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Driving Multidisciplinary Optimization Using ANSA - End User Case Studies

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Overview

- **Optimization - early days and current status**
- **ANSA key enablers - what made the projects succeed**
- **Case studies - highlighting key enablers**
- **Current & future projects- where it is going**

Optimization

Past

- Component based morphing for what-if studies
- Lack of advanced supporting software functionality
- Limitation of computing capability
- Slow overall process
- Discouraging for the engineers due to above reasons

Present

- Full fledged morphing for multidisciplinary optimization
- 100’s of design variables
- Advanced computing capability
- Advanced software functionality
- Quick turnaround time
- Adopted by many automotive engineers in all phases of product design

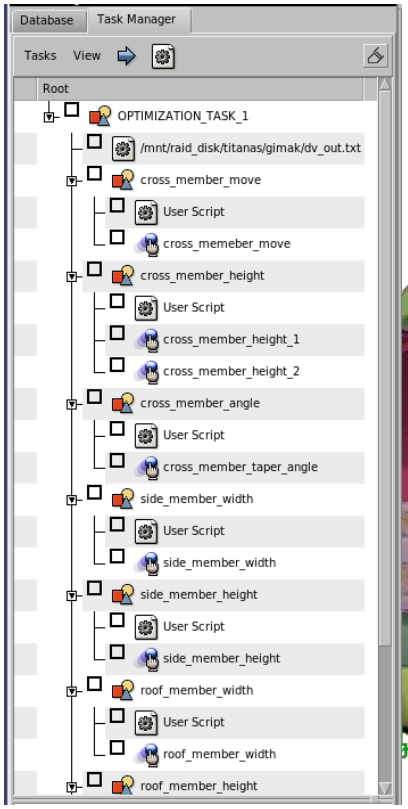
ANSA - Key enablers for supporting optimization

- Efficient re-shaping of both FE and/or Geometry based models
- Precise control over dimension changes
- Maintaining integrity of a variety of different weld types
- Re-welding, adding/removing welds based on new dimensions
- Maintaining smooth mesh on morphed surfaces for external aerodynamic applications
- Automated mesh and model quality checks and fixes
- Support for user scripts to perform additional actions
- Full model build-up capability in an integrated environment

ANSA - Key enablers for supporting optimization

- Ability to build different discipline models from same base model
- Ability to create library of complete meshed models for DOE studies
- Automated tasks to perform morphing and final FE model building
- Robust process for performing DOE's and optimization studies
- Batch mode for driving the model variants using the "design variable" ASCII file interface
- Easy interface for coupling this process with commercial optimization software
- Writing reports about the weight, welds, dimension changes, etc.

