The Automated Development of Casting & Moulding Ribbing Designs through the Application of the Reinforcement Derivation Method®

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Overview

- **Introduction to GRM**
- **GRM Additional Modules for Design Studio**
- **The Reinforcement Derivation Method (RDM®)**
- **Application of RDM for casting & ribbing design**
- **Case Study in Seat Armrest Design**
- **Summary and Conclusions**

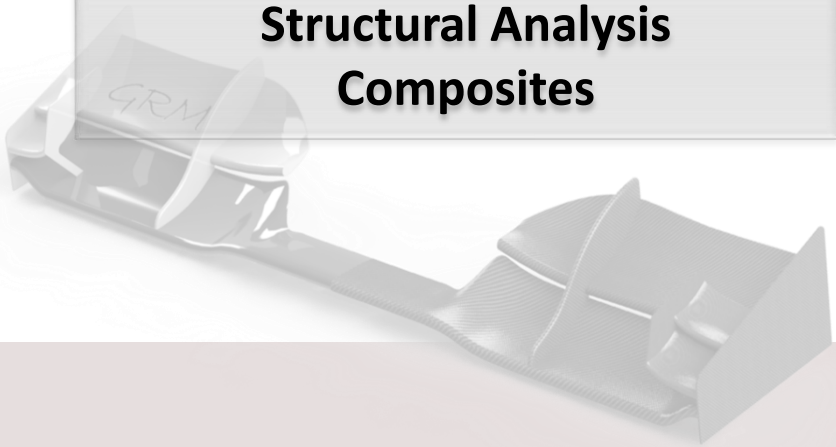
GRM

Engineering Consultancy

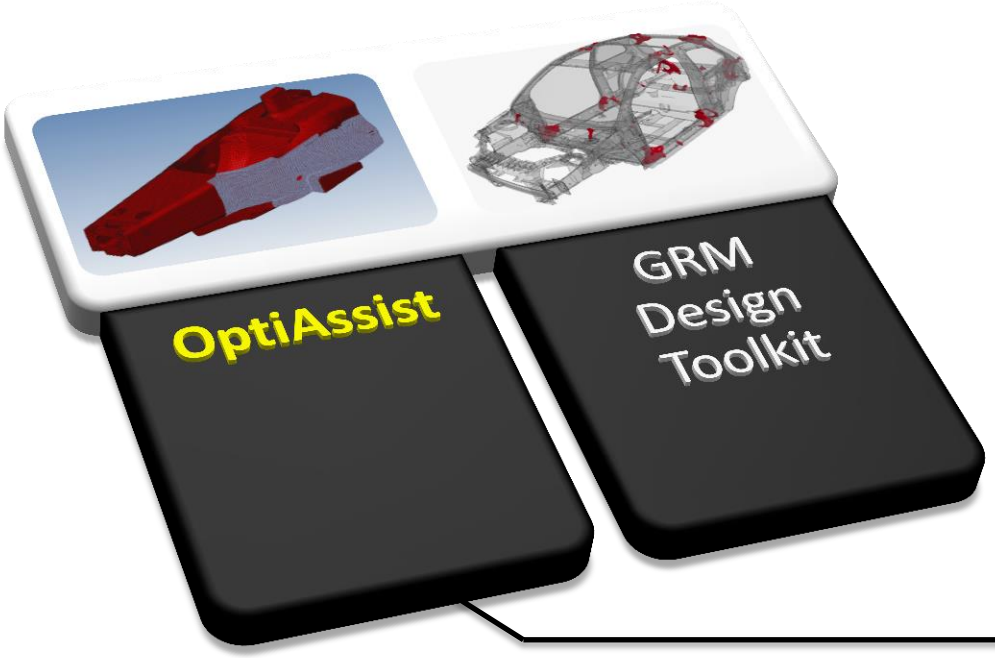
Optimisation
Design Engineering
Structural Analysis
Composites

FE Analysis & Optimisation Software

UK & EU Sales
Technical Support
Standard & Bespoke Training
Software Development



GRM Additional Modules for Design Studio



- **Composite Analysis & Optimisation Suite**
  - Composite Modeller
  - Composite Reporter
  - Material Library
  - Ply Sensitivity Plotter
  - Global Ply Design
  - Ply Pattern Reporter
  - MultiRun

GRM Additional Modules for Design Studio

- **Analysis & Optimisation Process Tools**
  - LSPP Mesher
  - Material Library
  - Thickness Sensitivity Plotter
  - RDM®
  - Abaqus Model Import
  - SolidWorks Simulation Import
  - LS-DYNA Export

