



# ***GENESIS* Structural Optimisation: Current and Upcoming Key Features**

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# Presentation Outline

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- **Introduction to VR&D**
- **Optimisation..**
  - What is it?
  - A brief history
- ***Genesis & Design Studio***
  - *Overview*
  - *New Features*
- **Conclusions**

# ***Introduction to VR&D***



- **Vanderplaats Research & Development, Inc.**
- **Founded by Gary Vanderplaats in 1984**
- **Specialists in Optimisation Software & Services**

# Company Mission

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- **VR&D exists to develop and provide world leading Optimisation software and Engineering Services**
- **Our goal has always been to provide the best Optimisation software**
- **Through the application of our tools, clients can deliver and produce better products**

"Saving even a few pounds of a vehicle's weight ... could mean that they would also go faster and consume less fuel. Reducing weight involves reducing materials, which, in turn, means reducing cost as well."

Henry Ford, 1923.

# VR&D Offices & Distributors



- Britain
- France
- Germany
- Russia
- India
- Japan
- Korea
- China
- Others

## VR&D Offices in U. S.



# ***What is Optimisation?***

# What is Optimisation?



Find the set of **design variable values** that will minimize the **objective function** while satisfying all the **constraints** and **side constraints**

Minimize:

$$F(\mathbf{X})$$

Subject to (Such that):

$$\left\{ \begin{array}{l} g_j(\mathbf{X}) \leq 0 \\ X_i^{Lower} \leq X_i \leq X_i^{Upper} \end{array} \right.$$

“Constrained optimization is the art of compromise between conflicting objectives. This is what design is all about.”

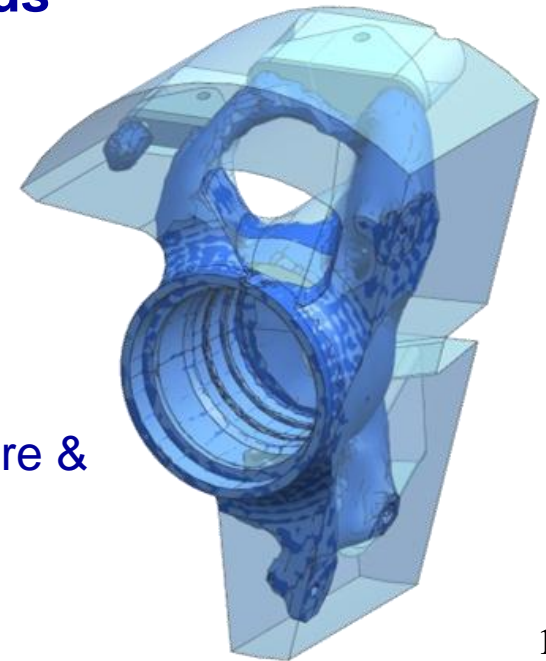
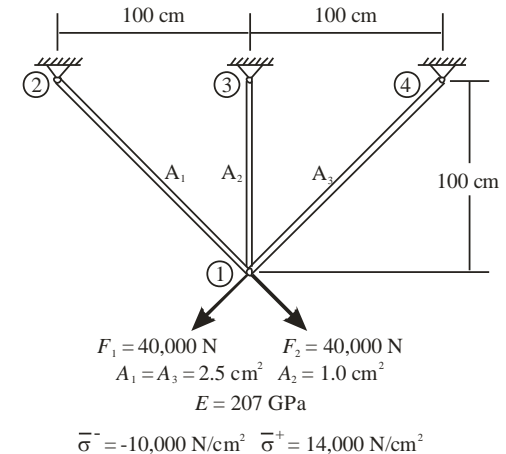


