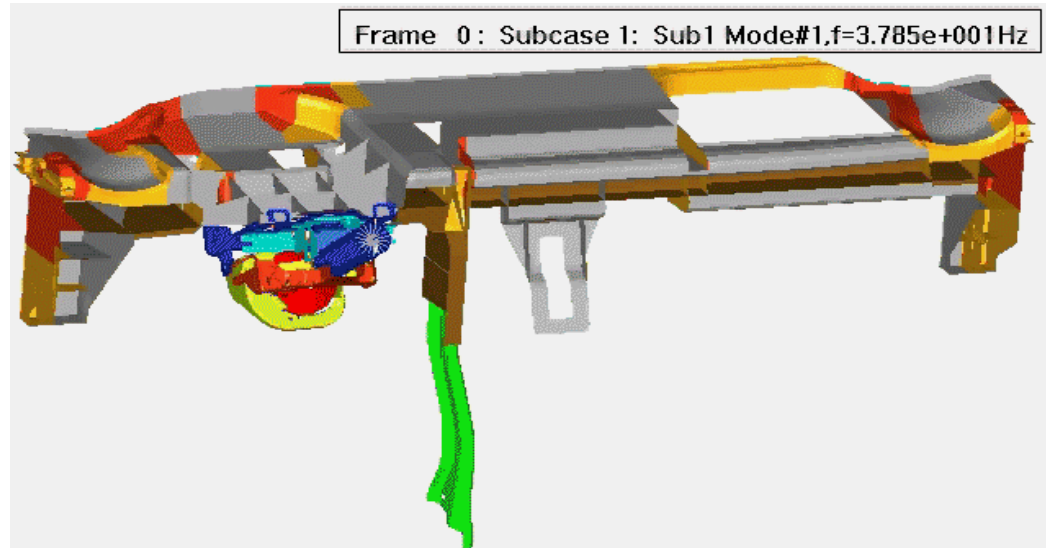
$$frequency = 26.67Hz$$



Concept Development – LINEAR – ASSESSMENTS

Assessments

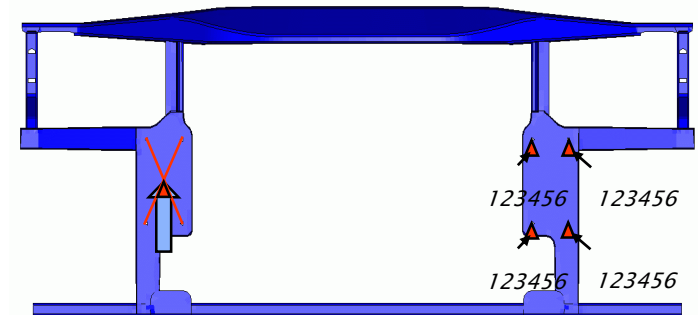
- NVH/Modal Main driver
 - Most widely used



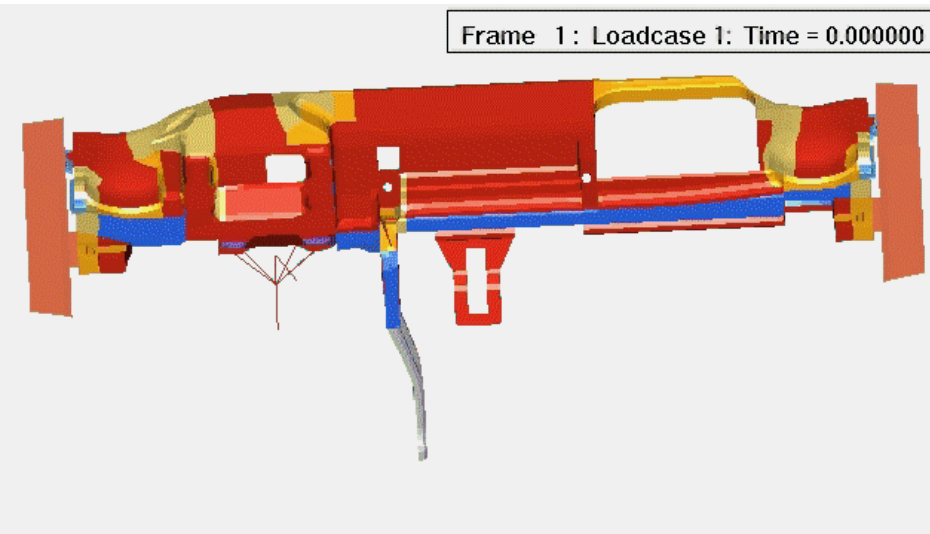
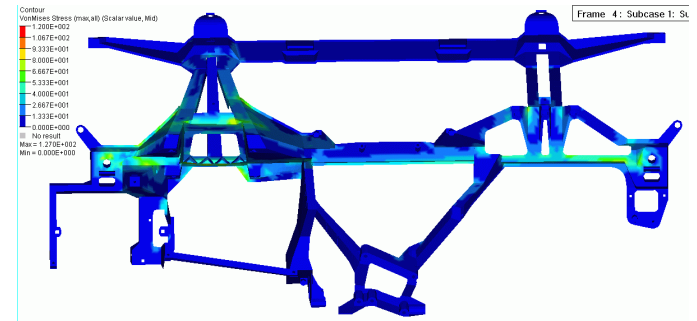
- Static Stiffness
 - NVH analysis can be cascaded to column stiffness target
 - PAB/Kneebag assessments
 - Latch Assessment