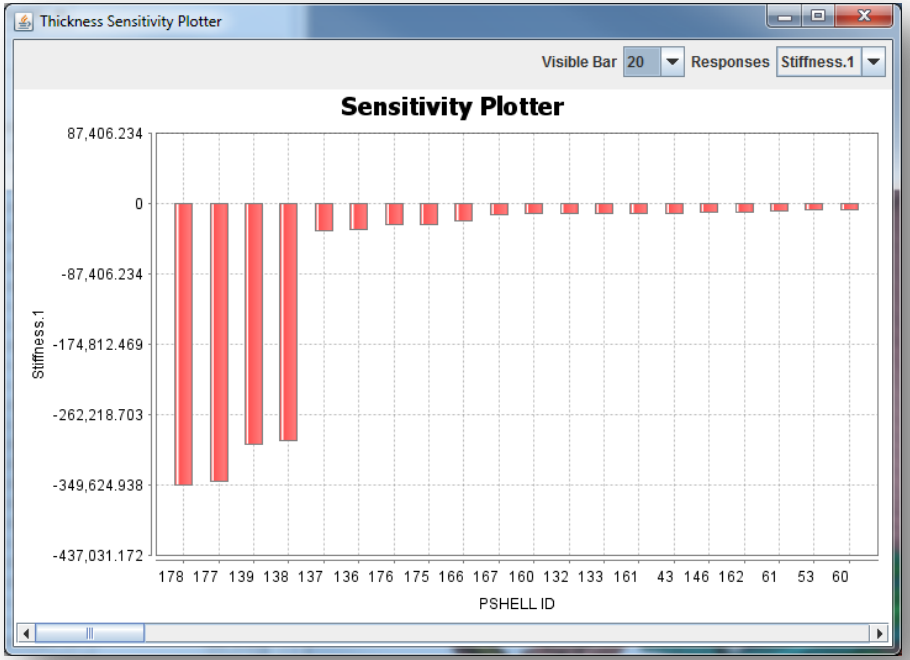
Sensitivity Plotters

PSHELL Thickness

- Automatically plot and rank stiffness & mass sensitivities to selected shell properties

Global Ply

- Automatically plot and rank stiffness & mass sensitivities to selected global plies



Design Studio for Genesis 14.0 [tutorial_6_sens.dsg] (modified)

File Edit Color Genesis Help

Display Analysis Topology Design Post

GRM Design

<Back Next>

Select Sensitivity

Select C:\TRAINING\RDM\Tutorial_6\tutorial_6_sens

Proce

ID	Name
178	PSHELL 178
177	PSHELL 177
139	PSHELL 139
138	PSHELL 138
137	PSHELL 137
136	PSHELL 136
176	PSHELL 176
175	PSHELL 175
166	PSHELL 166
167	PSHELL 167
160	PSHELL 160
132	PSHELL 132
133	PSHELL 133
161	PSHELL 161
43	PSHELL 43
146	PSHELL 146
162	PSHELL 162
61	PSHELL 61
53	PSHELL 53
60	PSHELL 60
90	PSHELL 90
145	PSHELL 145
62	PSHELL 62

