

FEA in the Design Process



- CAE in the Product life cycle
- CAE in concept development
- Concept Example
- Comparison of costs and timing of CAE v CAD led concept
- Concept to production example
- Summary

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

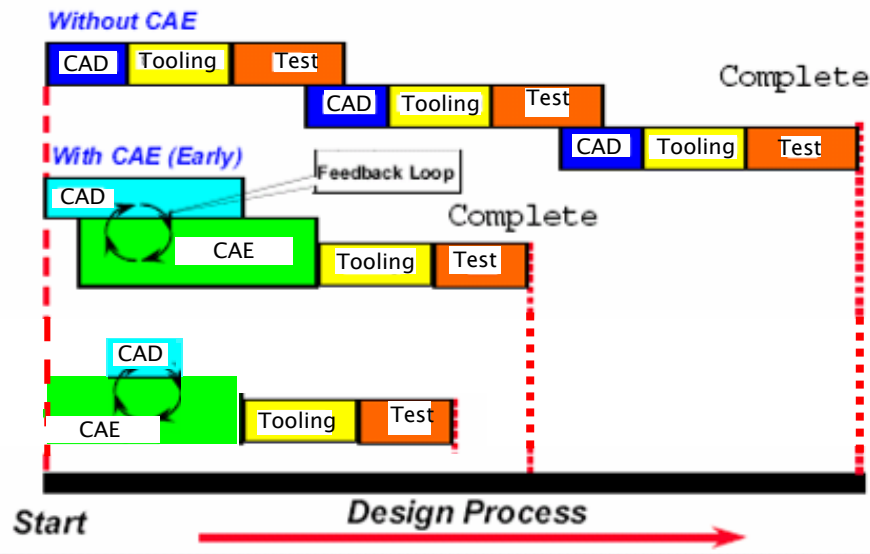
■ CAE led design

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

Produce CAD > Assess in CAE >

Build Tools > Test parts

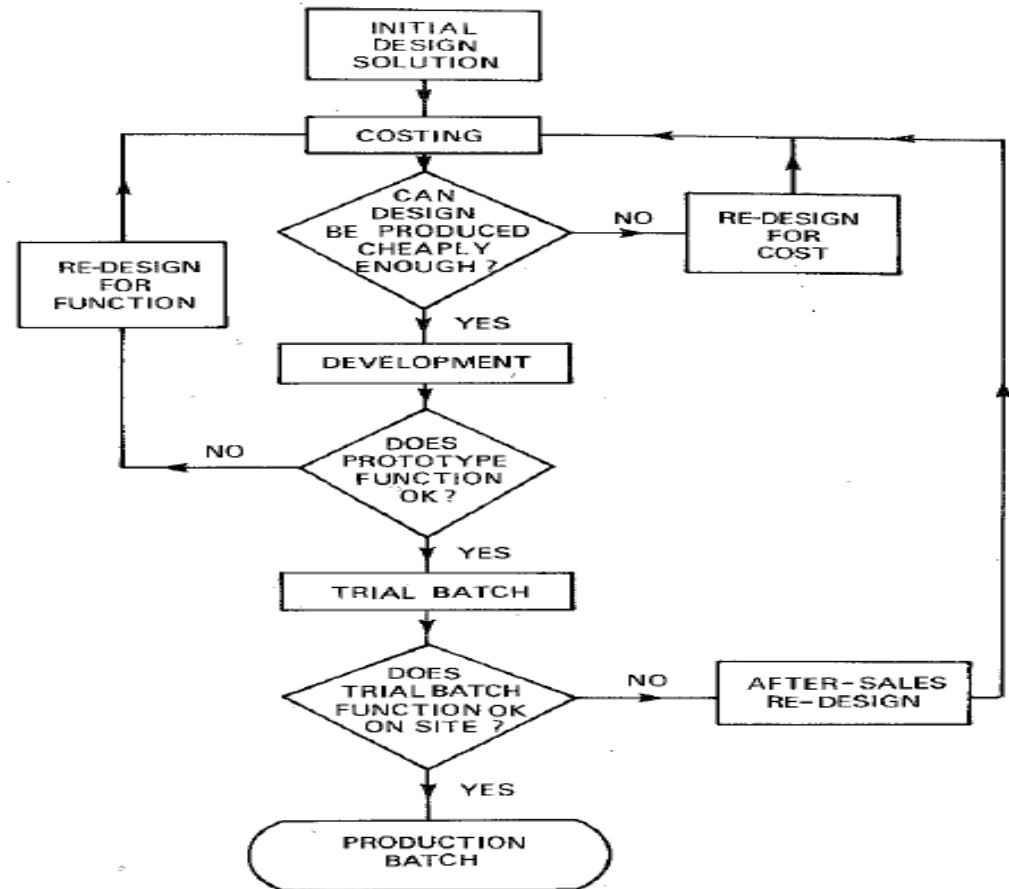
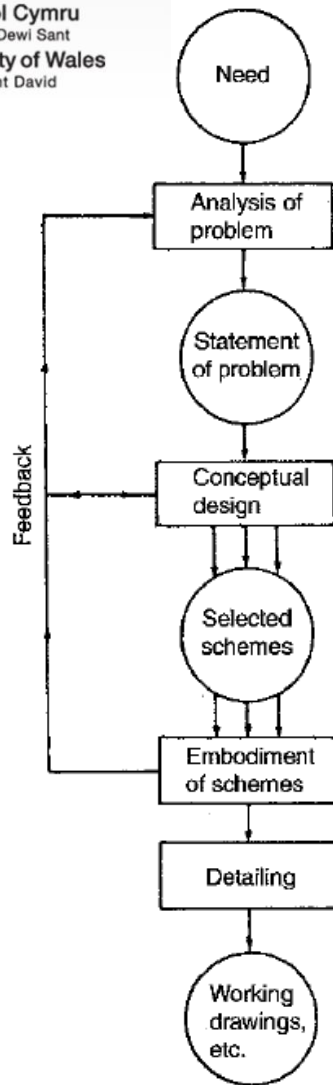
Feedback Look Identifies Problems Early