• Global Torsion

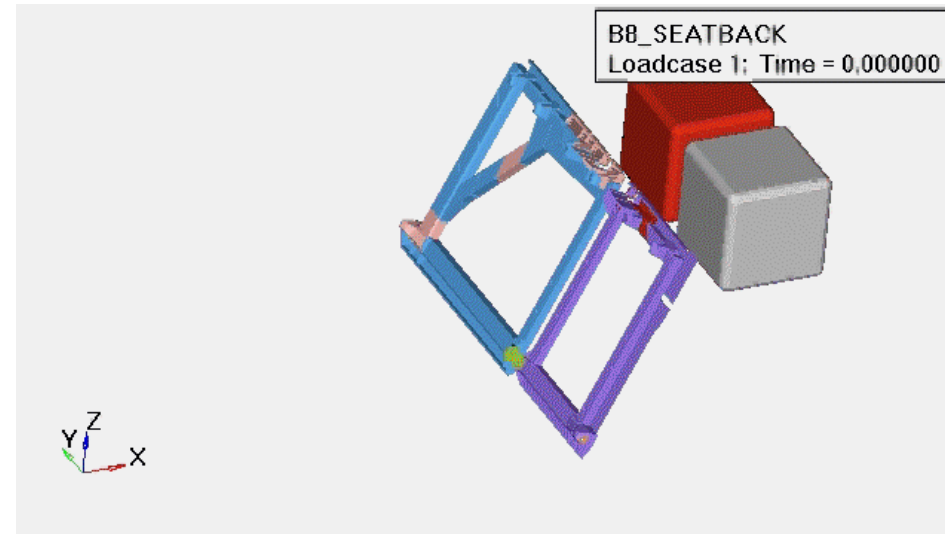
- Contribution of FEC
- Assessed in bedplate or clipped BIW



- Simplify to linear analysis and ensure material does not exceed yield



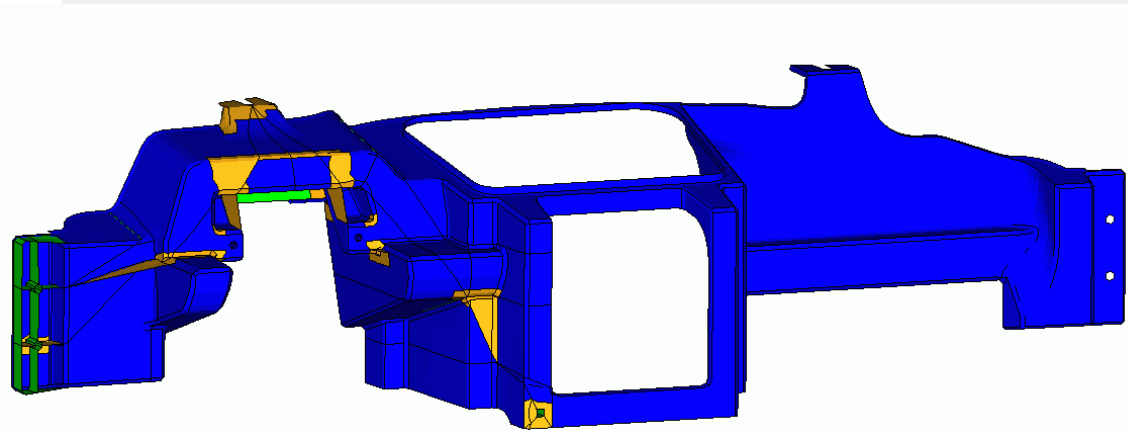
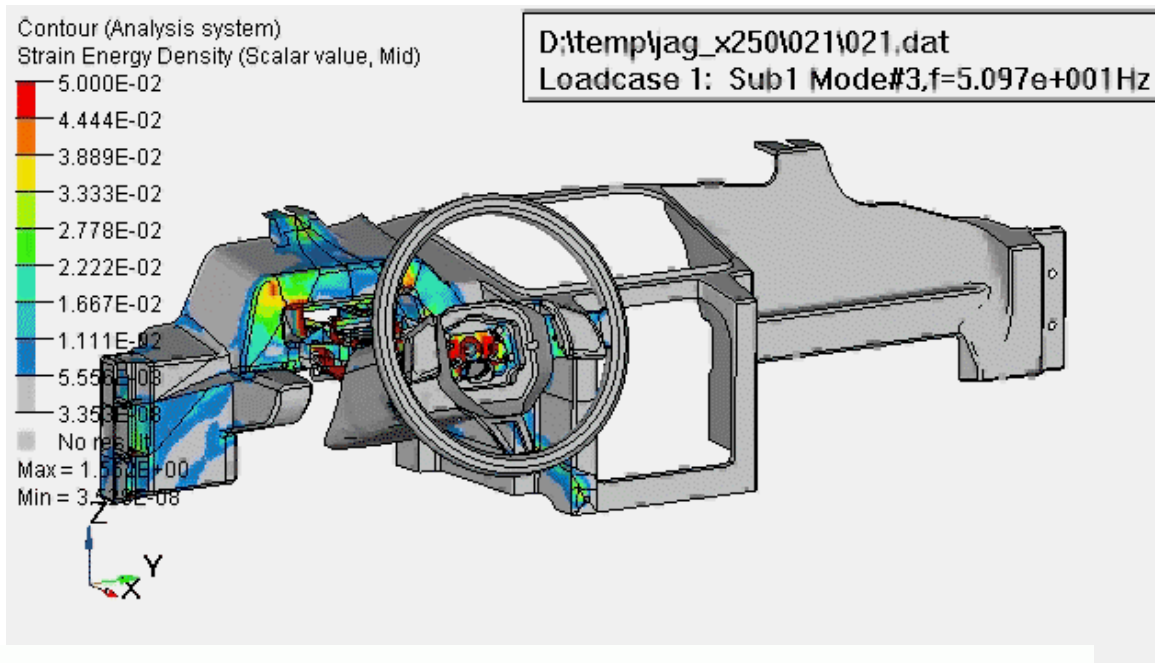
- Set-up generic loadcase as supplied by customer