0.0005415960 -7644.7

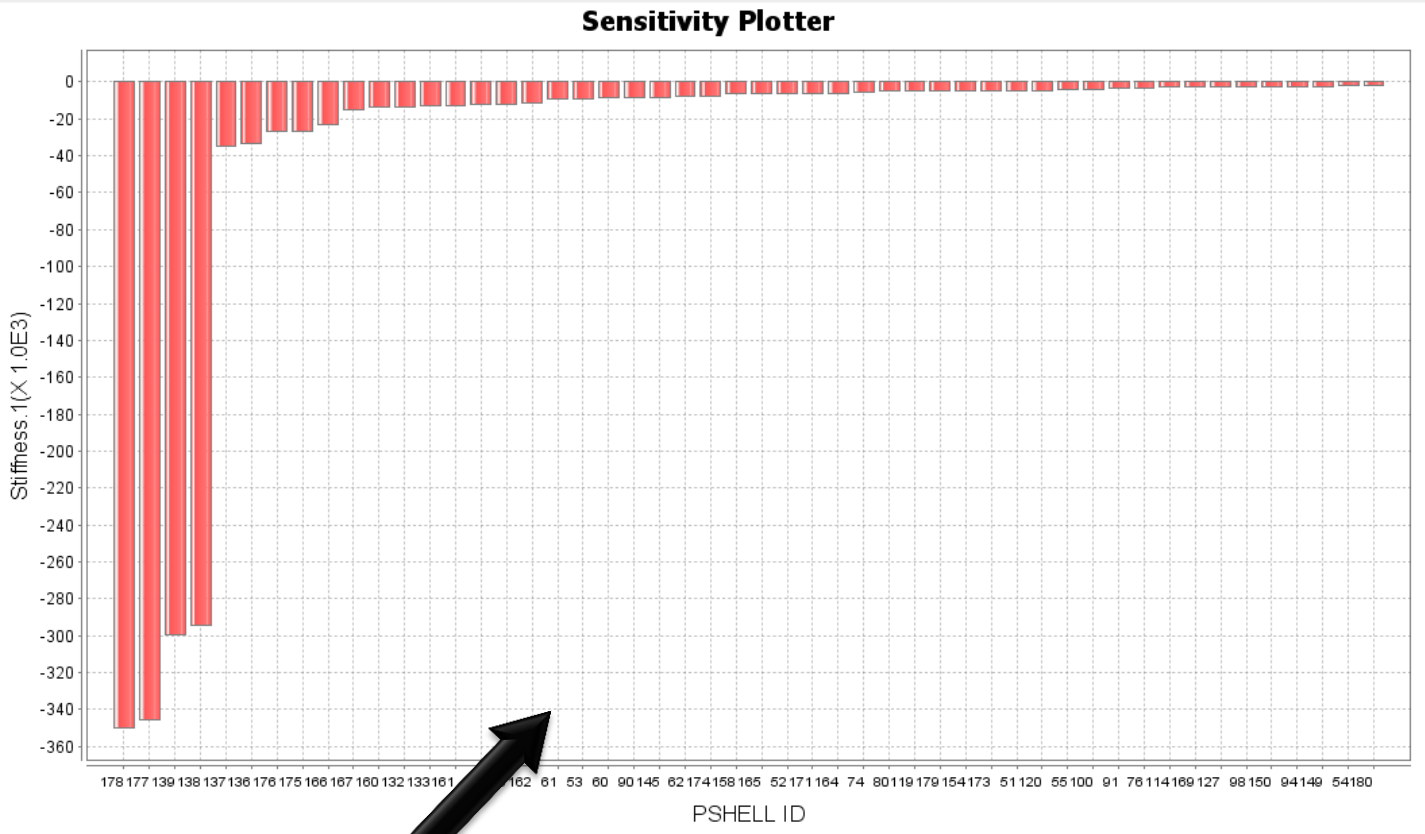
Save as .csv

Plot Sensitivity Bar Chart

Build:29/09/2014

Thickness Sensitivity Plotter

Visible Bar 50 Responses Stiffness.1



View Coord. Sys.: Basic

Choose elements from the viewport or by ID

```
##### License Server grm-wkm4 located
## GRMToolkit license is available
Process time = 0.079 secs
Reading sensitivity data from .SEN file process has stopped...
```

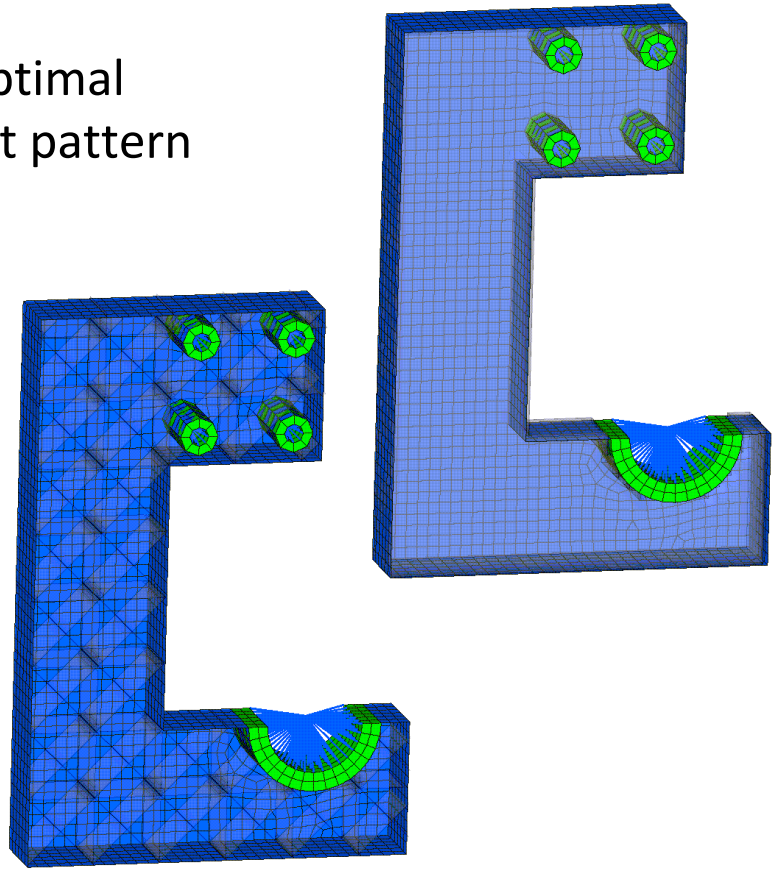
RDM®

The Reinforcement Derivation Method® (RDM)

- RDM enables rapid identification of the optimal load path identification and reinforcement pattern development

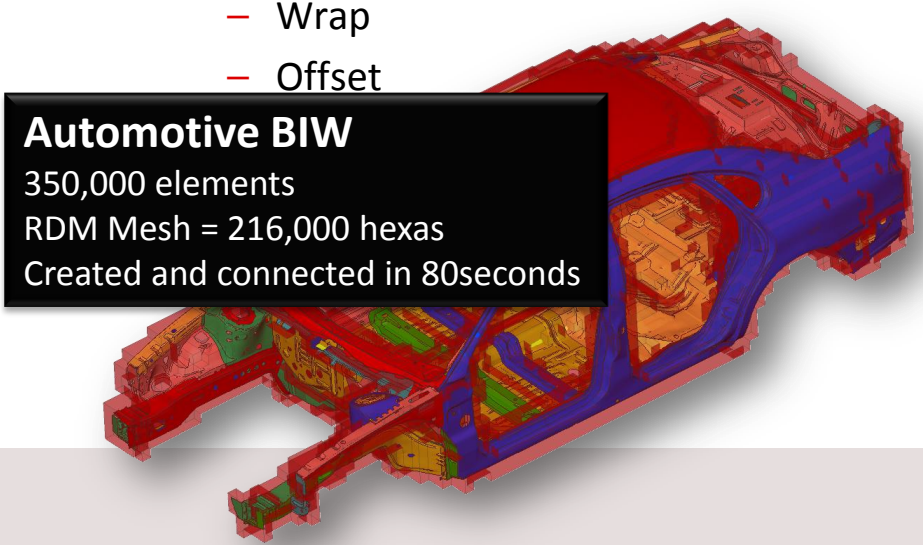
- Process allows:
  - Idealised load path identification
  - Automatic optimisation of rib patterns