Design Methodologies

- Analysis problem or design problem?
- Descriptive Models or Prescriptive Models
 - Descriptive models are solution focused – E.g. French's model
 - Prescriptive Models emphasize the need for analytical work to be carried out upfront in the design process

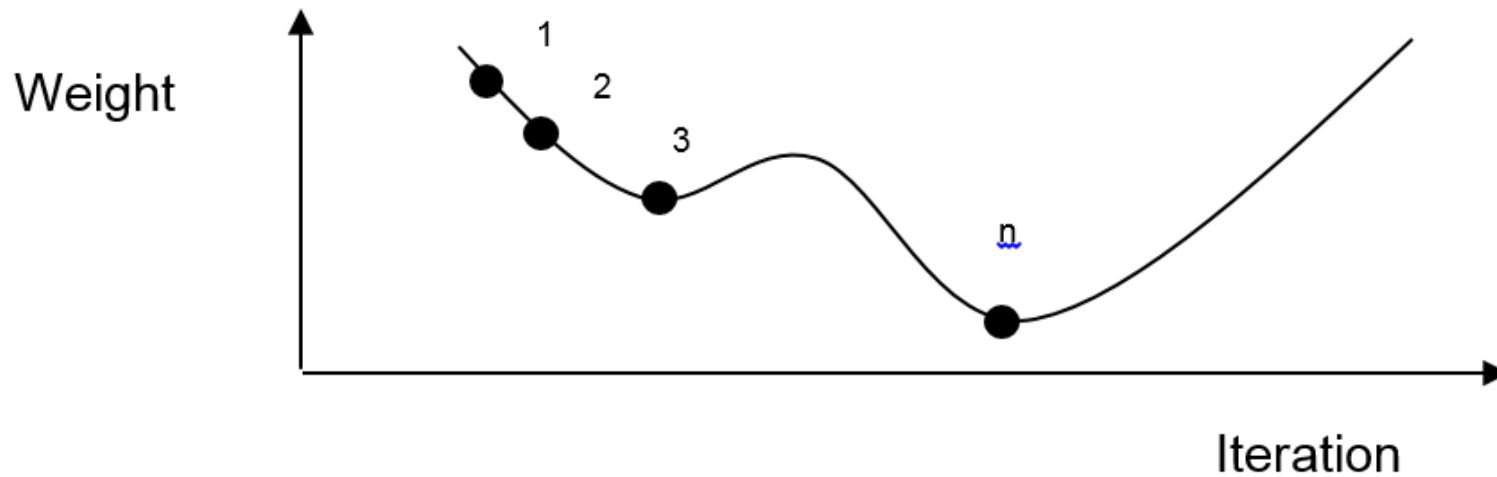
Descriptive Models (Iterative Design)



- French's model of the design process
 - Circles > outputs
 - Rectangles > Activities

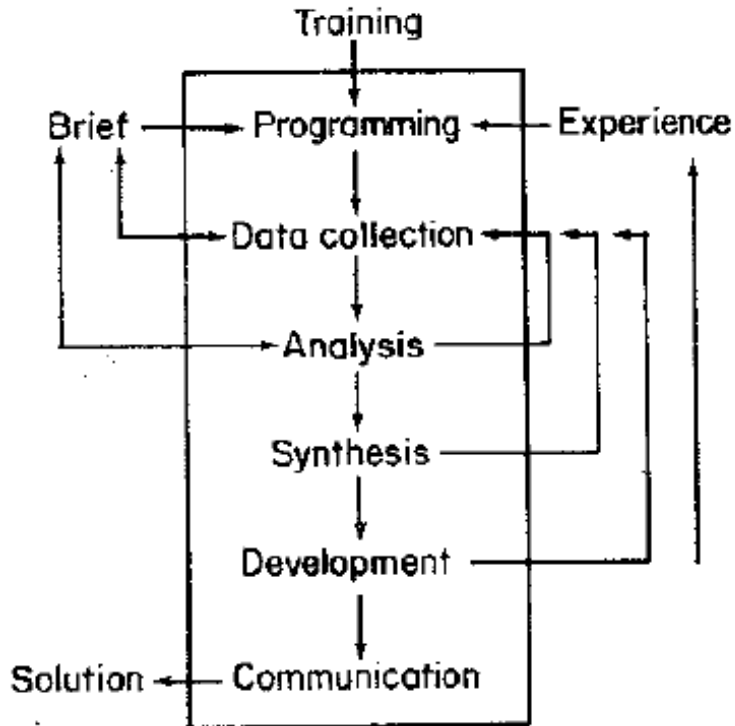
- Initial design is proposed
- Refined iteratively until a solution is found
- Each iteration is assumed to be 'better'

Descriptive Models (Iterative Design)



- A local minimum may be found!

