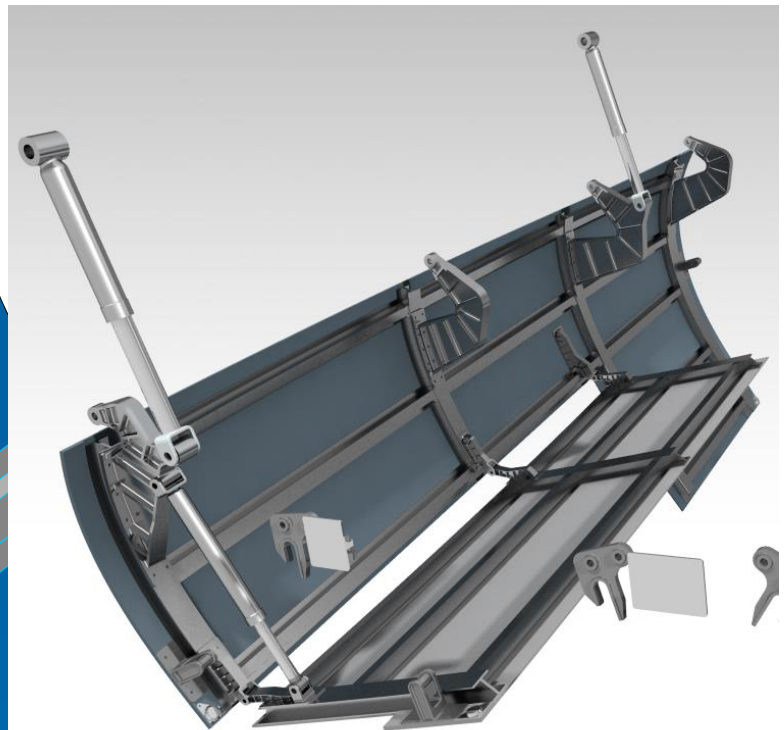
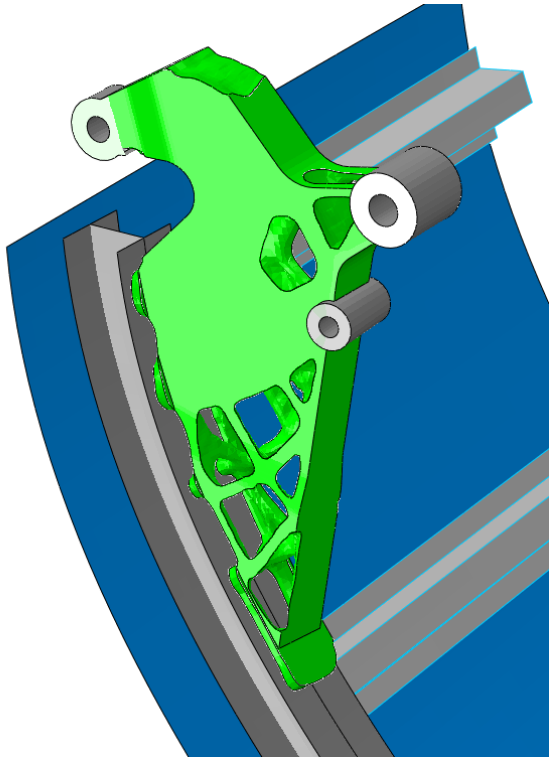