- Set-up generic loadcase to simulate crash test

• Strain Densities

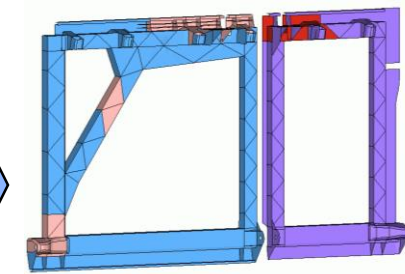
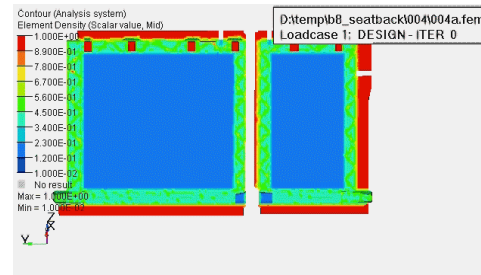
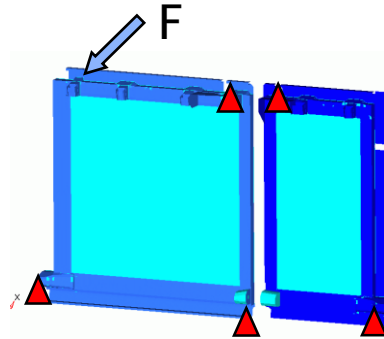
Concept Development – LINEAR – TOOLS



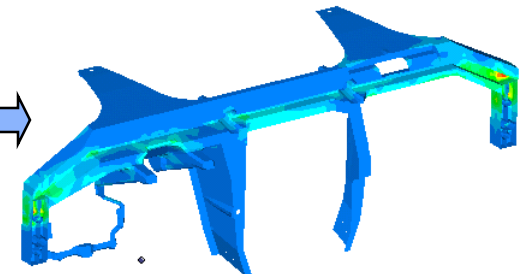
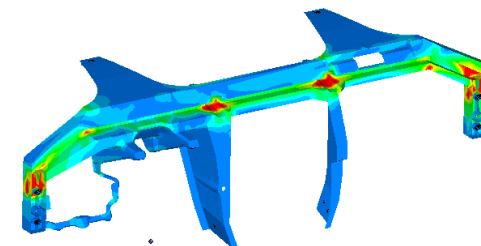
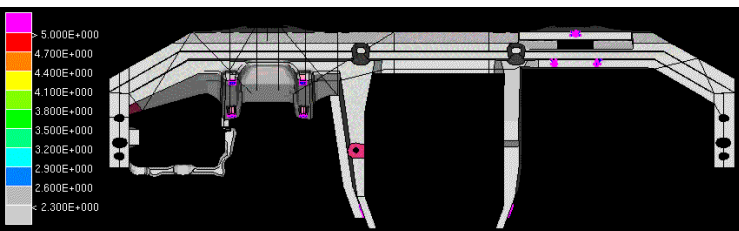
2.5mm
5.0mm