- User has control of candidate rib patterns generated, ensuring feasible designs are developed

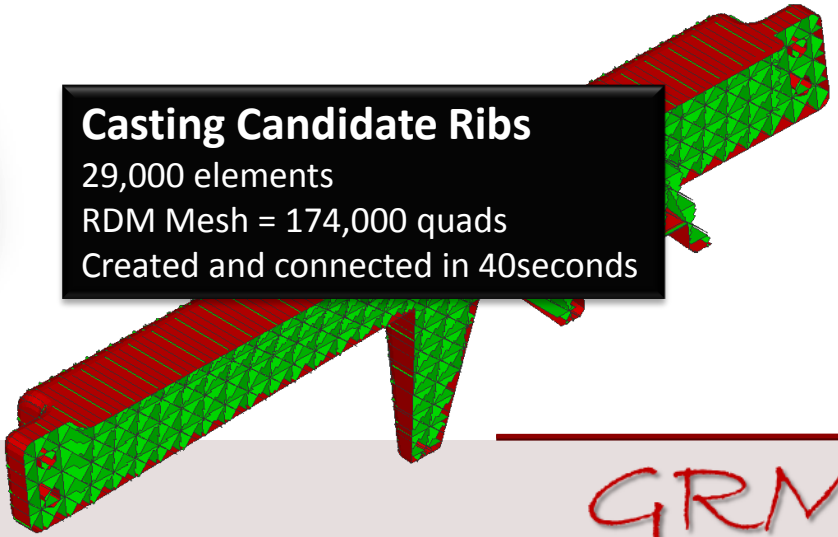


RDM Design Space Creation Process

- Eliminates often prohibitive time to create and connect candidate design space mesh
- RDM® tool enables auto creation and connection of design space in seconds
  - Block Search
  - Projection
  - Wrap
  - Offset

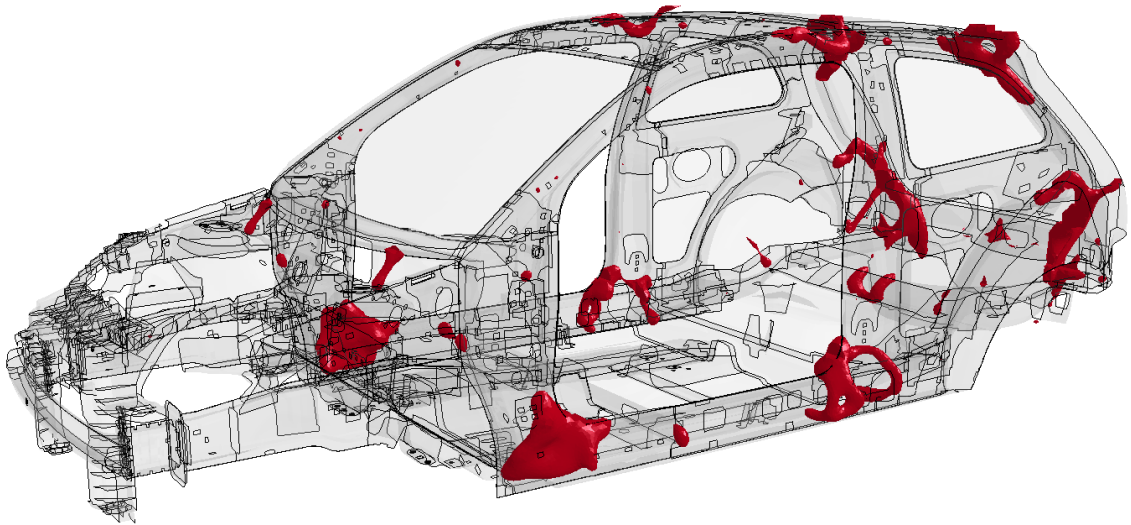


Automotive BIW
350,000 elements
RDM Mesh = 216,000 hexas
Created and connected in 80seconds



Casting Candidate Ribs
29,000 elements
RDM Mesh = 174,000 quads
Created and connected in 40seconds