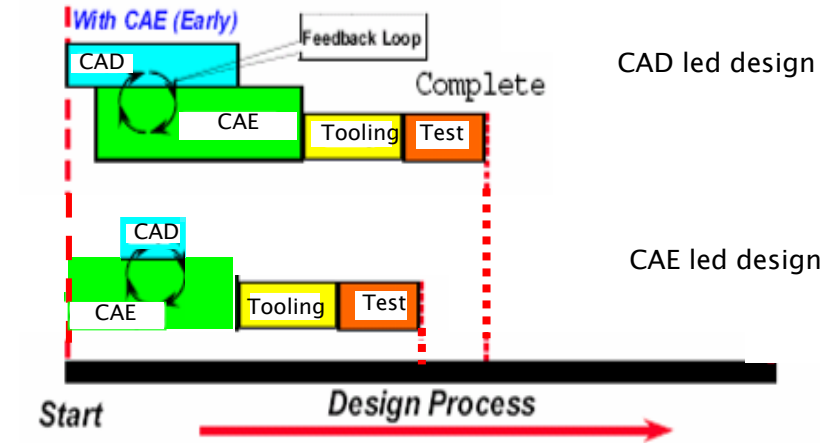
Prescriptive Models



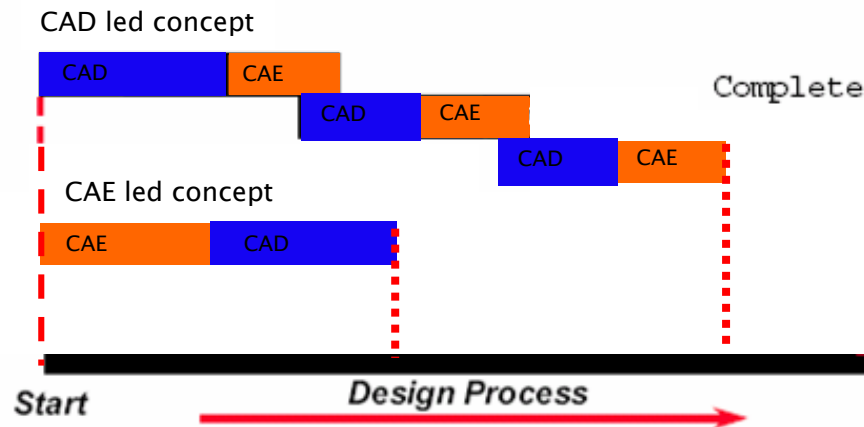
- *Programming – Establishing crucial issues*
 - *E.g. critical bending or torsion values or natural frequencies*
- *Data Collection – collect, classify and store data*
 - *E.g. obtaining material properties.*
- *Analysis – identify subproblems*
 - *E.g. correlation of CAE models for sub-system responses.*
- *Synthesis – Prepare outline design proposals*
 - *E.g. involve optimisation techniques*
- *Development – Develop prototype design*
 - *Is significantly reduced by above*
- *Communication – preparing manufacturing documentation*
 - *E.g. preparing Ply-Book*