Examples of Tools for Development

• Topology



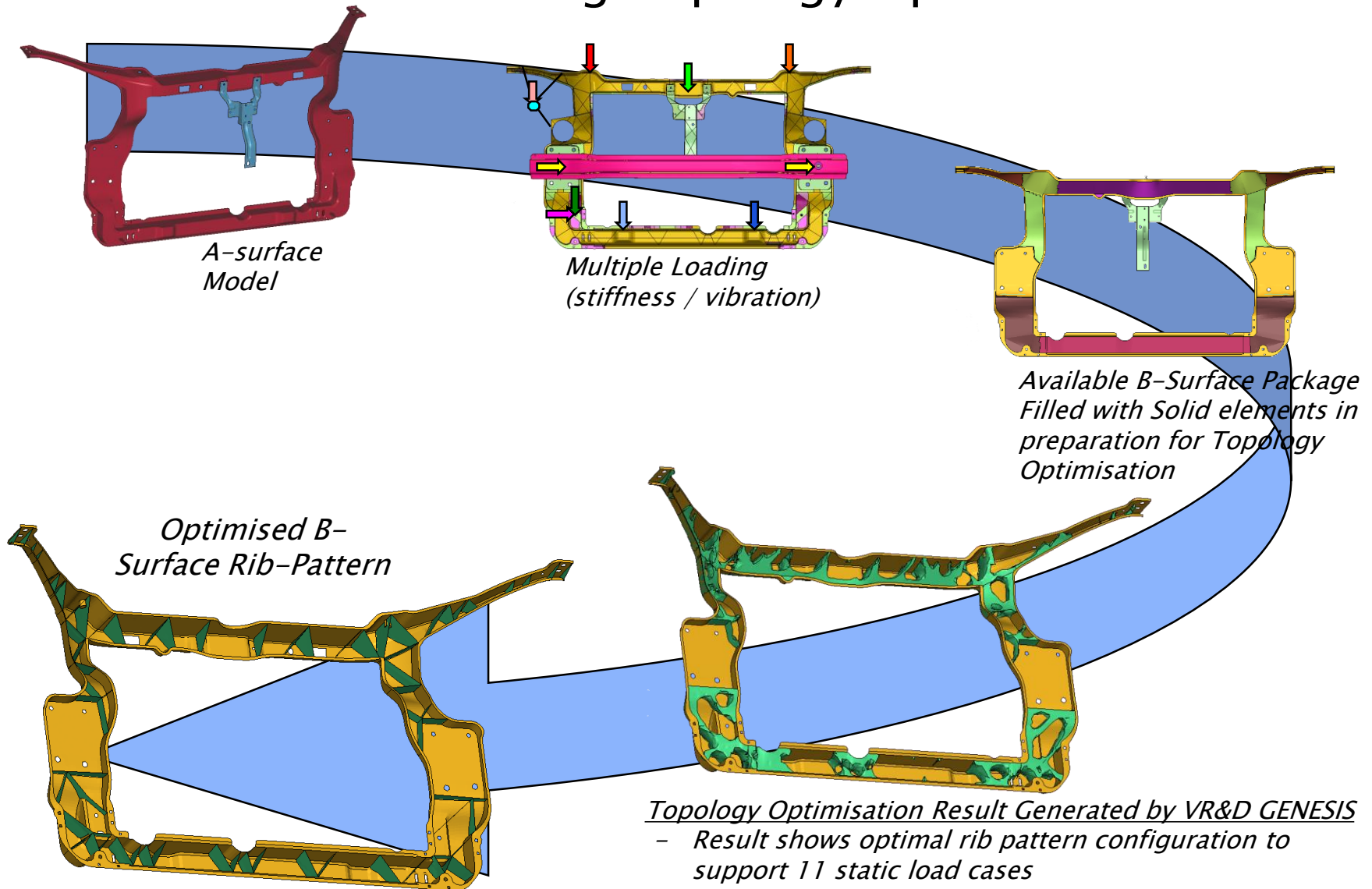
• Topometry



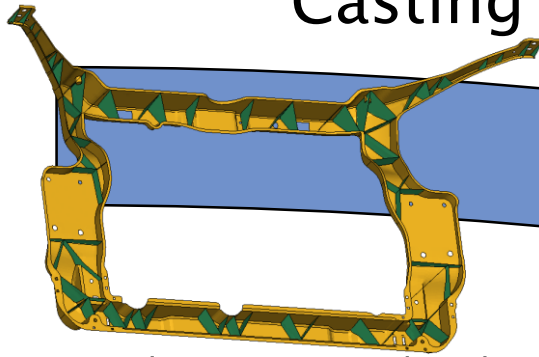
Stress Before optimisation

Stress After optimisation

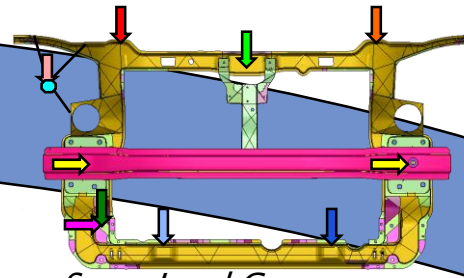
B-Surface Ribbing Topology Optimisation Process



Casting Thickness Topometry Optimisation



*Optimised Geometry Developed
using Topology Optimisation
(Constant Wallstock Assumed –
eg 2.3mm)*

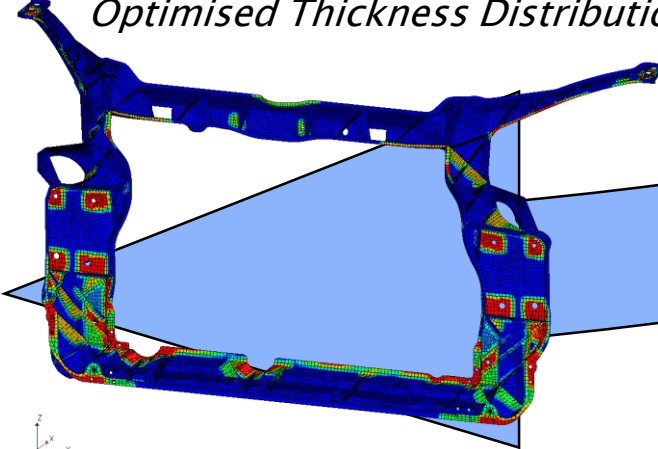


*Same Load Cases as considered
for Topology Optimisation*

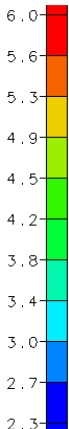
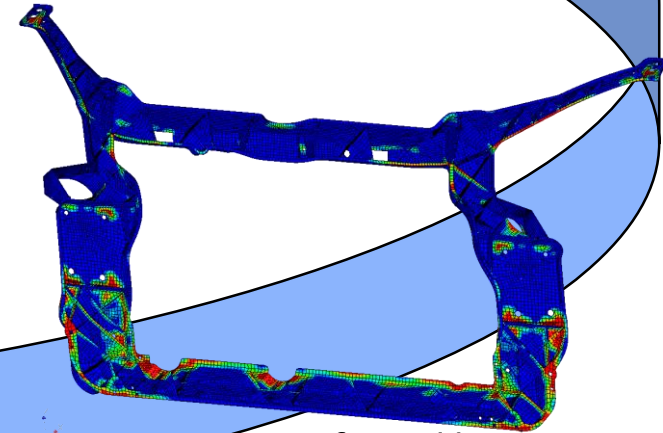
Optimised Design

*Interpretation of Topometry Result into
Optimised Thickness Distribution*

THICKNESS, THICKNESS CHANGE, THICKNESS FRACTION



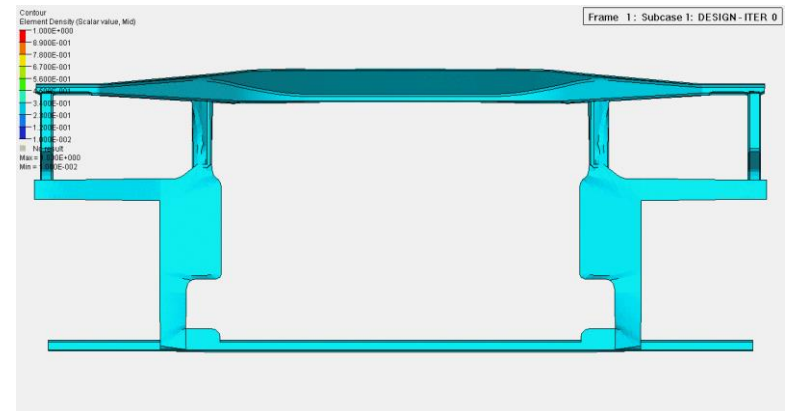
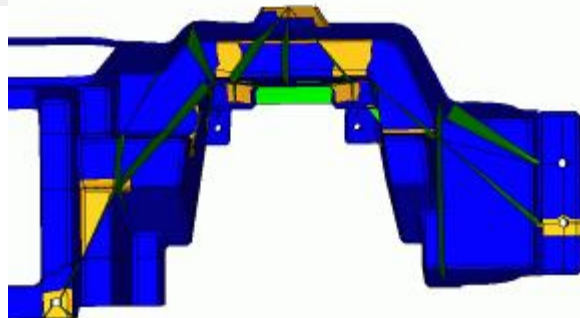
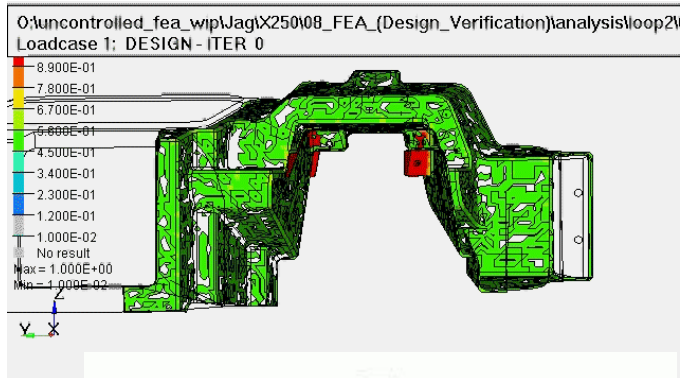
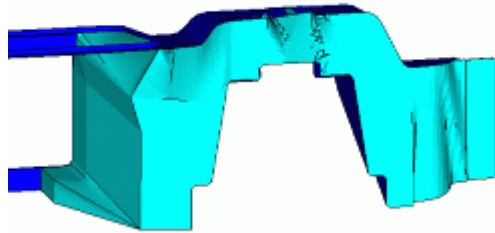
P32M MAGNESIUM FEC
THICKNESS, THICKNESS CHANGE, THICKNESS FRACTION