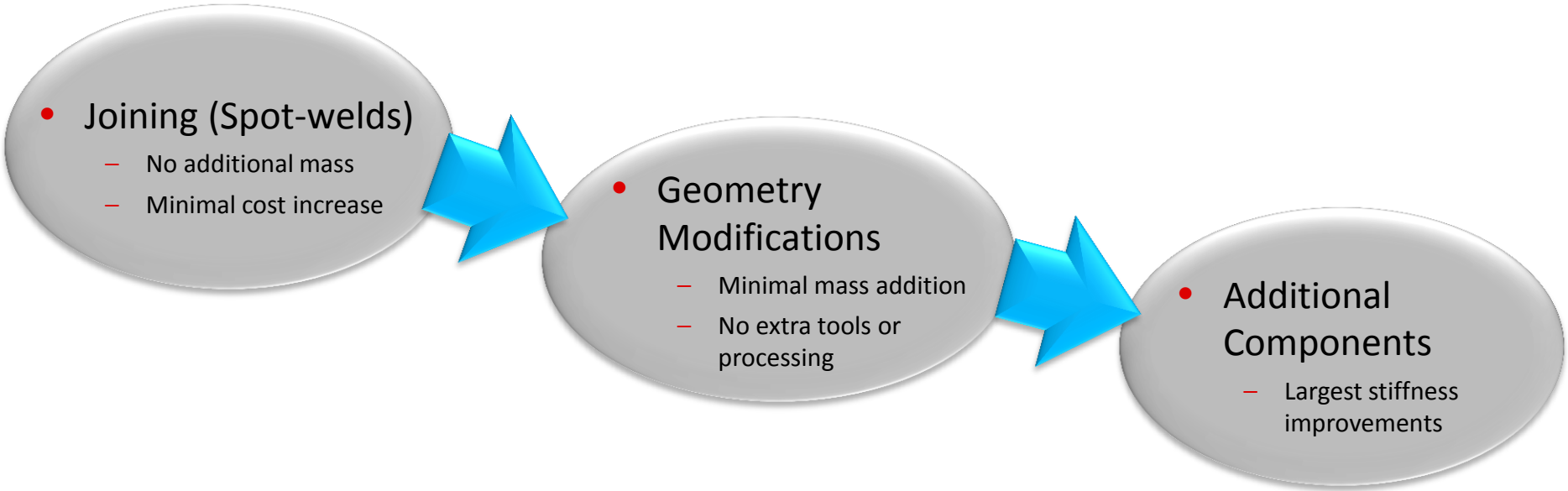
Global Load Path Improvement



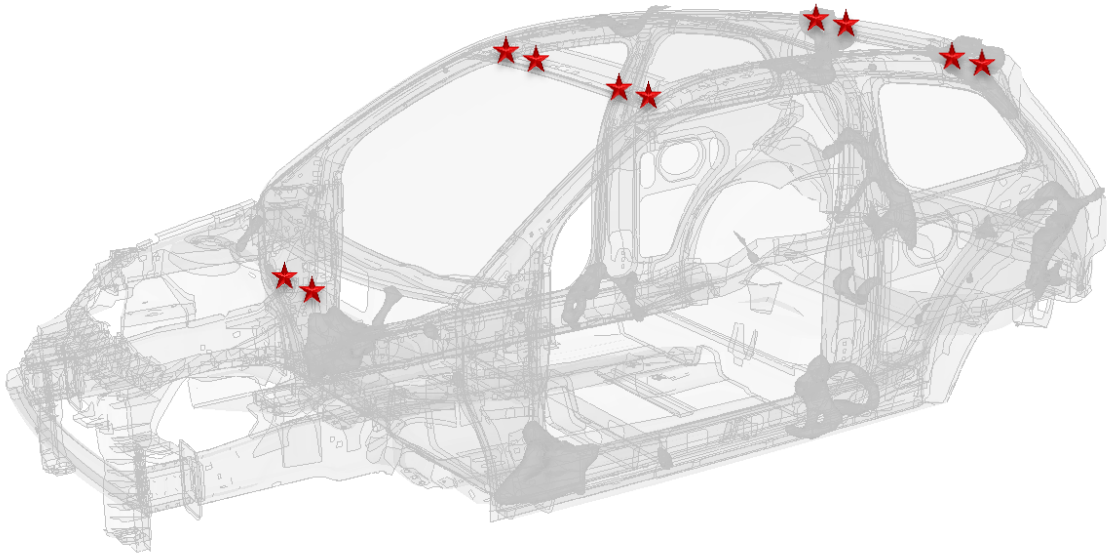
- An existing FE structure is our starting point.
- The RDM® region is automatically created in Design Studio over the top at user-defined limits.
- Genesis carries out an optimisation for multiple load-cases, removing superfluous material and only leaving the most important parts.