# ***Brief History of Structural Optimisation***

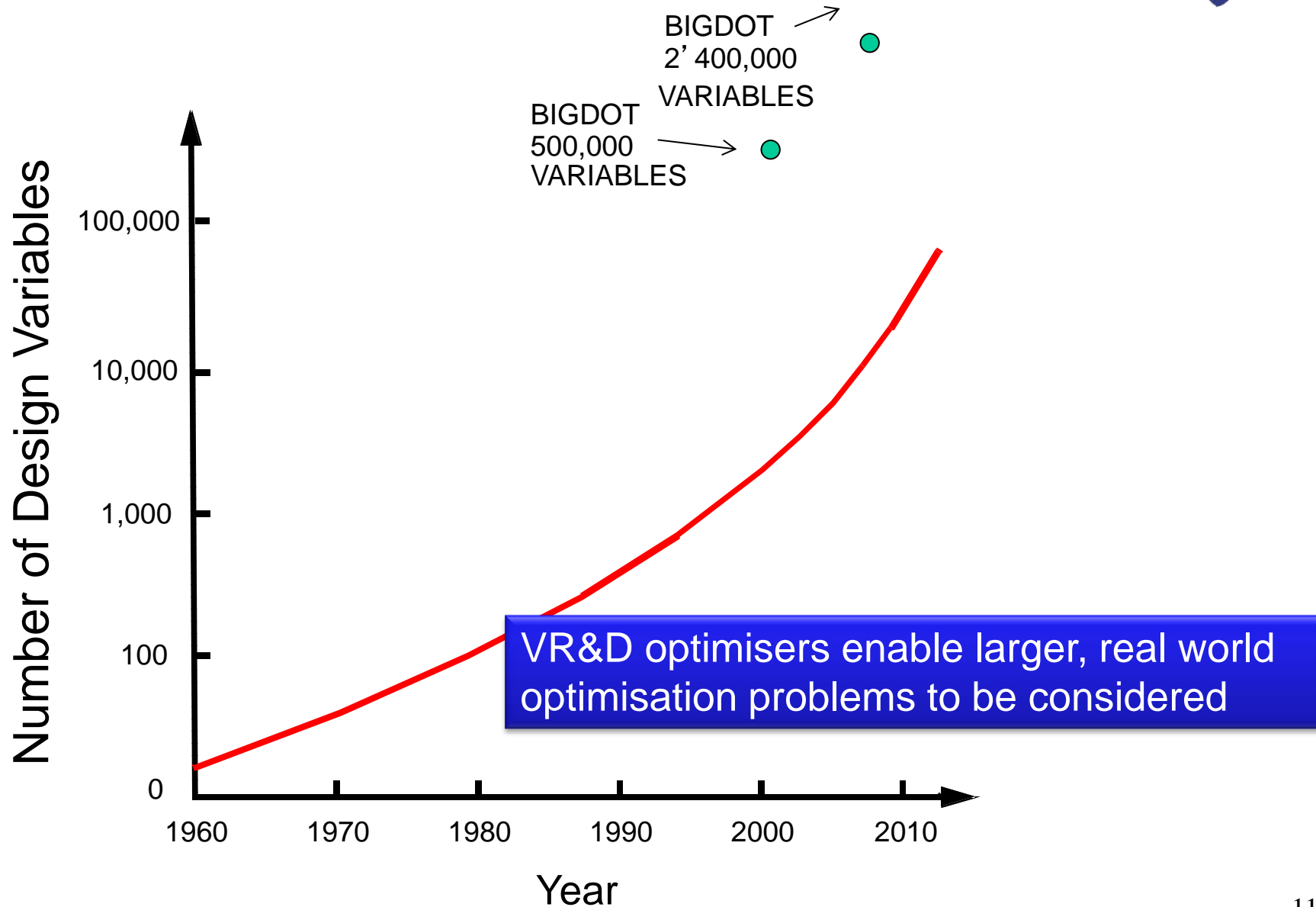
# Structure Optimisation History



- **1960s – Early Research**
  - Schmit combined FEA with Numerical Optimisation
- **1970s – Development of Practical Methods**
  - Gary Vanderplaats developed first large scale optimiser, CONMIN
- **1980s – Development of Contemporary Methods**
  - Topology optimisation
- **1990s – Expansion of Number of Advanced Methods**
  - Topography, Sizing, Shape
- **2000s – Methods meet demands of Industry**
  - Vanderplaats develop Design Studio, a dedicated pre & post-processing environment for optimisation



# Optimisation Problem Size



# ***GENESIS & Design Studio***

## ***Current Features***

## Structural Analysis & Optimisation Software

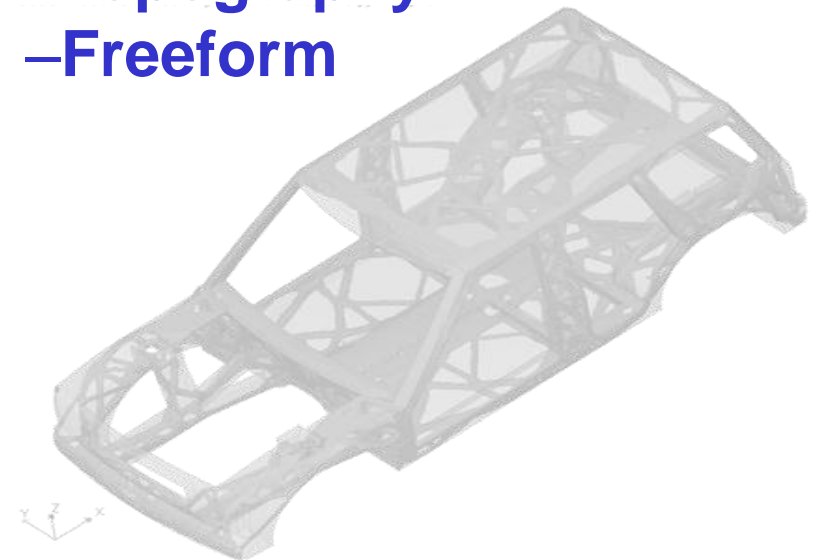
- Analysis Options

- Linear statics
- Inertia relief
- Normal modes
- Frequency response
- Heat transfer
- Buckling
- Random
- Nonlinear GAP
- SMS fast Eigenvalue Solver



- Optimisation Options

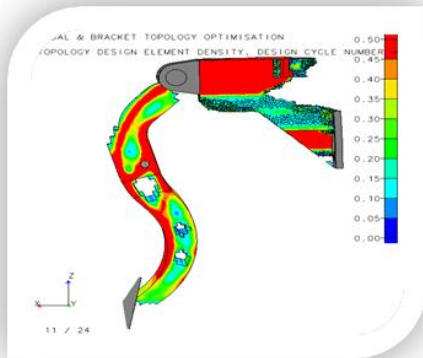
- Topology
- Sizing
- Topometry
- Shape
- Topography
- Freeform



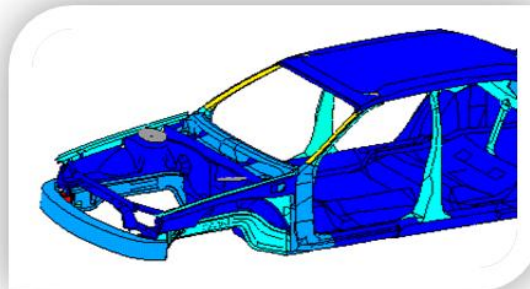
Cycle 28 Topology Result

# GENESIS Optimisation Capabilities

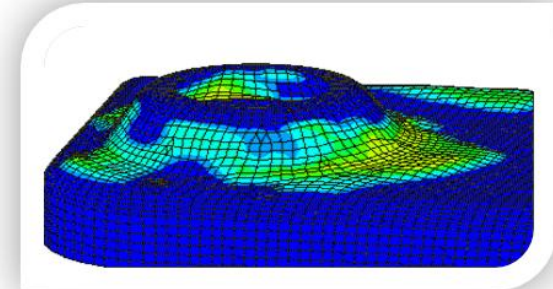
- GENESIS provides the most complete suite of optimisation capabilities
- Each method is available for all analysis methods within Genesis and can efficiently consider combination of multiple loading requirements