- Archers model of the Design Process

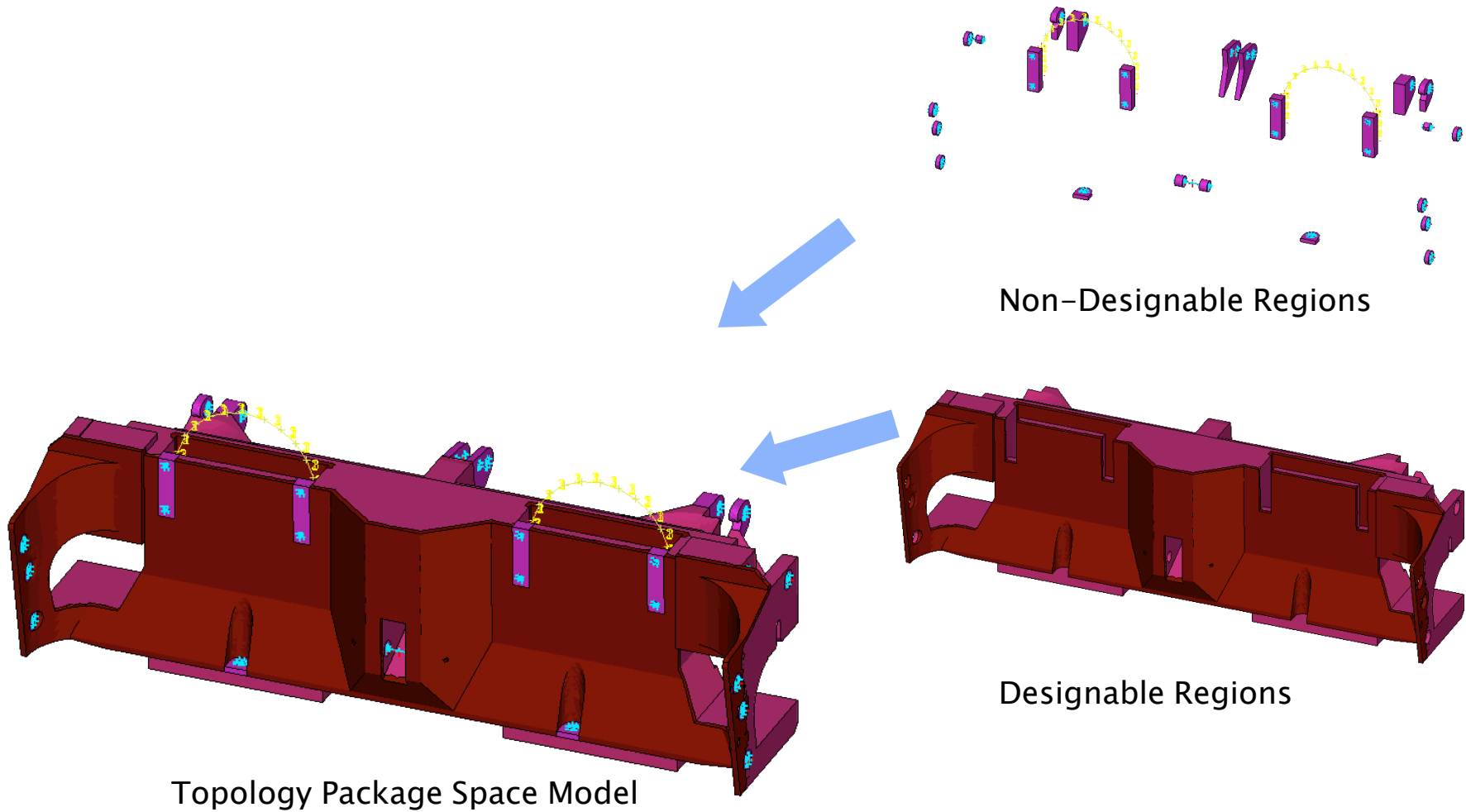
CAE in conceptual design



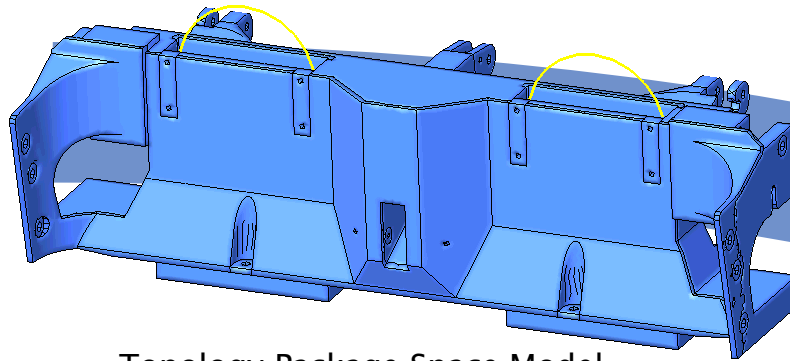
Feedback Look Identifies Problems Early



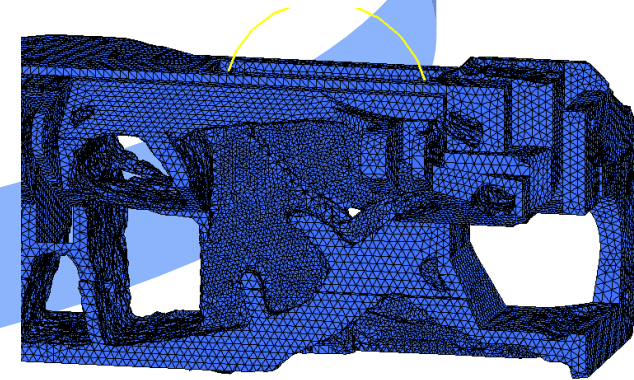
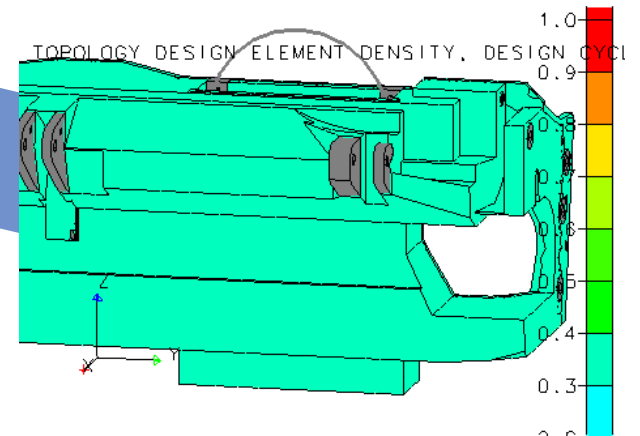
Example of processes used in CAE led concepts – Rear CCB