Interpreting the Results

- The RDM® result is ideal for identifying areas of weakness and demonstrates the most effective solution.
- However, the results need to be interpreted into feasible changes which will satisfy manufacturing and practicality constraints. 3 options apply:

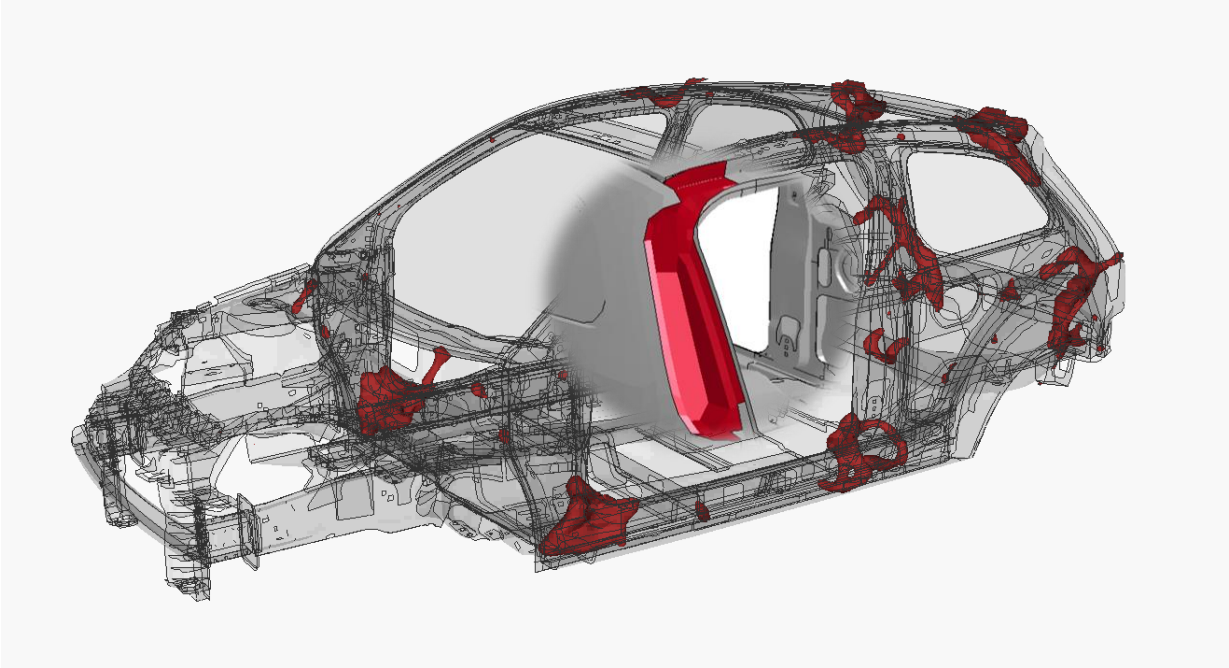


Joining (Spot-welds)



- The smaller local RDM® “nuggets” are represented as spot-welds. A total of 10 were created which increased the body stiffness by 1% for no mass change.

Geometry Updates



- Geometry change in upper corner of boot aperture to reduce offset in flow of load-paths.
  - 0.06kg (0.01%) mass increase
  - 3.7Hz (13%) increase in first mode.