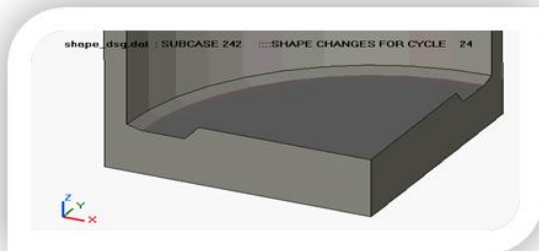
Topology



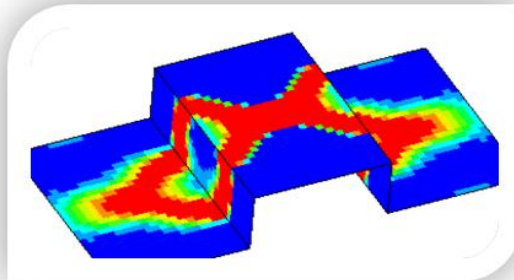
Sizing



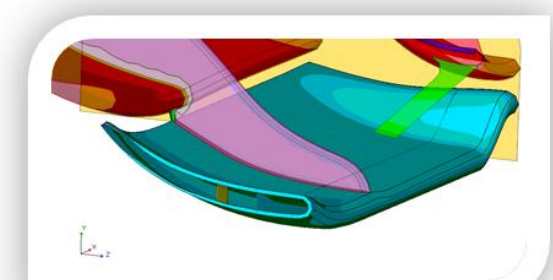
Topography



Shape

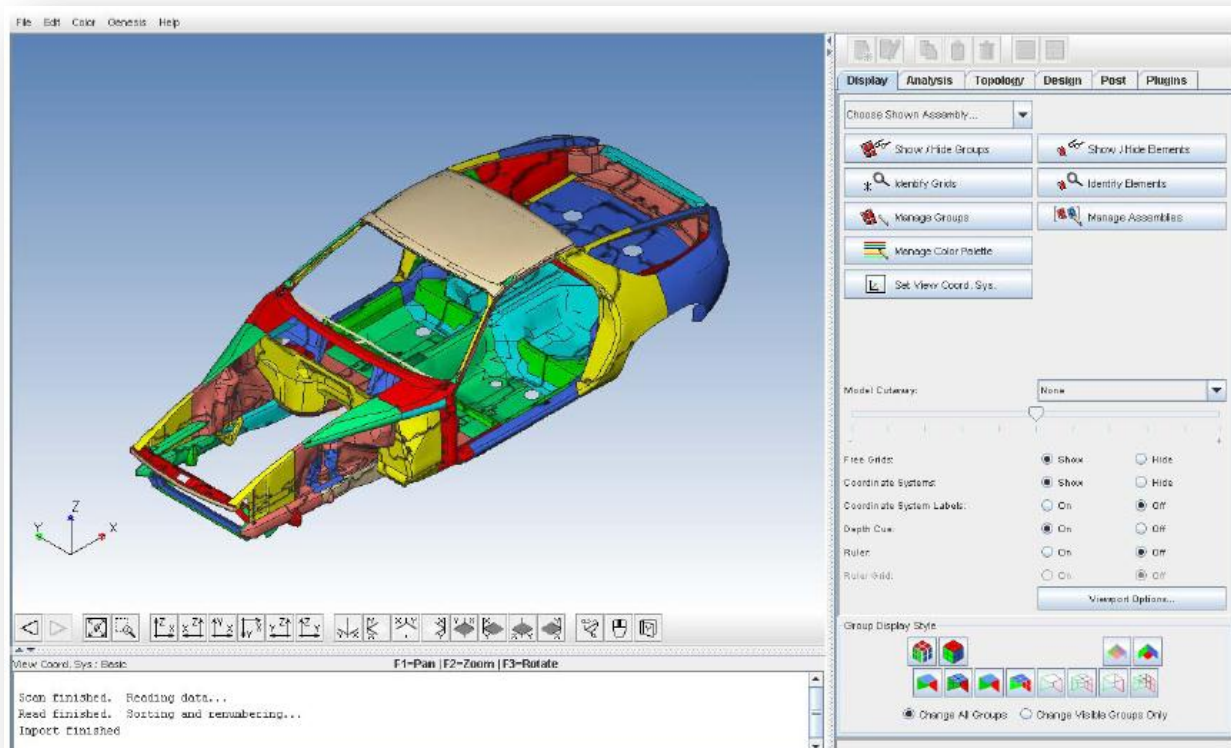


Topometry



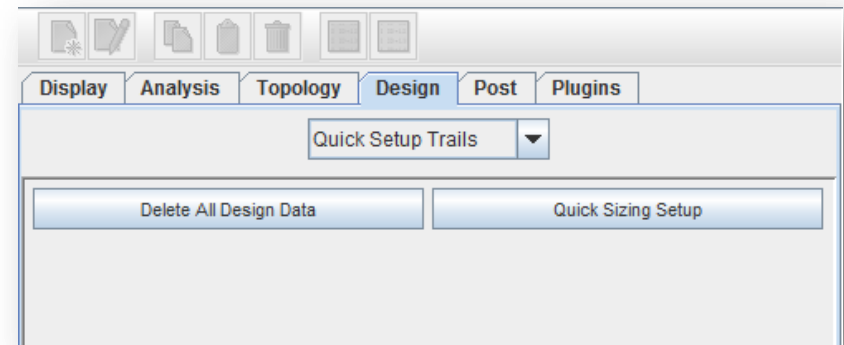
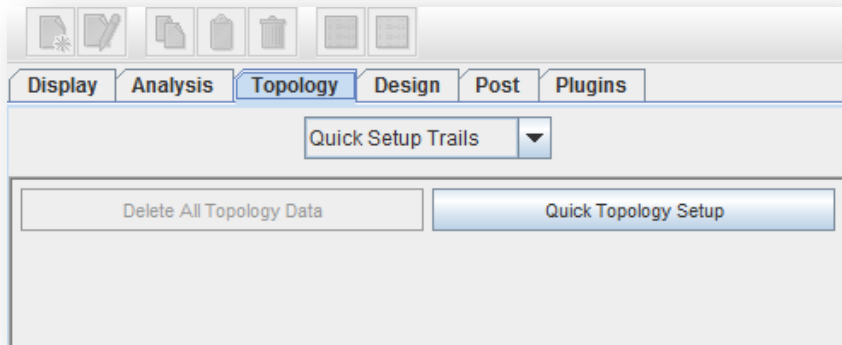
Composites

- **What is Design Studio?**
  - A design pre/post-processor for **GENESIS**
  - The only pre/post-processor developed specifically for the efficient application of structural optimisation



- **Optimisation Workflows**

- **Task oriented:** Follow built-in trails (wizards) for all common and not-so-common design tasks
- **Customisable:** Plugins can be developed for customer specific tasks (for example GRM's OptiAssist and RDM)