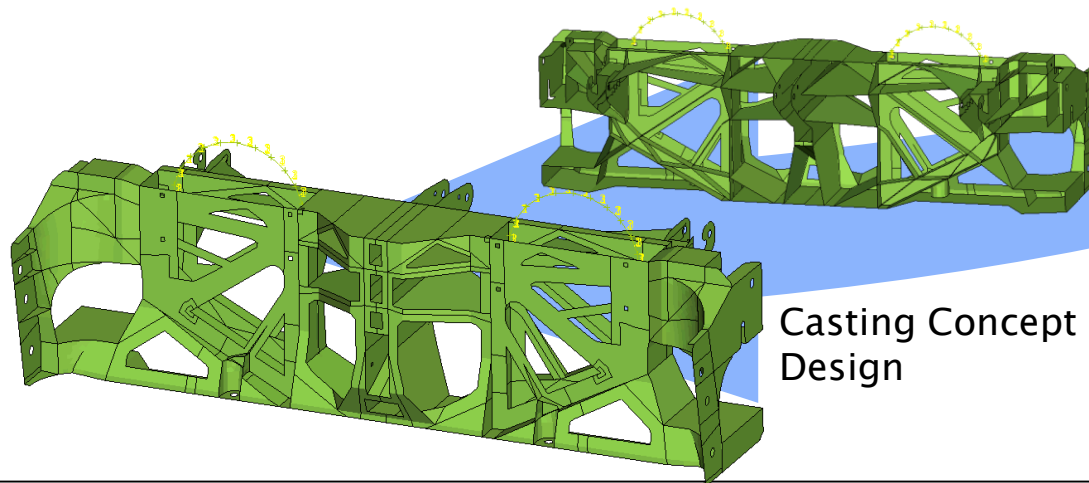
Topology Concept Optimisation



Topology Package Space Model

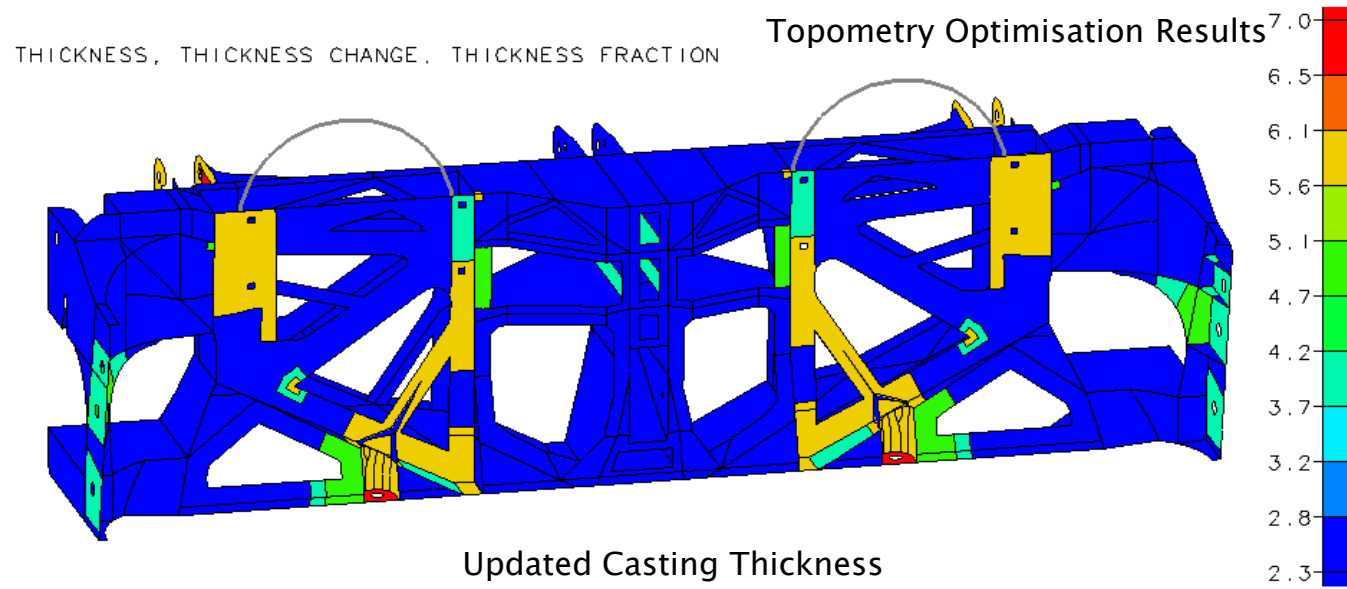
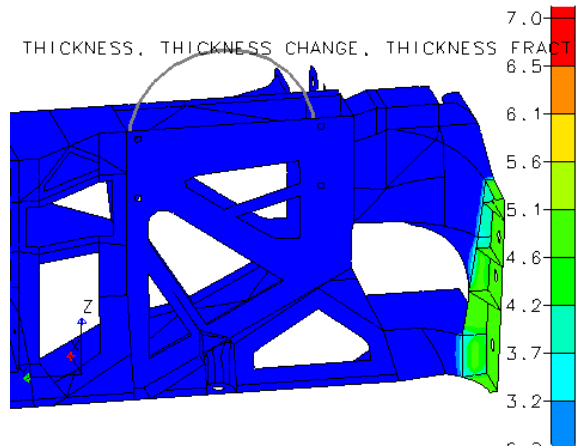


Topology Optimisation Results

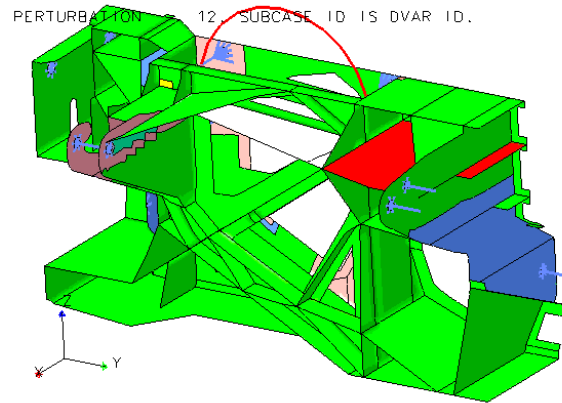


Casting Concept Design

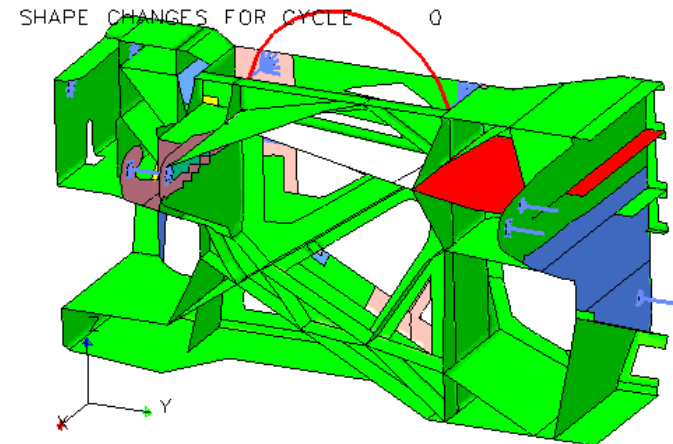
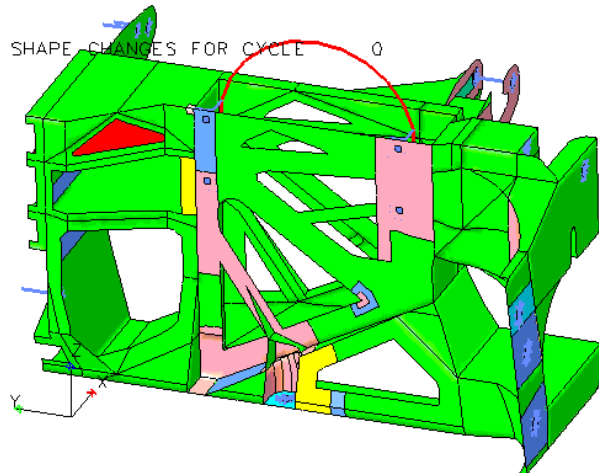
Topometry/Free Sizing Optimisation