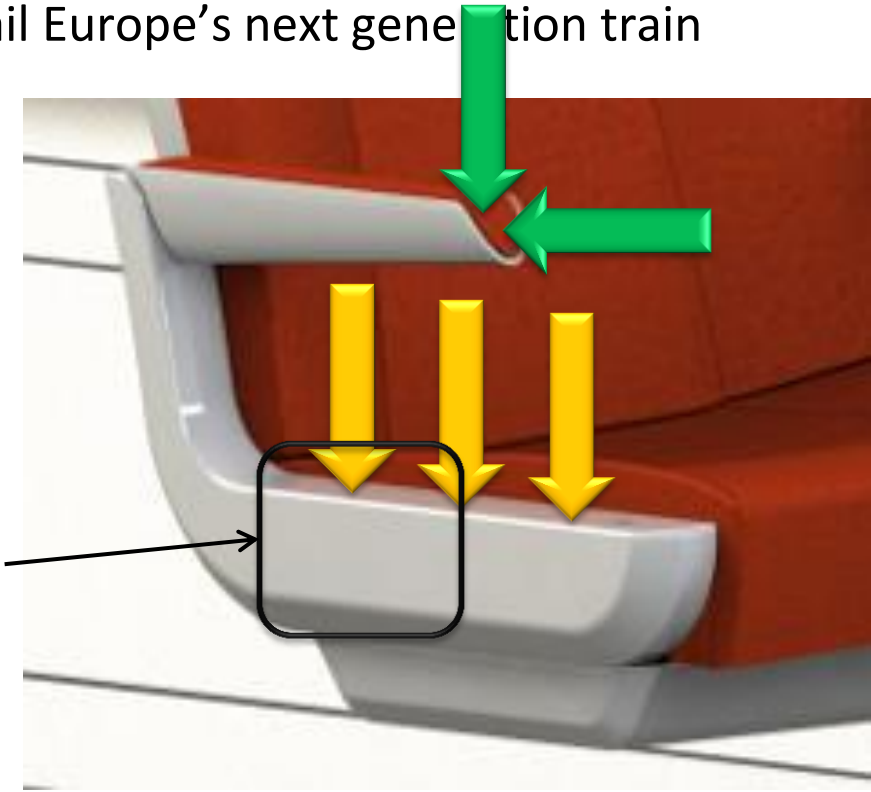
Case Study in Casting Optimisation

Hitachi Rail Europe AT 200 Prototype Mock-Up

Armrest Assembly Design

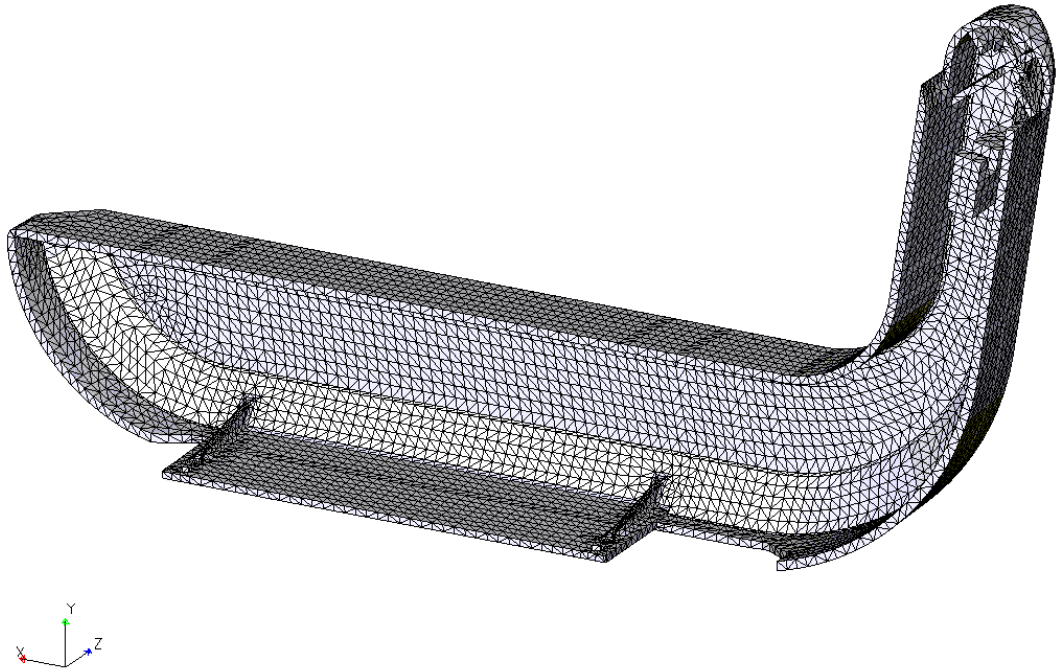
The Design Challenge

- GRM delivered engineering of Hitachi Rail Europe's next gene tion train seat designs
- Achieved design significantly lighter than current seats in market place, whilst developing cantilever mounting layout
- Achieved through extensive application of Genesis in key components
- Cast armrest assembly suitable for RDM application
  - **Lower Armrest Valence**
  - **Main Armrest**