TruForm ABAQUS

Efficient Topology Optimisation for ABAQUS/Standard

White Paper



SUMMARY

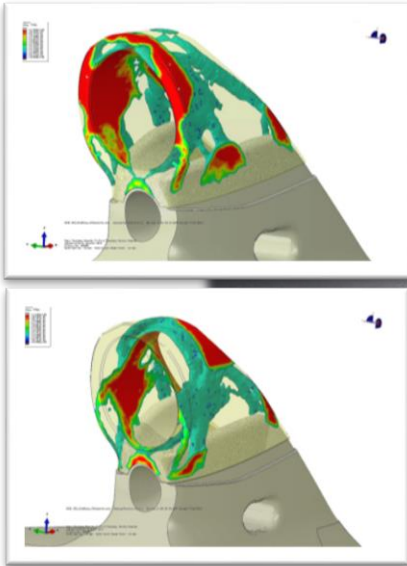
The Abaqus Unified FEA product suite offers powerful and complete solutions for both routine and sophisticated engineering problems covering a vast spectrum of industrial applications. Seamlessly integrating into the Abaqus product suite, TruForm extends the Abaqus/Standard solver with Topology Optimisation, either directly to the solver code or via the Abaqus/CAE environment. TruForm Abaqus guides engineers to develop the lightest, most cost effective structure, reducing the time spent designing and hence minimising the time to market.

TruForm v5.0 Features:

- Standalone & Embedded Abaqus/CAE interfaces
- Maximise Stiffness & Minimise Mass solver modes
- Displacement, Stress & Plastic Strain Constraints
- Multiple Manufacturing Constraint Options

Case Study – Designing a Lightweight, Principle Roll Structure for a Formula 1 Car

Forward Facing

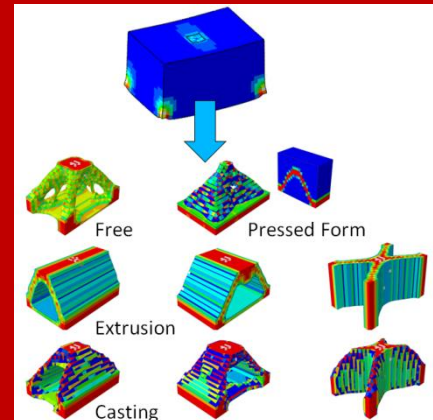


The following case study is extracted from a presentation given by Renault Sport F1 at OED2016 (www.grm-consulting.co.uk/presentation-renault)

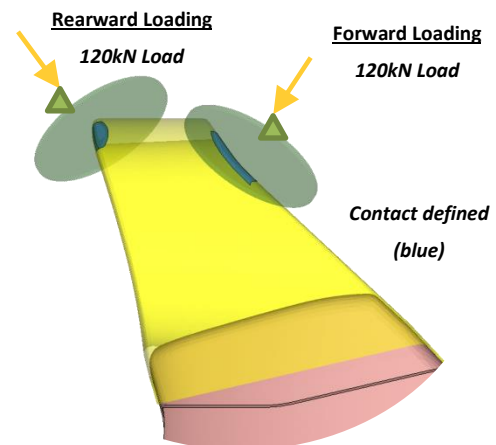
Rearward Facing

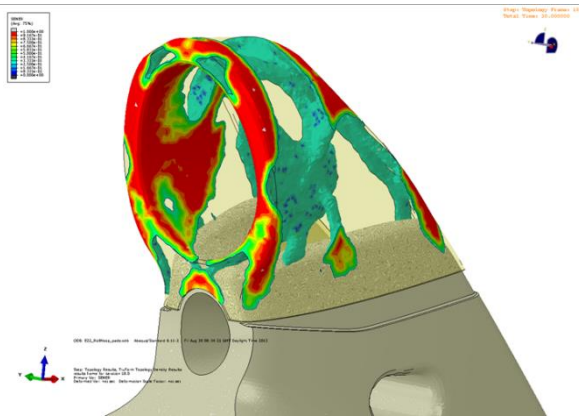
How TruForm Abaqus Works

Topology optimisation is the mathematical study that leads to the evolution of material within a design space based on defined loads and constraint sets. Working directly with the Abaqus/Standard solver, TruForm Abaqus automatically couples its efficient Topology optimisation solver to Abaqus, updating the Abaqus model and presenting the results in the .odb results file. This ultimately allows for the development of the most efficient and effective design; saving mass, cost and time without compromise on performance.