Shape Optimisation



Allowable Shape Changes

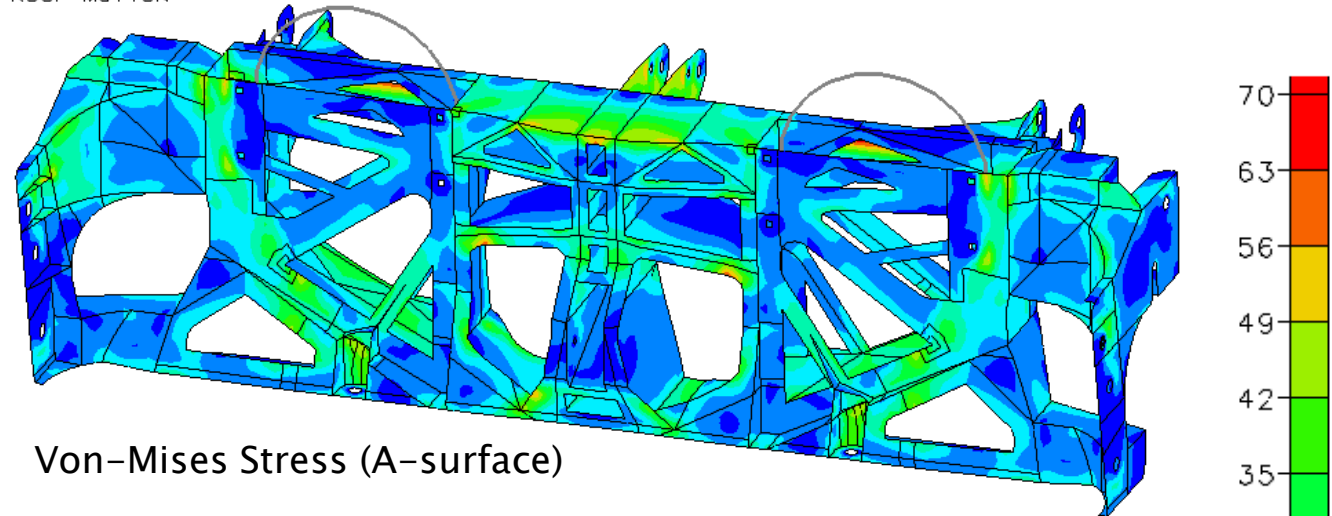


Shape Iteration History

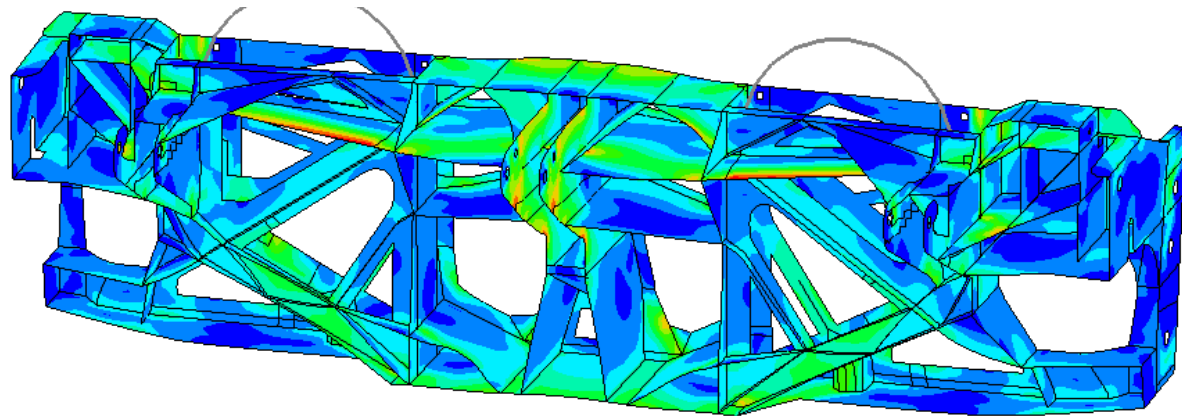
Performance Assessment

- Roof Opening Load Case
 - Maximum Stress = 70.0MPa (Target $\leq 70\text{MPa}$)

ROOF MOTION



Von-Mises Stress (A-surface)

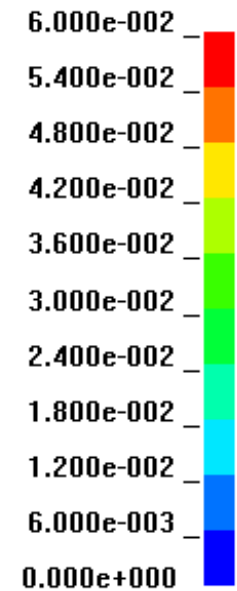
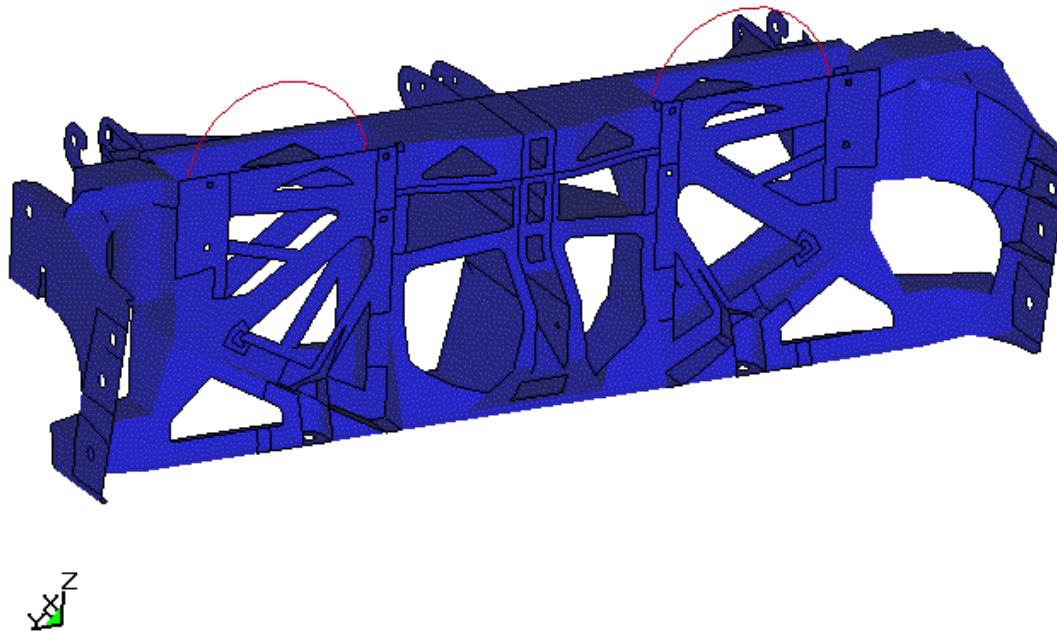