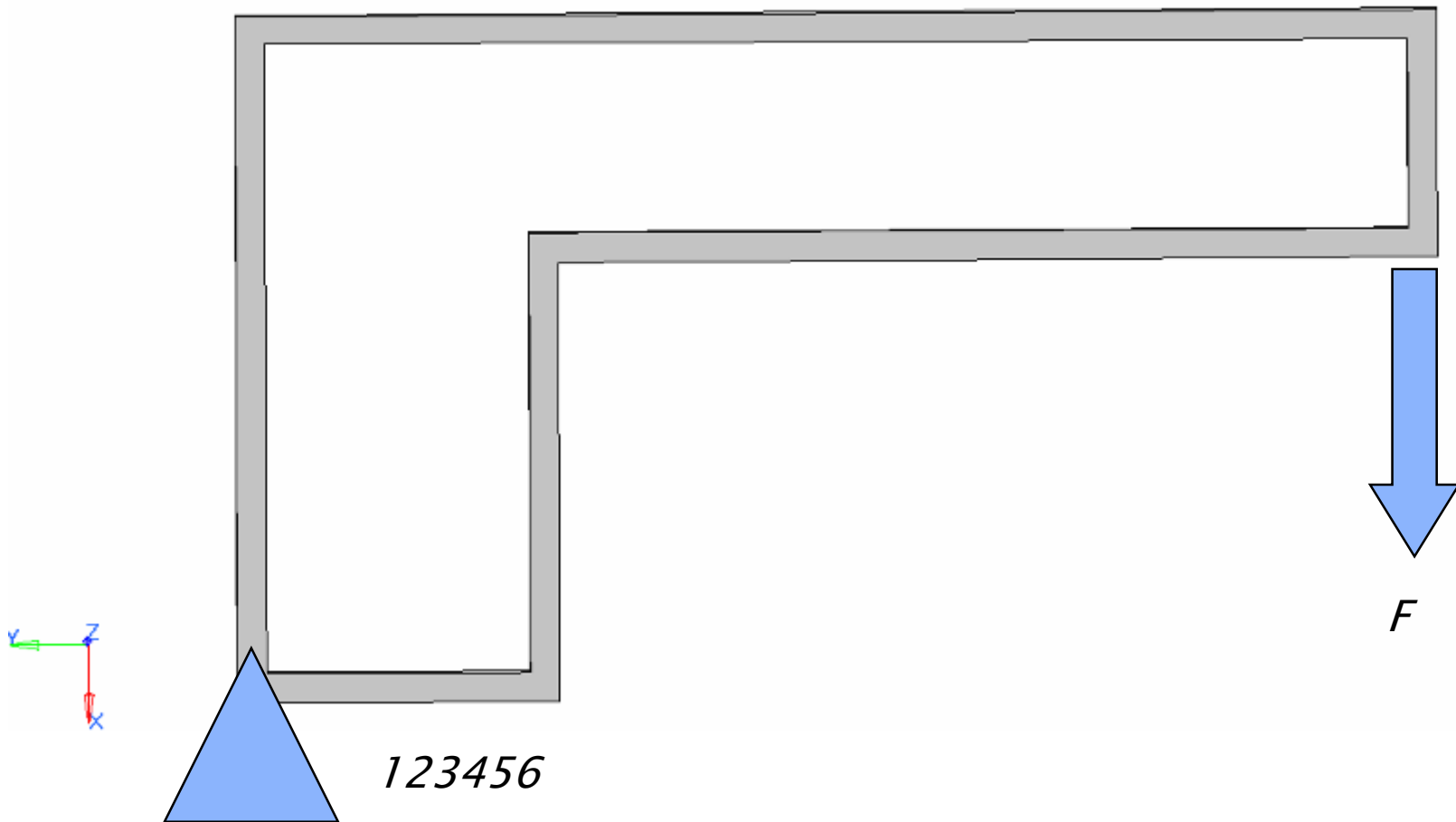
Topometry Optimisation Performed by VR&D GENESIS

- *Topometry calculates optimal material thickness distribution for casting to support multiple loading requirements*
- *Able to consider stiffness / strength / vibration / buckling / heat transfer*