Parameterizing parts of a BIW using separate morphing box groups



Use cases from

Body CAE

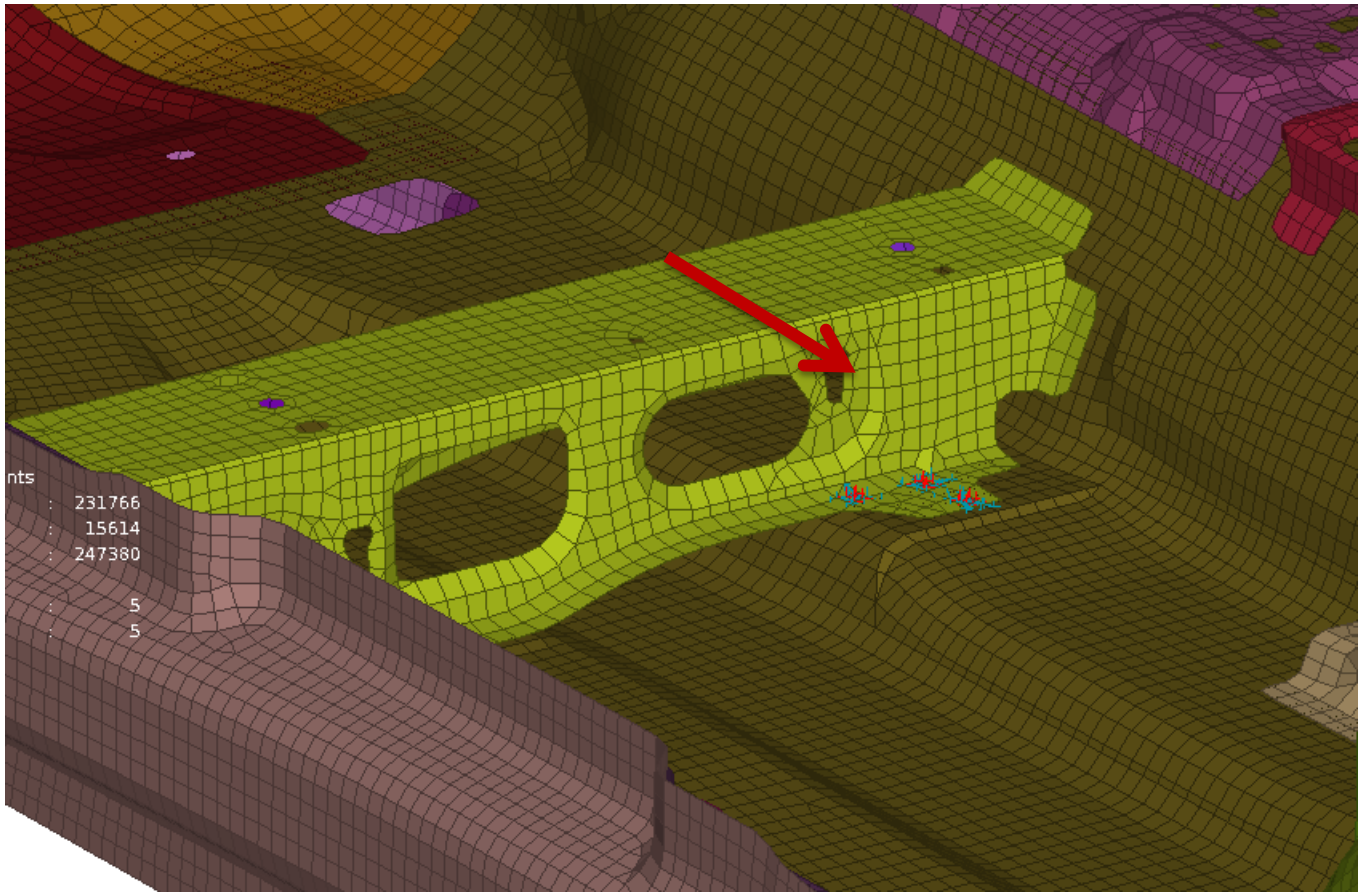
Truck Safety

Basic Design

Key Enablers

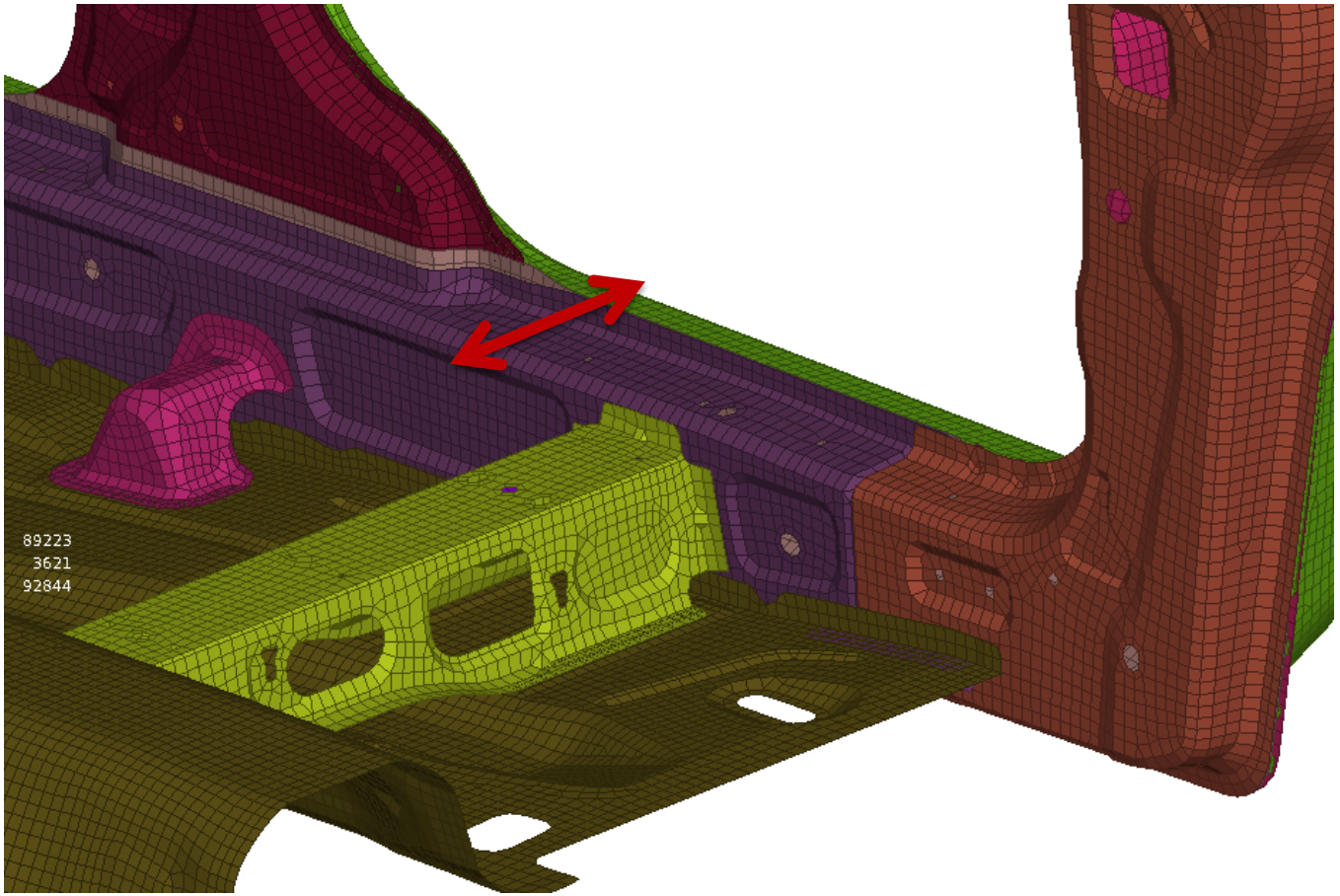