Von-Mises Stress (Rear View)

Performance Assessment

- ROPS Opening Load Case
 - Maximum Plastic Strain = 5.7%
(Target $\leq 6\%$)

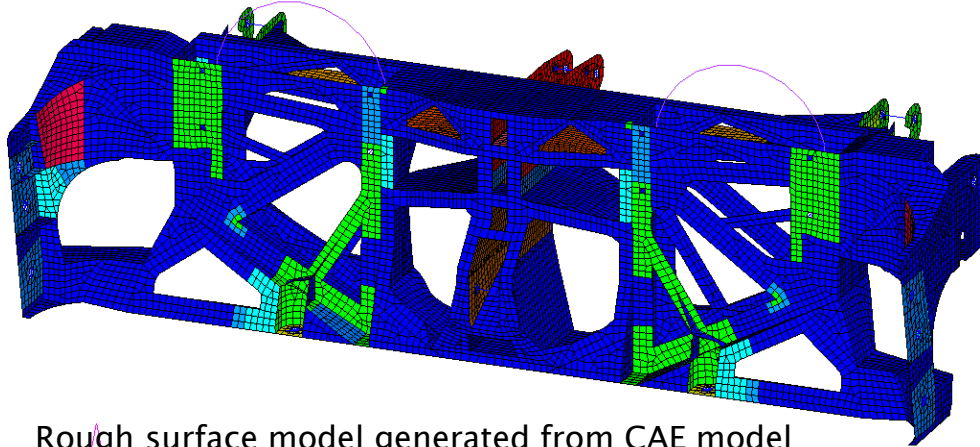
Time = 0



Effective Plastic Strain

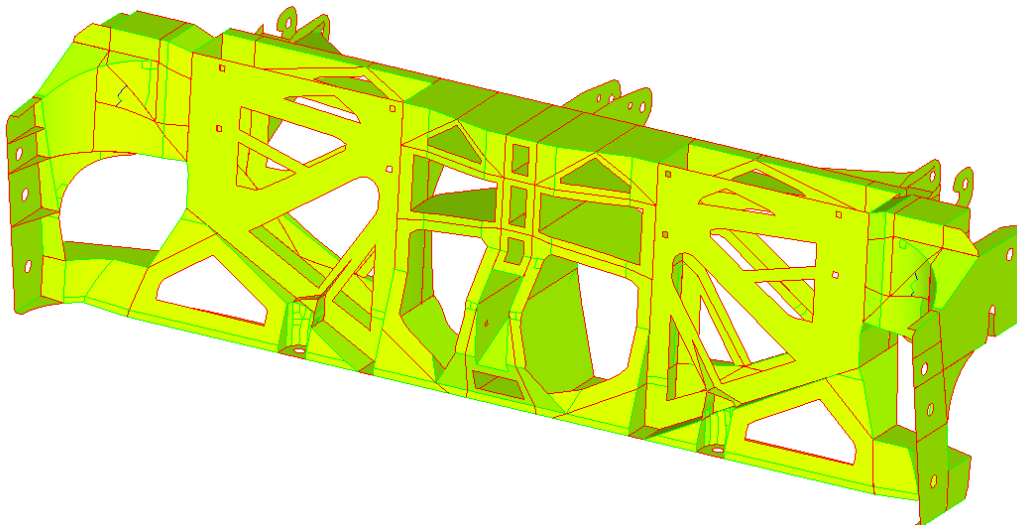
CAE Concept

- CAE_model
 - This has been developed and verified to meet customer requirements
 - This can be provided to the customer



Time to develop concept
~2 Weeks

- Rough surface model generated from CAE model
 - This can be provided for package checks