In order to develop a minimum mass design suitable for meeting the extreme demands of Formula 1, TruForm Abaqus was used to guide the design of Renault F1's roll hoop geometry. The design space for the optimisation was defined by the aero package and the bond-line to the chassis. Upon confirmation of the loading in Abaqus/Standard an optimisation was carried out in TruForm. The load and constraint set defined for the analysis were selected for the optimisation and, in order to meet the FIA regulations, the objective was set to minimise

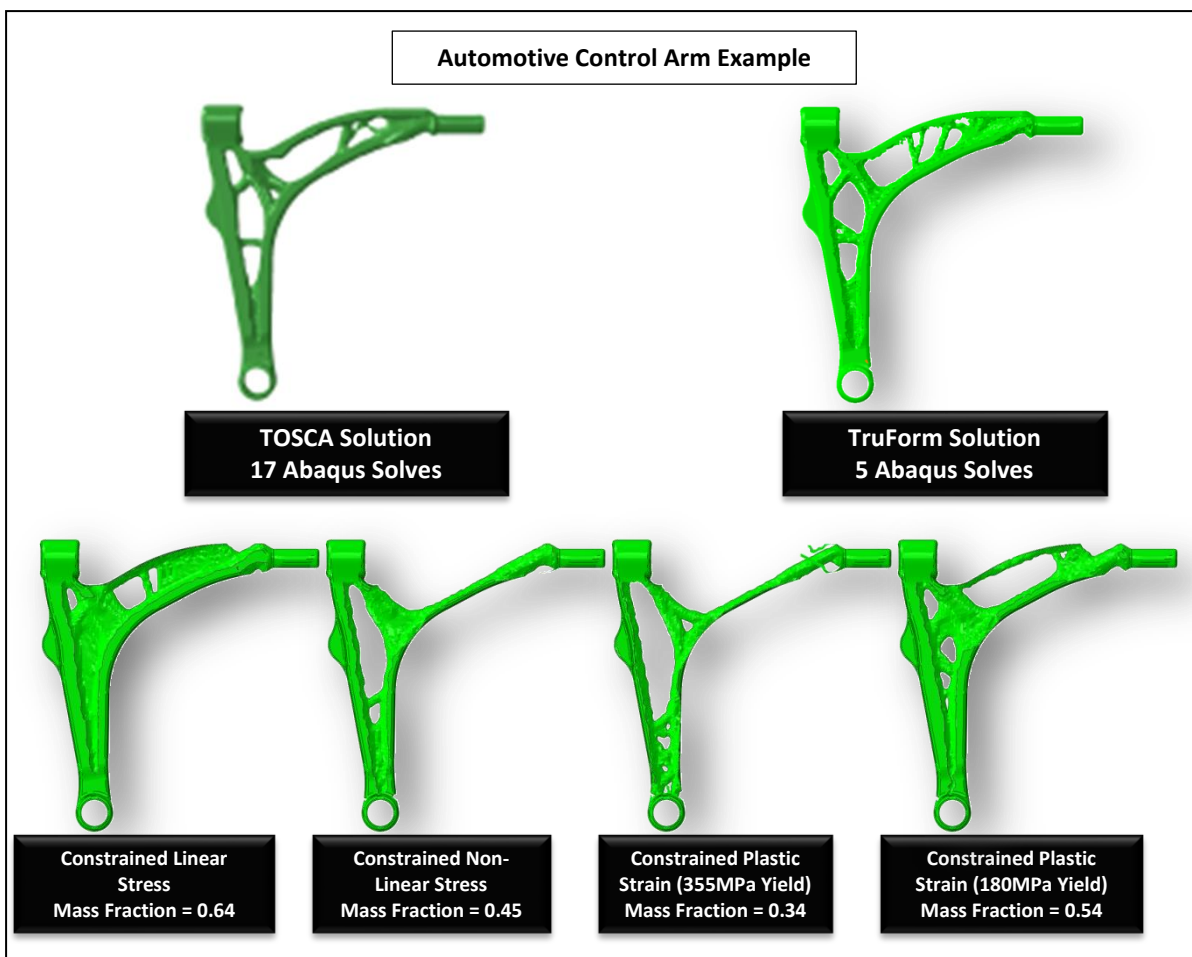




mass, while limiting plastic strain to less than 3%. The results of this optimisation for the combined loading are shown on the left. These results were then used to guide the engineering team towards the most efficient use of material, minimising weight and reducing the amount of time spent developing a solution. The final design was verified in Abaqus/Standard and ultimately cast in Titanium and featured on Renault's 2016 Formula 1 racing car.

EFFICIENT TOPOLOGY SOLUTION

Because of the clever way that TruForm works, using an efficient internal solver (GENESIS) in the background, it significantly reduces the number of required Abaqus iterations, keeping solution time to a minimum. Typically 5-8 Abaqus solves are required to converge on a solution compared to the built-in Tosca solution which typically takes 15-25 Abaqus solves per optimisation.

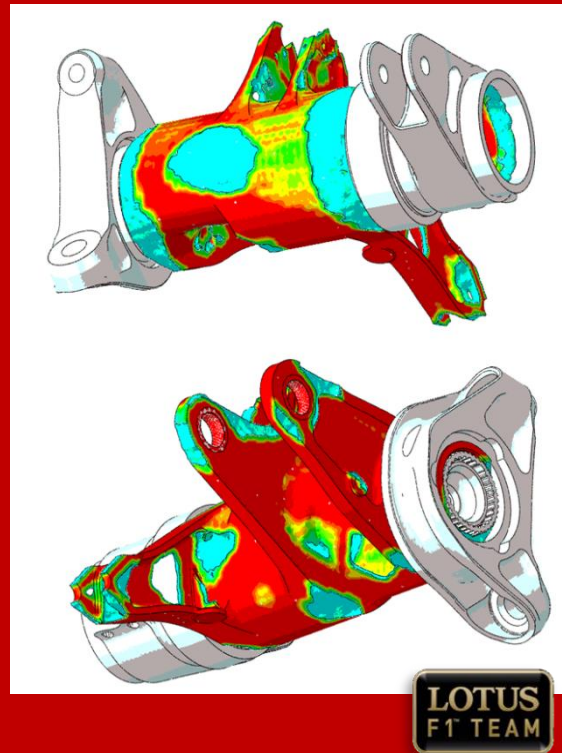


Case Study Examples