- Domain based morphing

Ford Motor Company: MDO - Body CAE



Ford Motor Company: MDO - Body CAE

Transition zone for absorbing change by adjacent parts



Use cases from

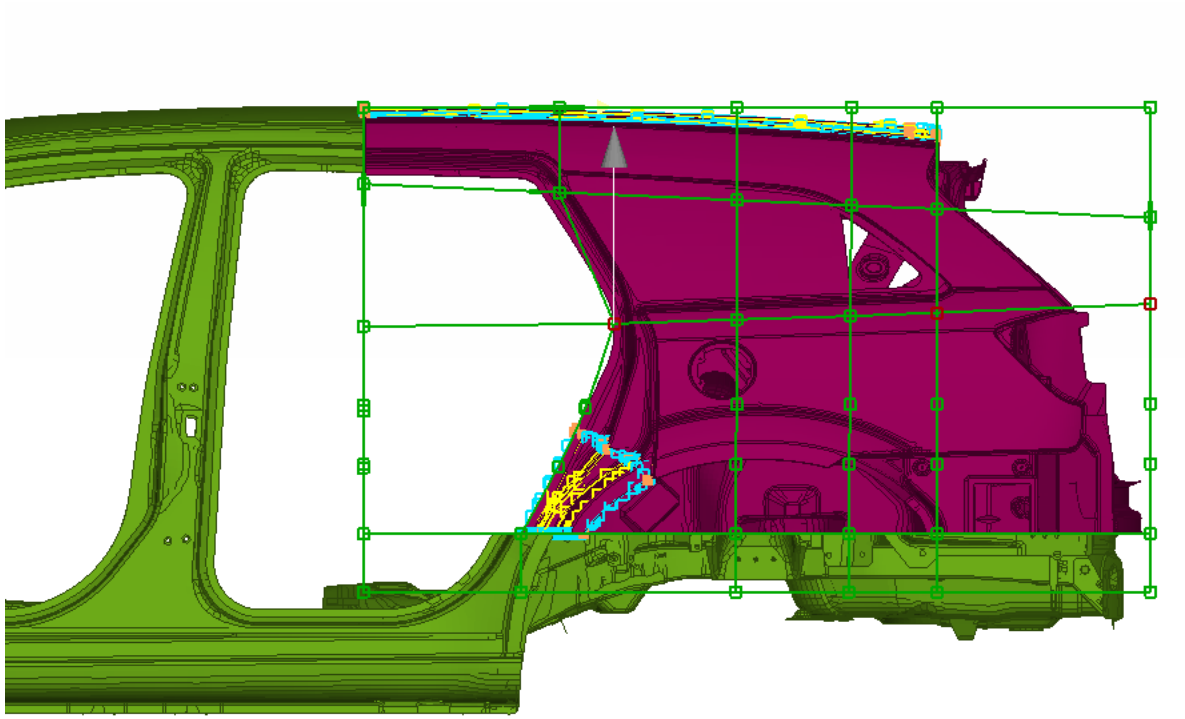
Concept designs application