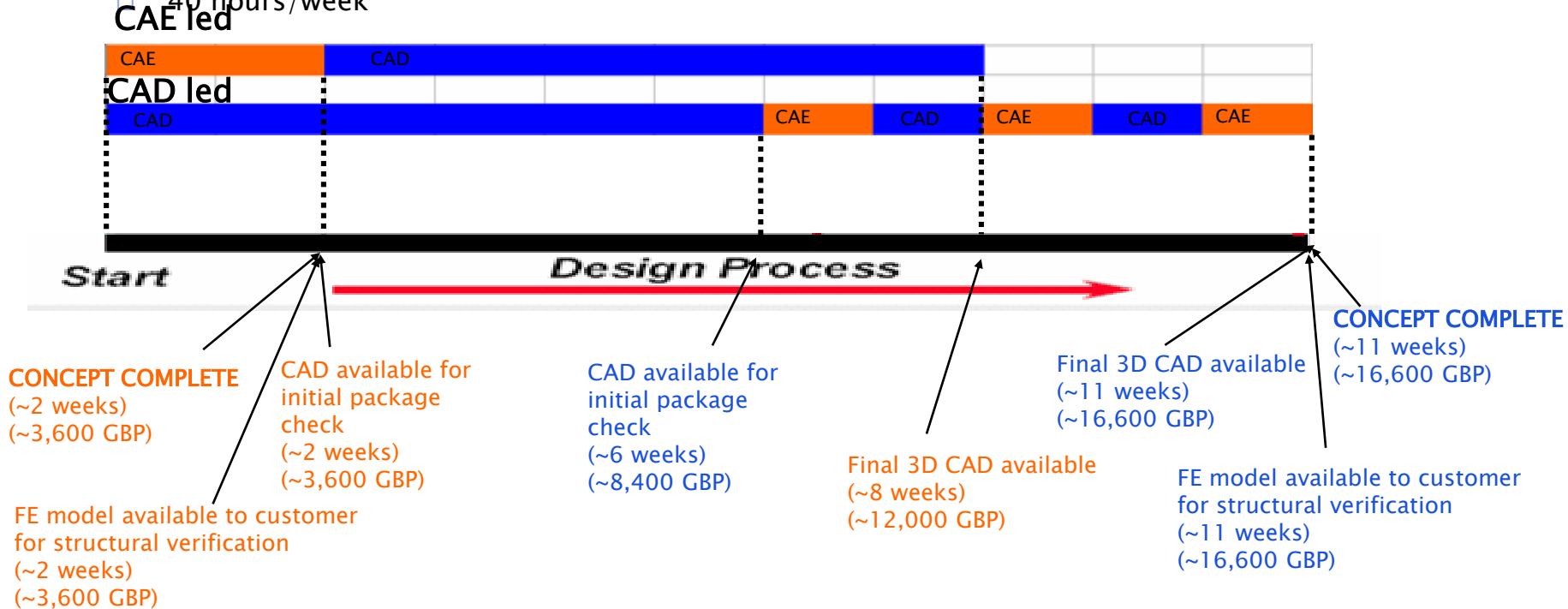


Time to generate rough CAD
~10 mins

Time to 3D CAD
~ 6 weeks

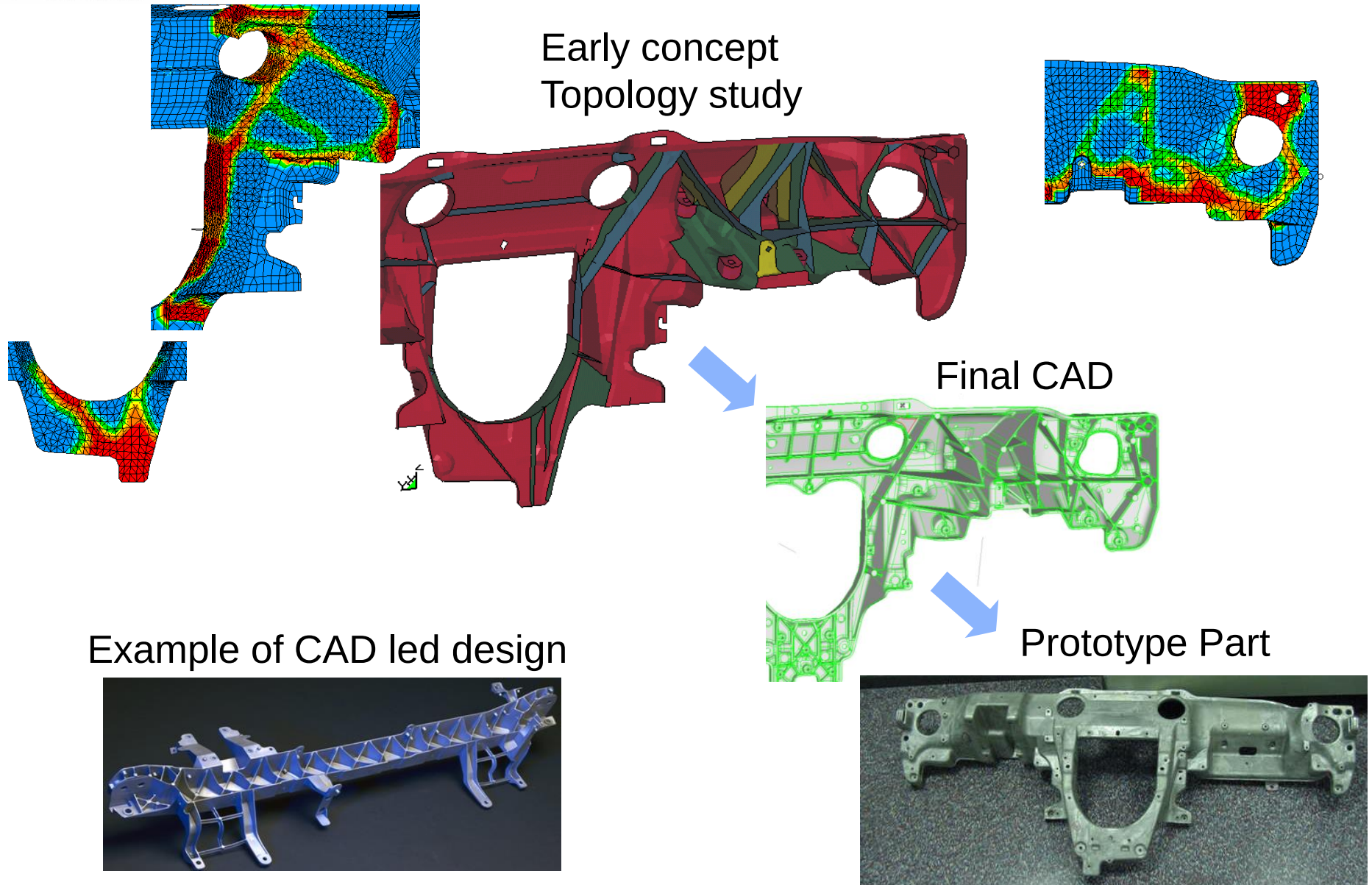
Comparison of concept approaches

- Timing Assumptions
 - Initial CAD = 6 weeks
 - CAE structural development = 2 weeks
 - CAE assessment = 1 week
 - CAD led approach requires 3 iterations to get structural performance working
- Cost Assumptions
 - CAE = 45 GBP/hour
 - CAD = 35 GBP/hour
 - 40 hours/week



- CAE approach is likely to be lighter
- Timings/Costs are approximate

Concept to production



- 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
 - Quicker
 - More robust
 - More Efficient
- Improved customer confidence in Business Development quotes.

Further Reading

■ Further Reading

- Cross, Nigel. *Engineering Design Methods*. s.l. : John Wiley & Sons Ltd, 2008.
- Hawkes, B and Abinett, R. *The Engineering Design Process*. s.l. : Longman Scientific and Technical, 1992.