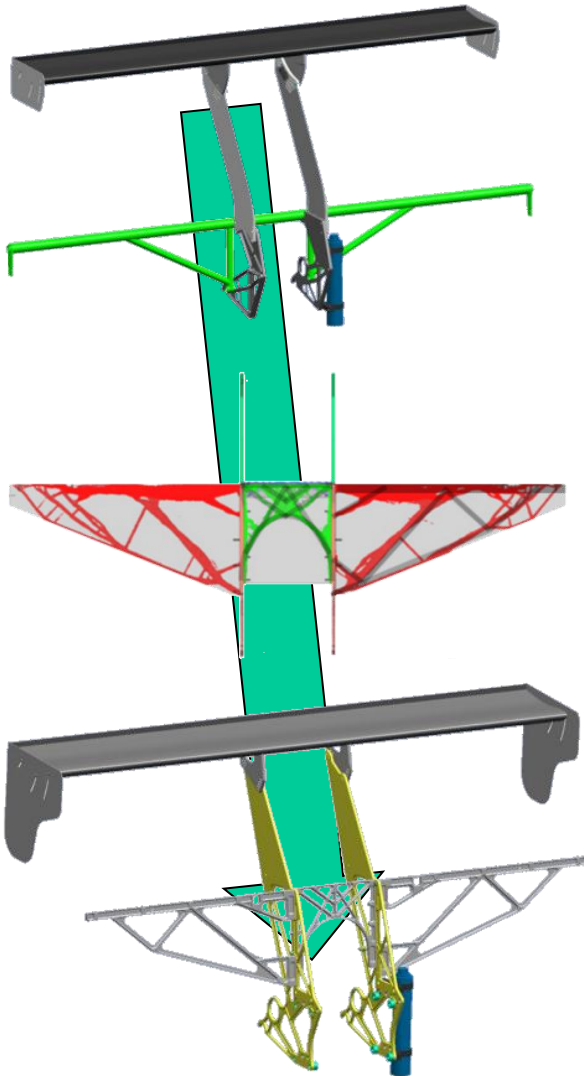




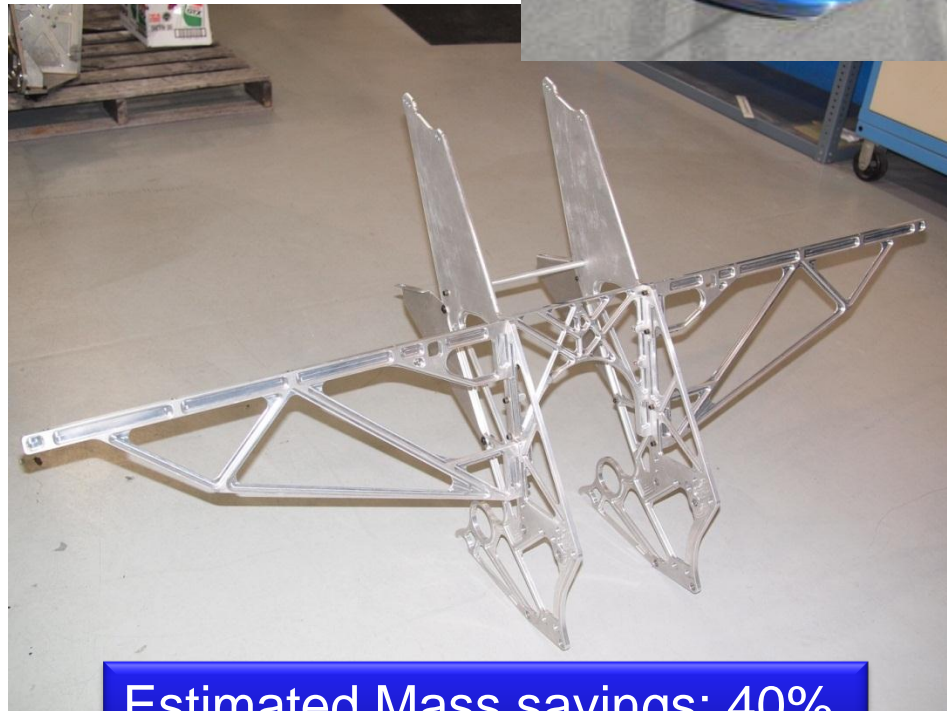
# Wing Frame Structure



Frame designed using Topology Optimisation



2012 Corvette  
Daytona Prototype



Estimated Mass savings: 40%

**PRATT  
MILLER**

# Transmission Optimisation

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- **Transmission acoustic optimisation removed at customer's request**



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# ***GENESIS* & Design Studio 13.0**

## **New Features**

# New Features

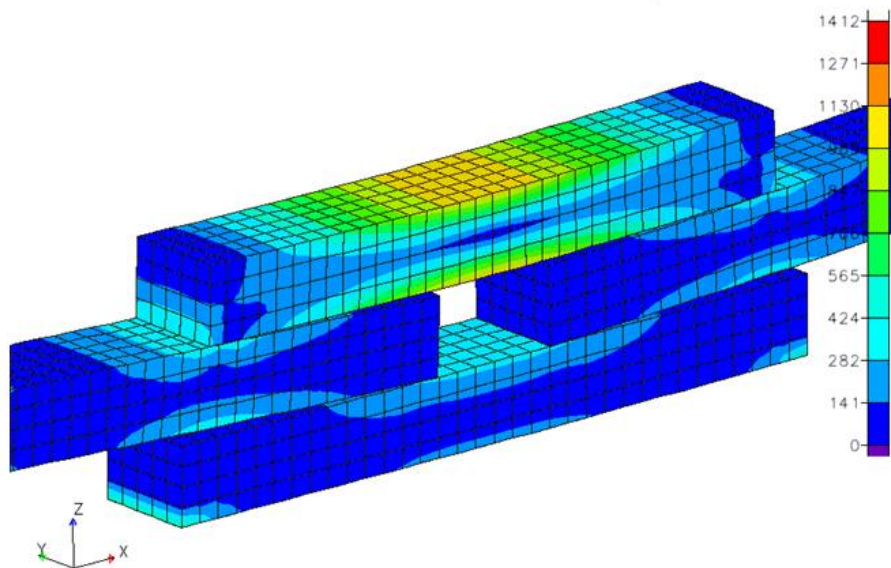
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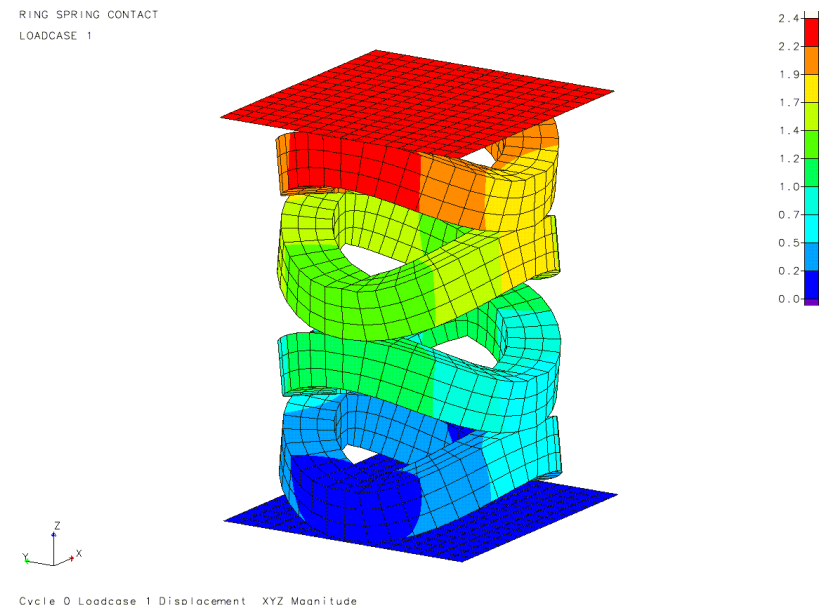
- **Analysis Enhancements**
- **Optimisation Enhancements**
- **Interface Enhancement**