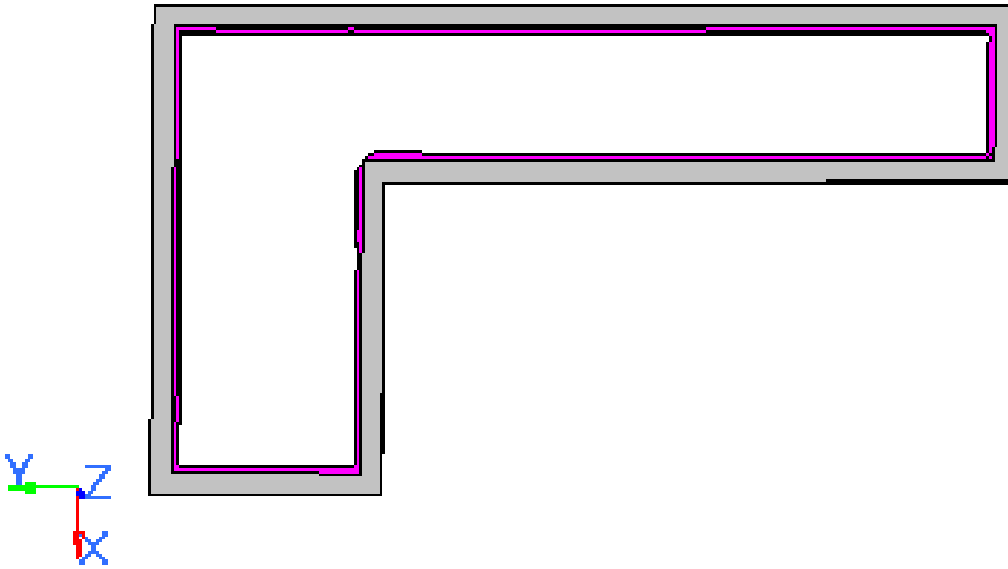
TOPOLOGY EXAMPLE – sounds like biology...organic



TOPOLOGY EXAMPLE – sounds like biology...organic



TOPOLOGY EXAMPLE – sounds like biology...organic



Summary of conceptual design

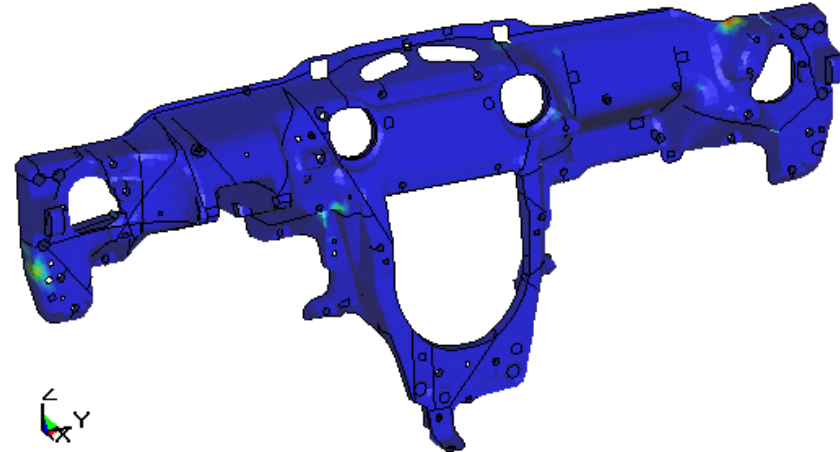
- CAE led design in these examples has achieved the following...
- Conceptual designs
 - Reduced cost and timing by approx
 - 80% when solid CAD is not required
 - 30% when solid CAD is required
- Production designs
 - Lighter
 - Cheaper
 - More robust
 - More Efficient
- Improved customer confidence in Business Development quotes.

Purpose

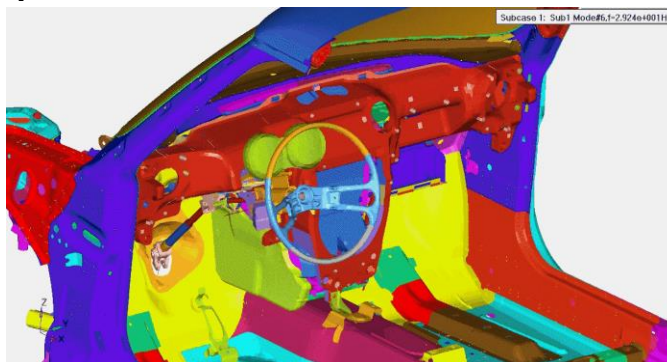
To develop concept bought into by customer
to production component

Examples of Additional Analysis

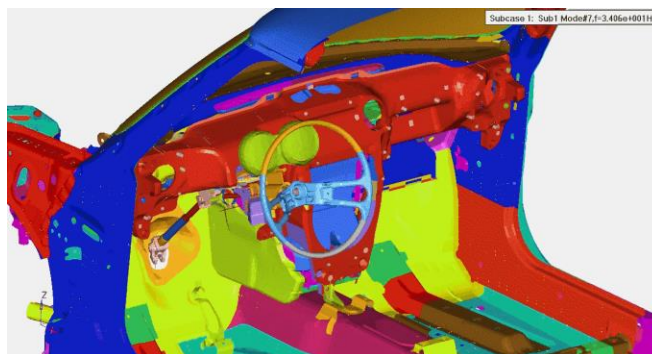
- LINEAR
 - NVH
 - Inclusion of HVAC etc
 - Forced responses
 - Durability
 - SAG
- NON-LINEAR
 - Crash
 - Loadcase 'matures' throughout development
 - Other loadcases to assess
 - IIHS
 - LINCAP
 - EURO side
 - FFB
 - ODB