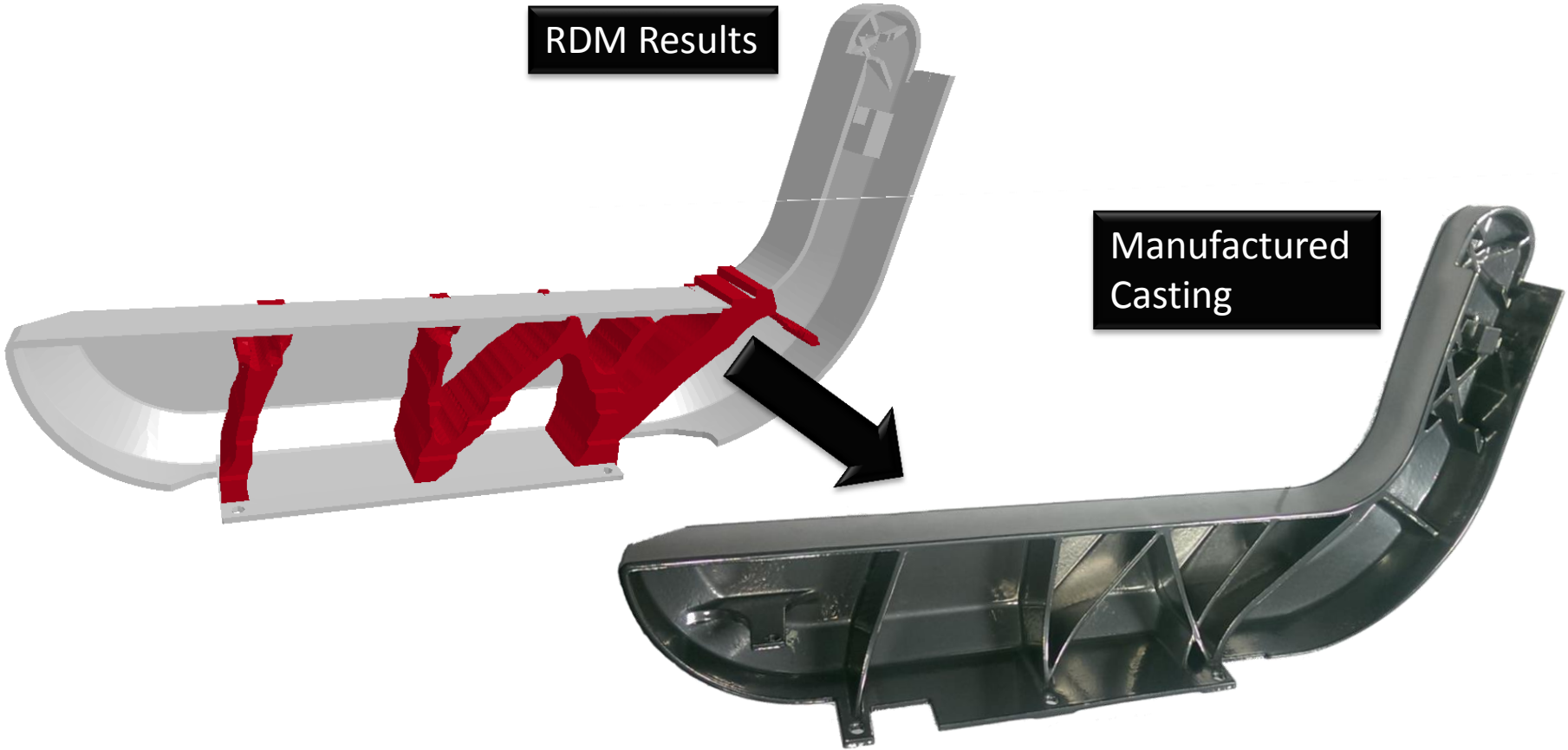


Lower Armrest Valence

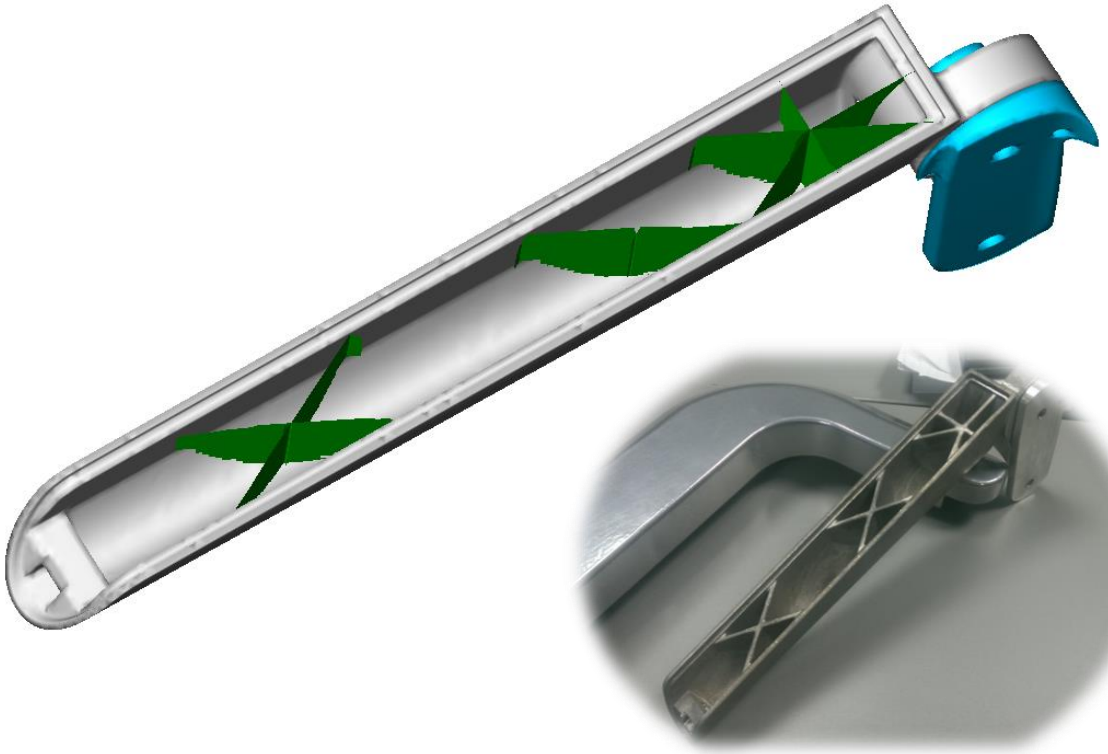
- Lower valence casting has requirement to support standing loads along top surface
- Solid RDM space creation used
  - Block Search
  - User Trimming
- Default Topology optimisation set-up of:
  - Minimise Strain Energy
  - Fixed Mass Fraction
  - Casting Constraint applied to design space



Lower Armrest Valence – Design Results



Primary Armrest Casting



- Casting/Moulding model designed without rib patten.
- The RDM® tool automatically generates candidate ribs based upon user manufacturing & design rules
- Genesis carries out an optimisation for multiple load-cases, eliminating ribs not required to meet the loading requirements

Design Results

- Armrests successfully installed on first class and standard seats for Hitachi demonstrator train
- Train launch in London in July 2014
- There's even one in our office!

Summary and Conclusions

- Genesis has, for a long time, contained the capabilities to optimise casting and moulding rib patterns
- RDM® tools objective is to enable users to rapidly and easily identify areas for design improvement
- Specific application to castings/mouldings can be achieved using either solid or shell RDM® design space options
- In the case of Hitachi's seat design Genesis and RDM® proved invaluable in delivering a lightweight design in such a short timescale

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Thank You…