## • Non-Linear Contact Analysis

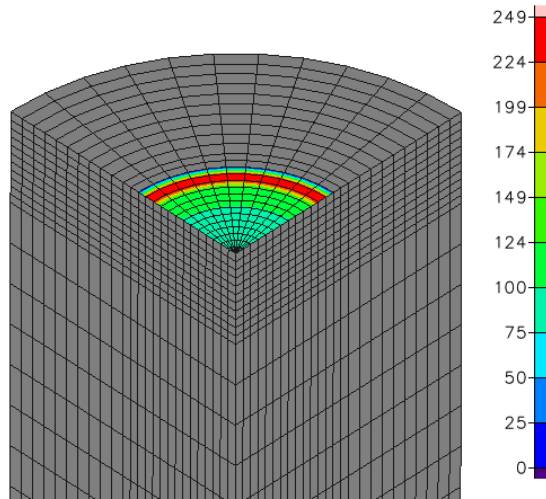
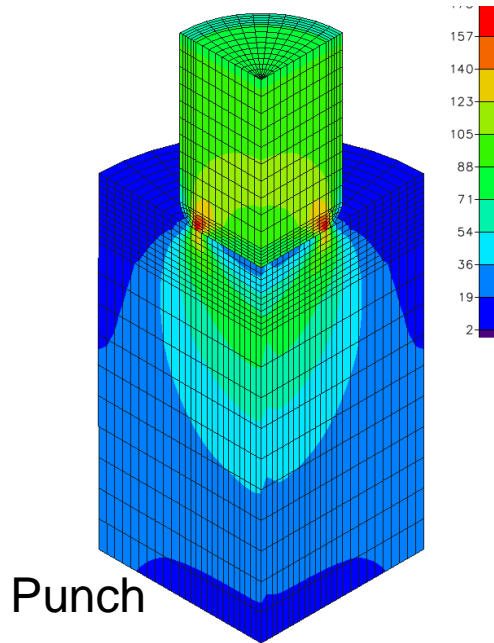
- Automatically generates potential contact points from surface definitions
- Works with static load cases
- Different static load case can have different contact conditions in the same run
- Accurate contact pressure results



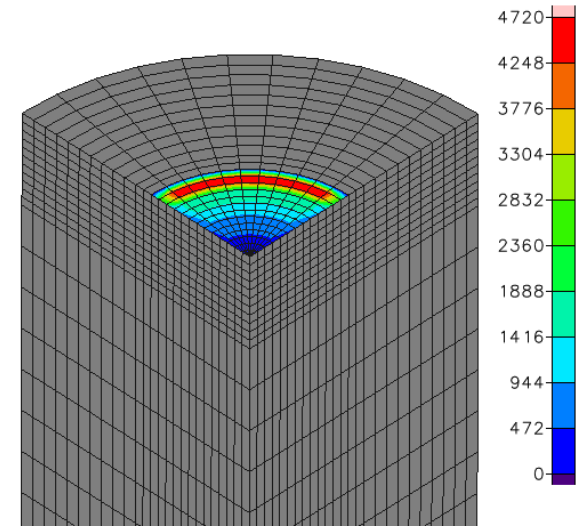
RING SPRING CONTACT  
LOADCASE 1



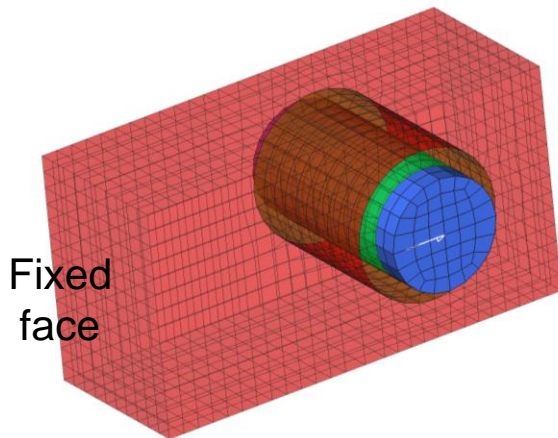
# Contact Pressure/Force/Clearance



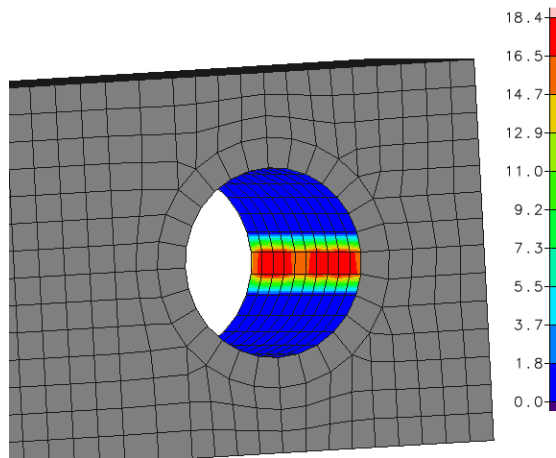
Contact pressure



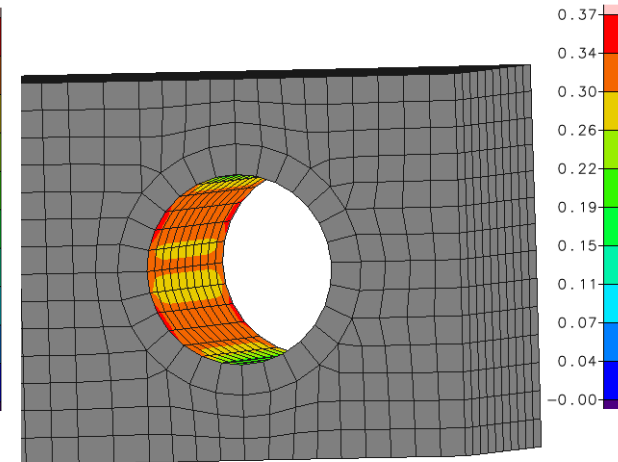
Contact force



3D loaded pin



Contact pressure



Contact clearance

- **Increased Nastran Compatibility**
  - DLOAD
  - RLOAD1/2 support of SPCD
  - Multiple TITLE & SUBTITLE
  - PBUSHT - Frequency dependent spring stiffness
  - PCOMPG – Composite Global Plies
  - Nastran compliant Grid Stress output

Improvements further enable Genesis to provide a complete, cost effective Nastran alternative.