TruForm Abaqus enables seamless topology optimisation for Abaqus/Standard users as it can read .inp files built in any pre-processor. TruForm Abaqus can be used for a variety of applications including automotive, aerospace and motorsport giving a typical part mass saving of 30%, and up to 50%. The Lotus F1 rocker on the right was developed using TruForm optimisation results, delivering weight, time and cost savings.

Using TruForm Abaqus

Since TruForm is integrated into the Abaqus environment, it is simply an extension of the simulation process. Optimisation can take part at the user's preferred stage. This can be an optimisation as a final part of the design, or the 'Right First Time' approach can be taken on a given design space. TruForm Abaqus can also be used to resolve design strength and stiffness issues through the ongoing development of a part.



BENEFITS OF USING TRUFORM ABAQUS

- Mass reduction within a design can:
 - Reduce - maintenance, production and running costs.
 - Improve - efficiency, effective use of material and environmental friendliness.
- Minimise time to market.
- Enable the development of creative and revolutionary designs.
- Topology results can be exported as XML data which can be used for design interpretation.

TRUFORM ABAQUS FEATURES

- Simple and easy to use single form set-up interface
- Intuitive optimisation problem definition
- Target Mass and/or targeted performance solver modes
- Multiple manufacturing constraints, including casting, extrusion & sheet metal
- Topology Results stored directly in Abaqus .odb results file