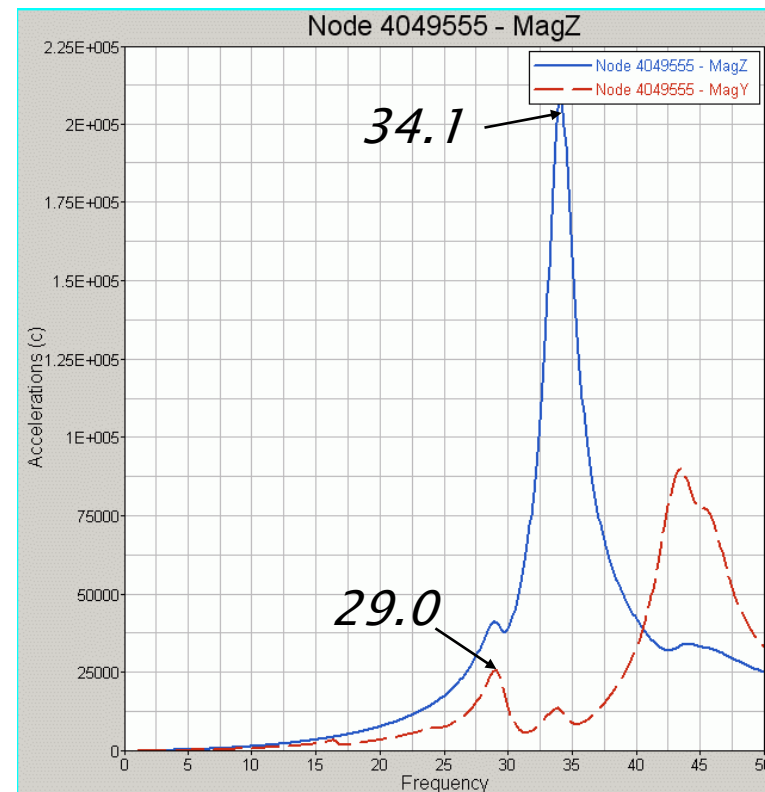
• *Forced Response*



29 Hz



34 Hz



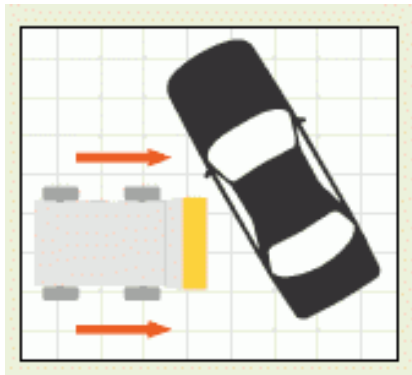
Production Intent – Additional Analysis – NON-LINEAR

ODB

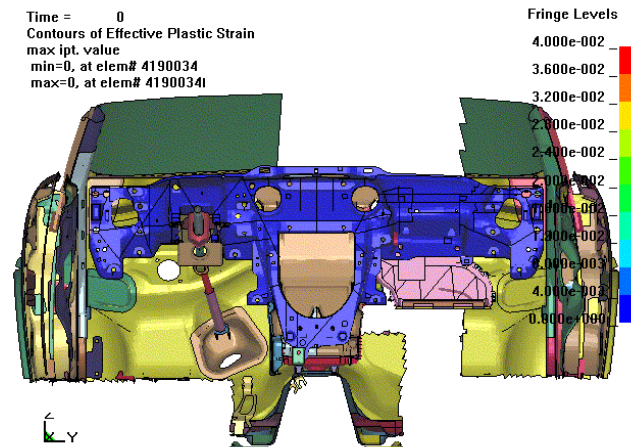
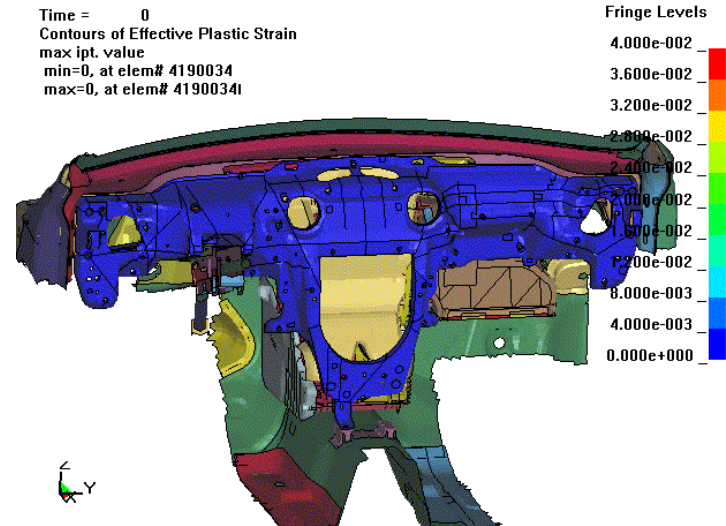


40% overlap – 40mph

Lincap

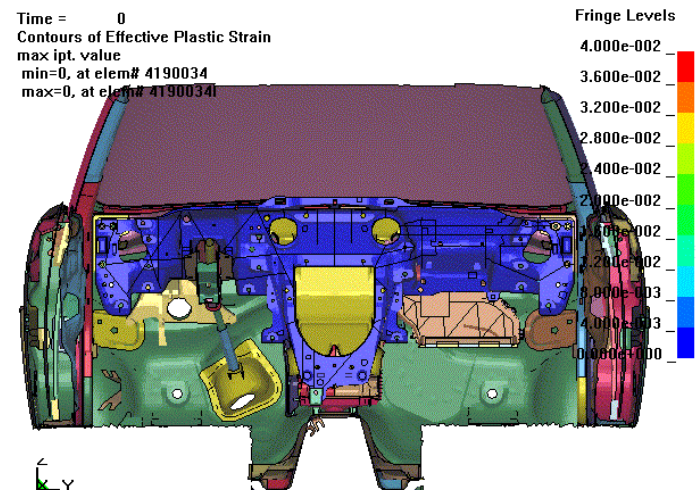
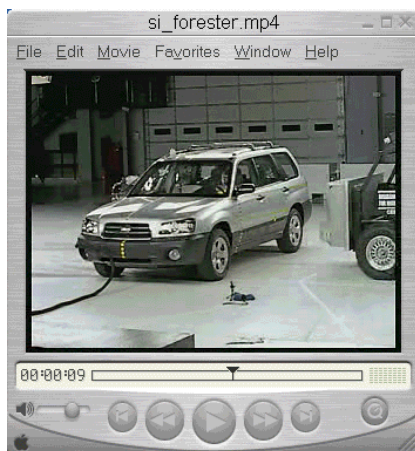