# Optimisation Enhancements

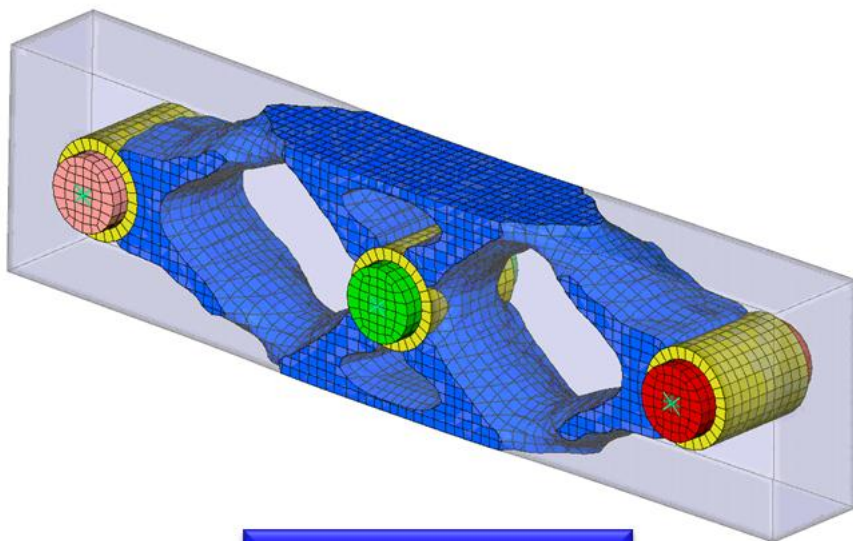


- **Contact Based Optimisation**

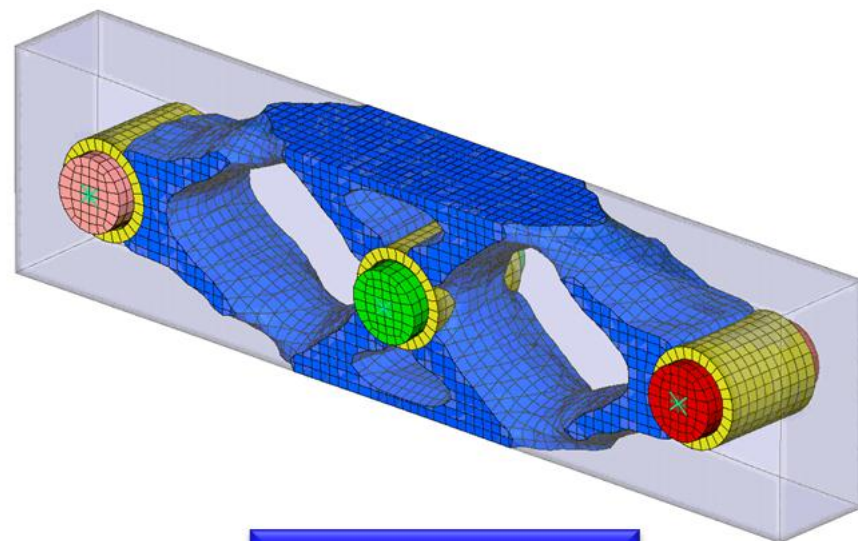
- Models with contact supported in optimisation
- Key contact parameters can be defined as objective and/or constraint data

**Example 1: Optimisation with Contact in the Analysis Phase**

- Minimise Strain Energy, 2 load cases
  - Mass Fraction = 0.3



**Bending**



**Torsion**

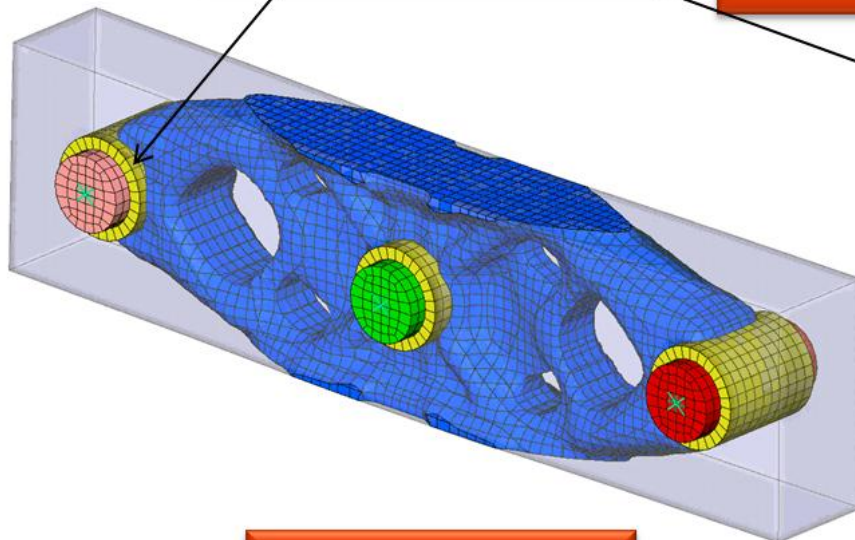
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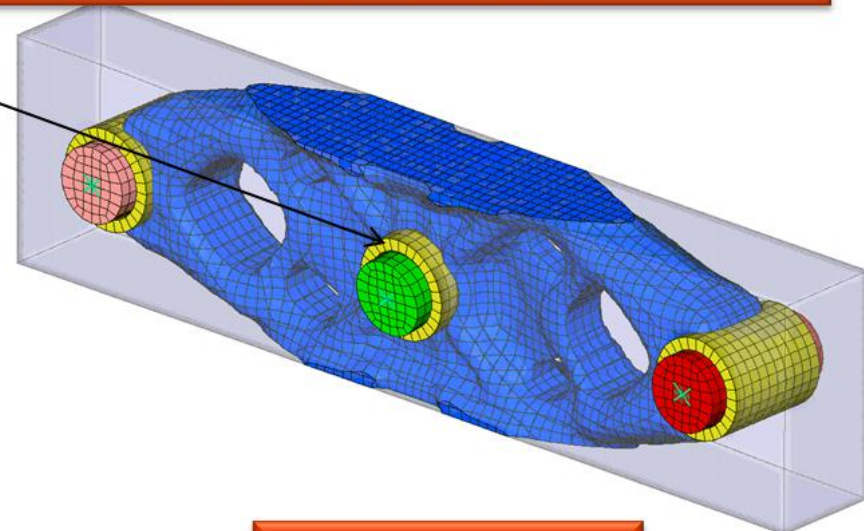
**Example 2: Optimisation with Contact in the Analysis & Optimisation Phase**

- Minimise Strain Energy, 2 load cases
  - Mass Fraction = 0.3
  - Contact Pressure < 500N/mm<sup>2</sup>

Material not developed at end of non-designable sections, relieving contact pressure