Key Enablers

- Domain based morphing for new concept cross-over designs

Chrysler: Creating a concept cross-over model

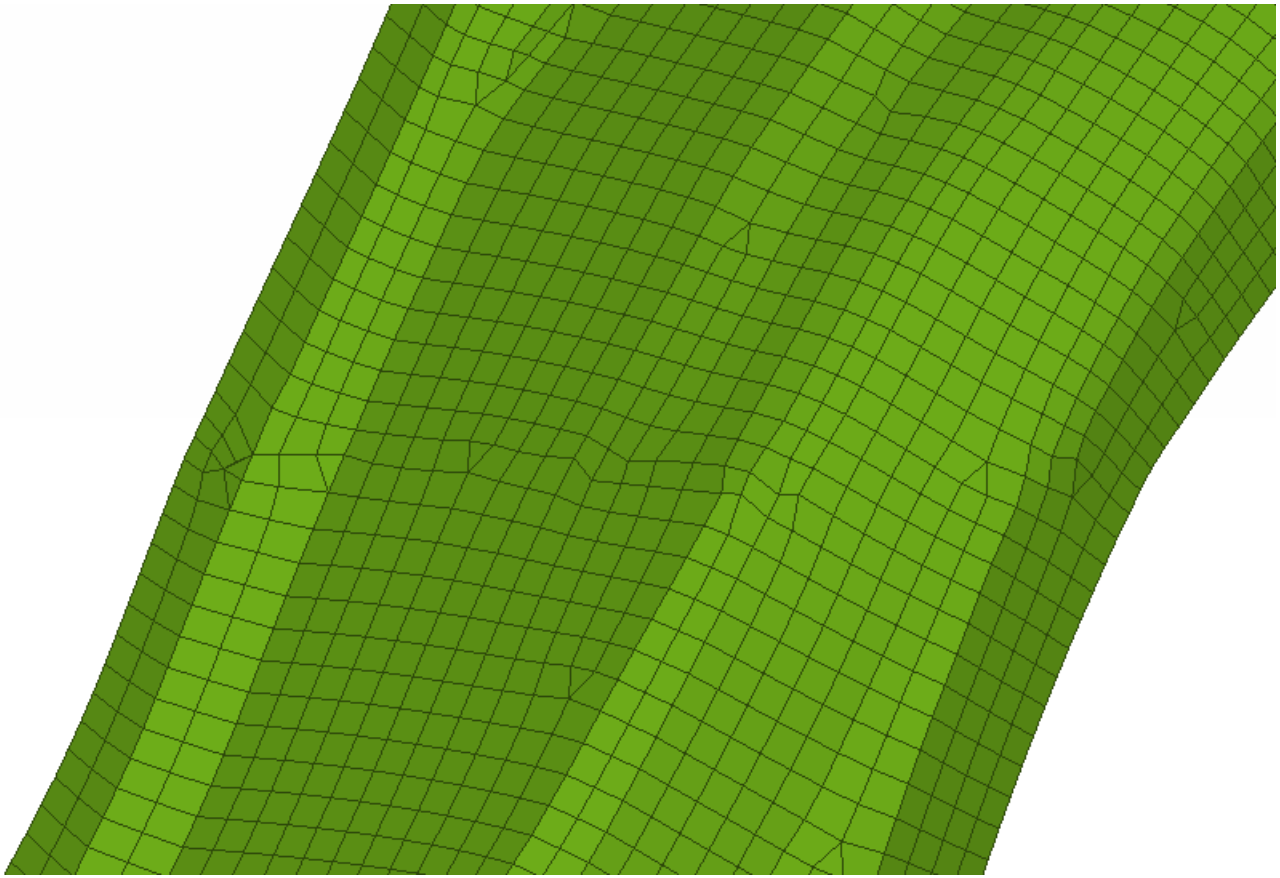
Proportions morphing to bring the models close