38mph car

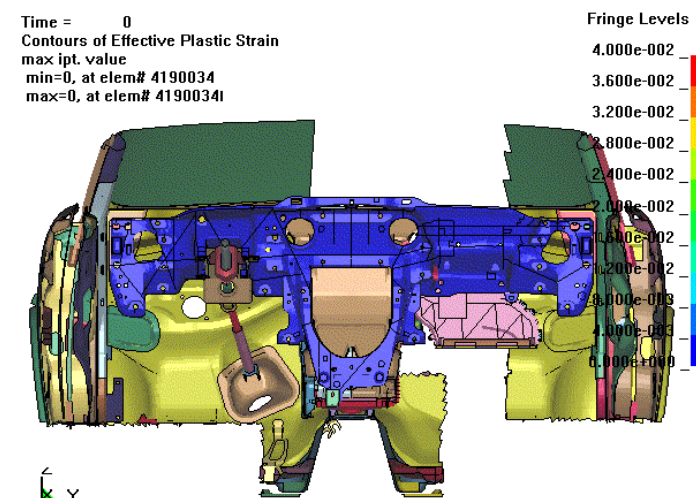
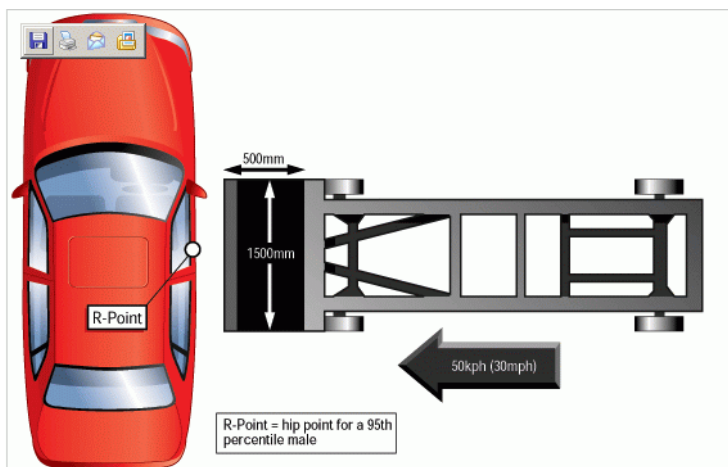


Production Intent - Additional Analysis - NON-LINEAR

IIHS 30mph Truck

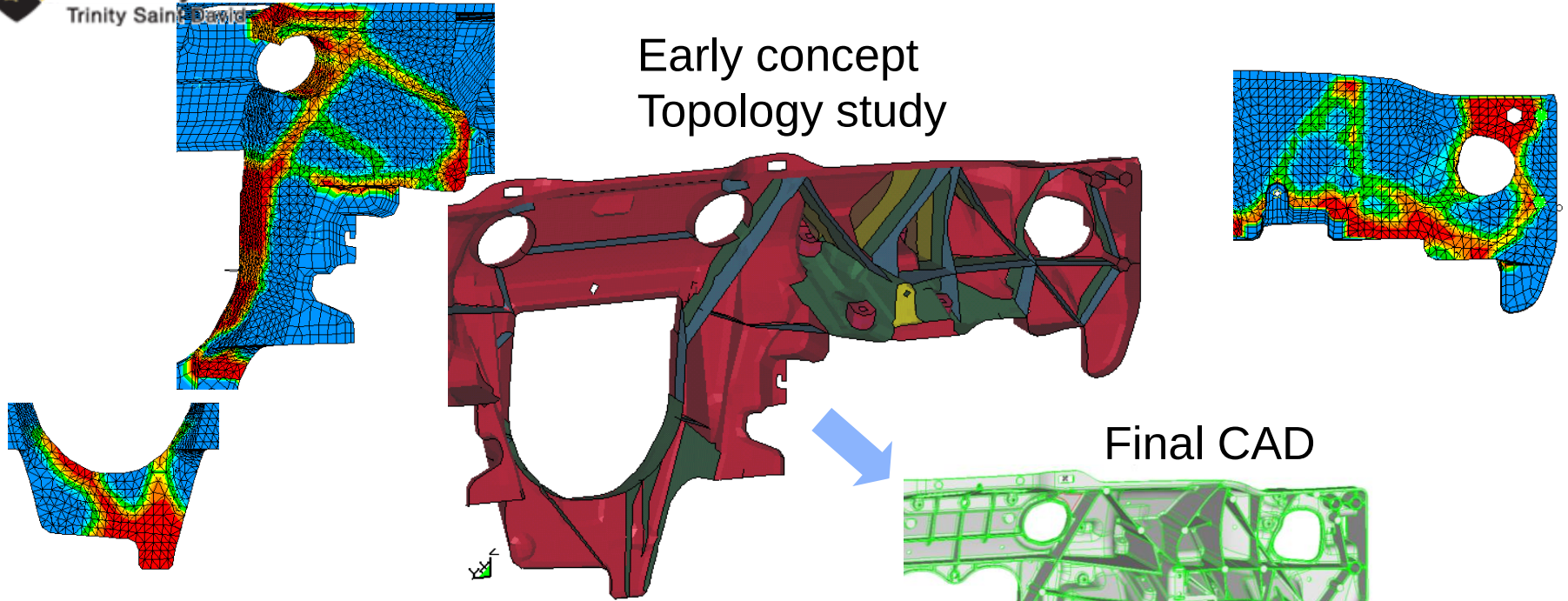


Euro Side 30mph car

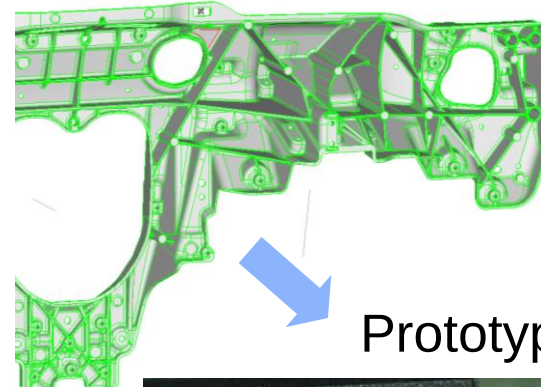


Concept to production

Early concept
Topology study



Final CAD



Prototype Part



Example of CAD led design



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CAE is an excellent **TOOL** to do the following

- Quickly develop concepts
 - NVH
 - Crash
- Develop products that will perform to meet the customers expectations in terms of performance

Customers expectations of ‘full service suppliers’ is increasing – this will result in more CAE throughout development

However, it is only a computer program – BD/AE must provide the correct inputs!

*Garbage in **==** Garbage out*