**Bending**



**Torsion**

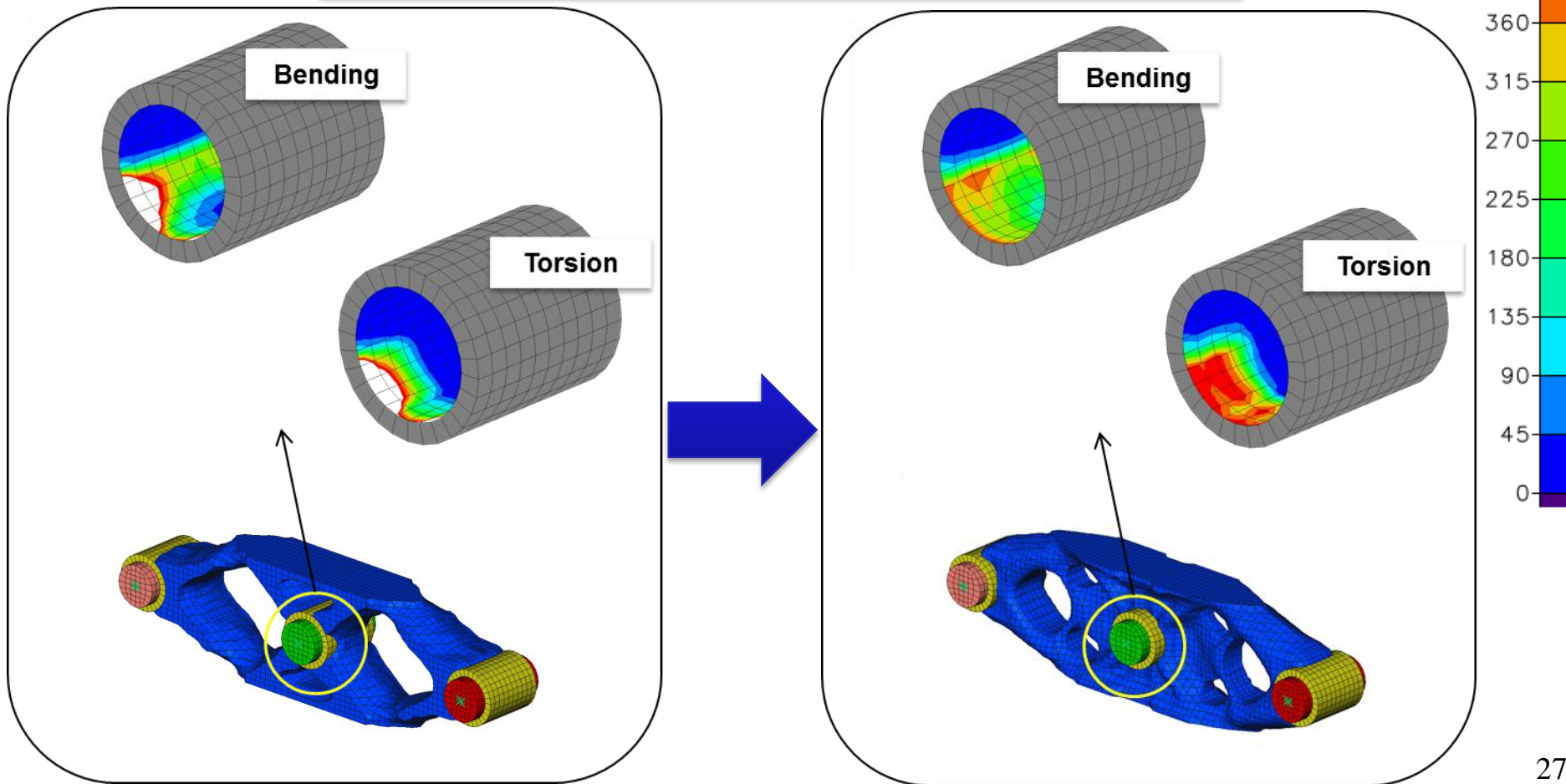


# Design Enhancements



- **Contact Based Optimisation**

## Comparison of Contact Pressure

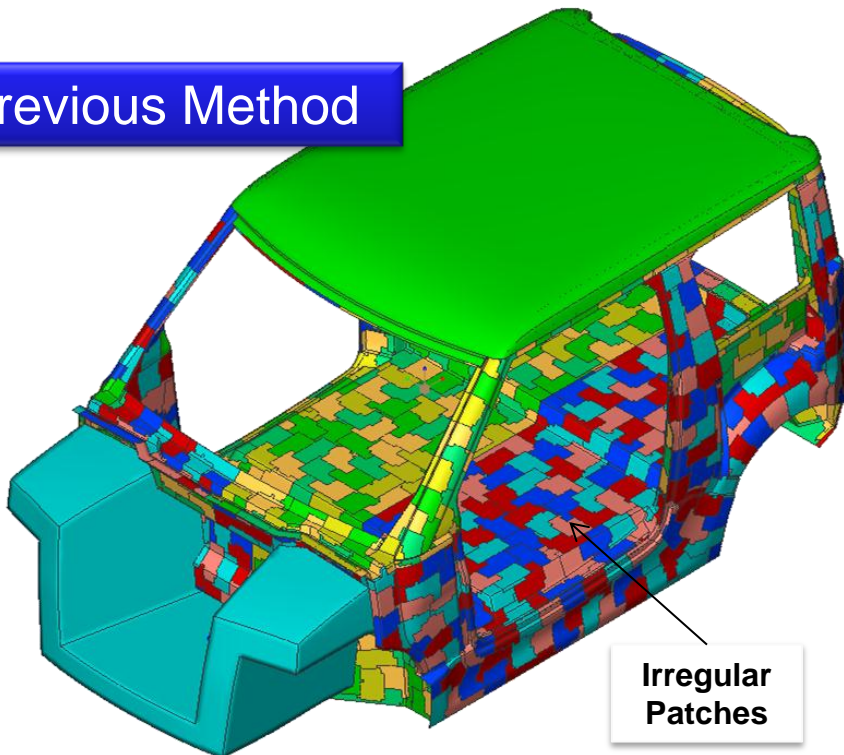


- **New Topometry Splitting Method**

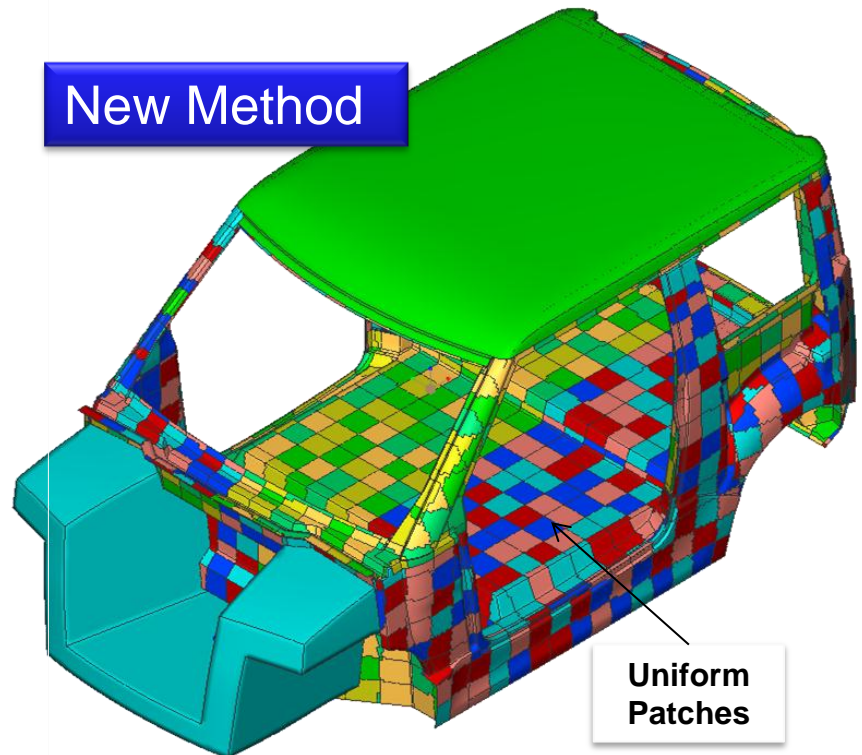
- DSPLIT Type=Length

- Provides more regular patterns, greatly simplifying interpretation of results
    - Allows larger patches to be used, whilst maintaining regular patterns

Previous Method



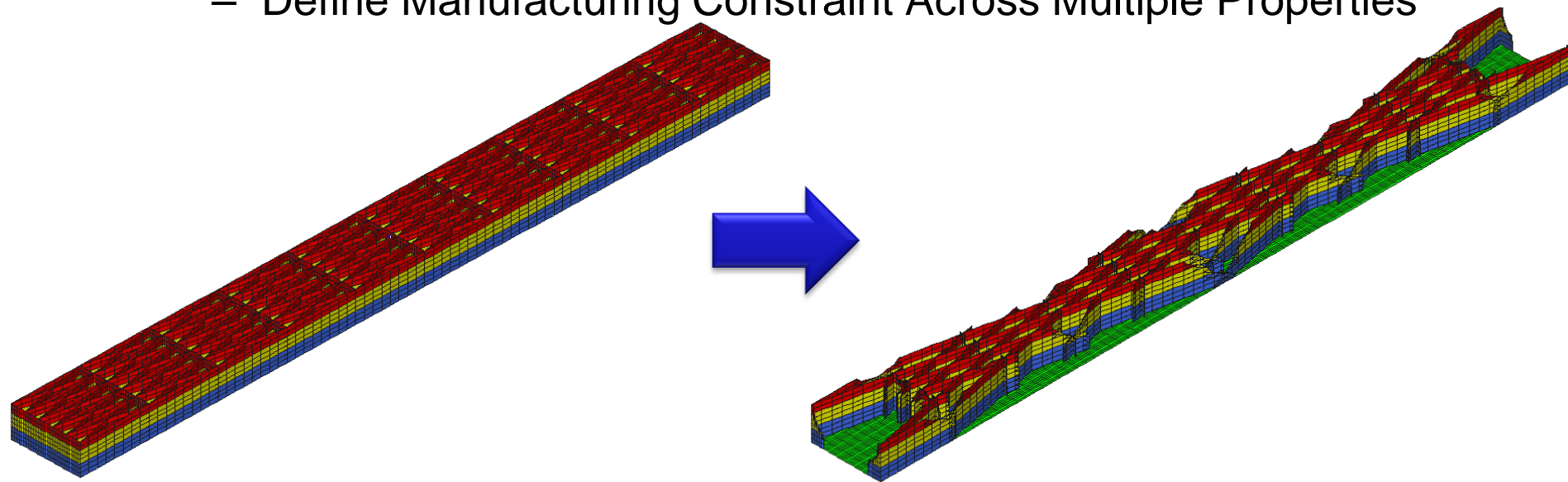
New Method



# Design Enhancements



- **Linking of Topology manufacturing constraints between properties**
  - TPROP option = PLINK
  - Define Manufacturing Constraint Across Multiple Properties



- Genesis is uniquely able to apply casting constraints to shells
- Coupled with new PLINK, ribs with draft angle can be accurately modelled and efficiently optimised

# New Design Responses

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- **Contact**

- Pressure
- Force
- Clearance displacement

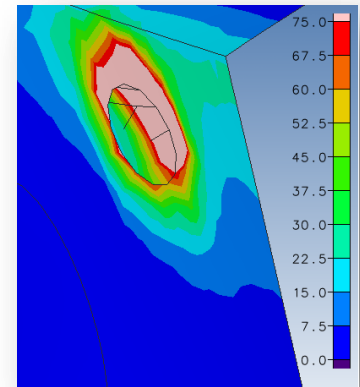
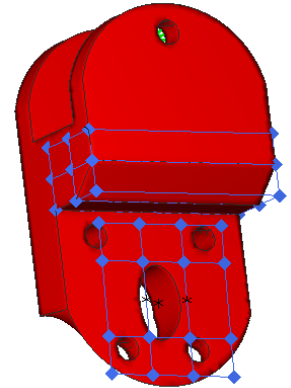
- **Composites**

- Laminate thickness (defined by property or element selection)
- Ply Thickness (absolute or as fraction of laminate)
- Ply Stress & Strain

# Interface Enhancements

- **Developments focussed on:**

- Improved usability
  - Message and checks when working through set-up trails
  - Improved model selection methods
- Improved model and results visualisation
  - Updated element visualisation
  - Improved post-processing
- Support of Genesis new features
  - All contact features
  - Analysis solver options



- Most features driven by user requests and focussed on improving day-to-day usability of analysis and optimisation environment



# Conclusions and Commentaries

- ***GENESIS* provides mature and robust technology that can be used for many applications**
- **Design Studio is a useful tool for pre and post process GENESIS data**
- **GENESIS and Design Studio are continually developed based upon:**
  - Our drive to deliver the best structural optimisation methods
  - Listening to and meeting the requests of customers
- **Key New Feature presented: Contact Analysis and Optimisation**

# Questions?

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## Thanks for Attending

More Information: [jp@vrand.com](mailto:jp@vrand.com)