Chrysler: Creating a concept cross-over model

Fitting cross sections

Pasting FE Models and applying reconstruct



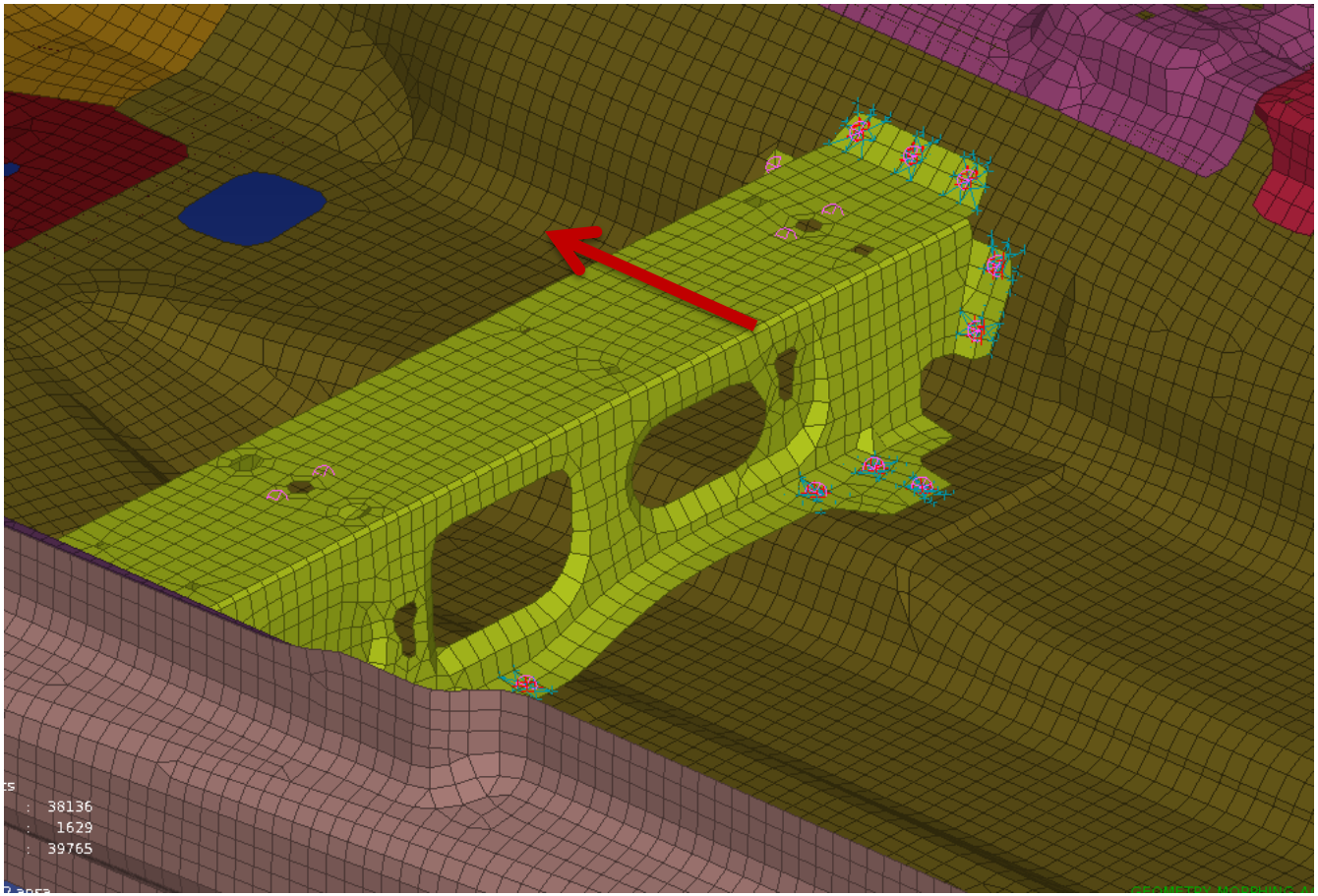
Use cases from

Body CAE applications

Key Enablers

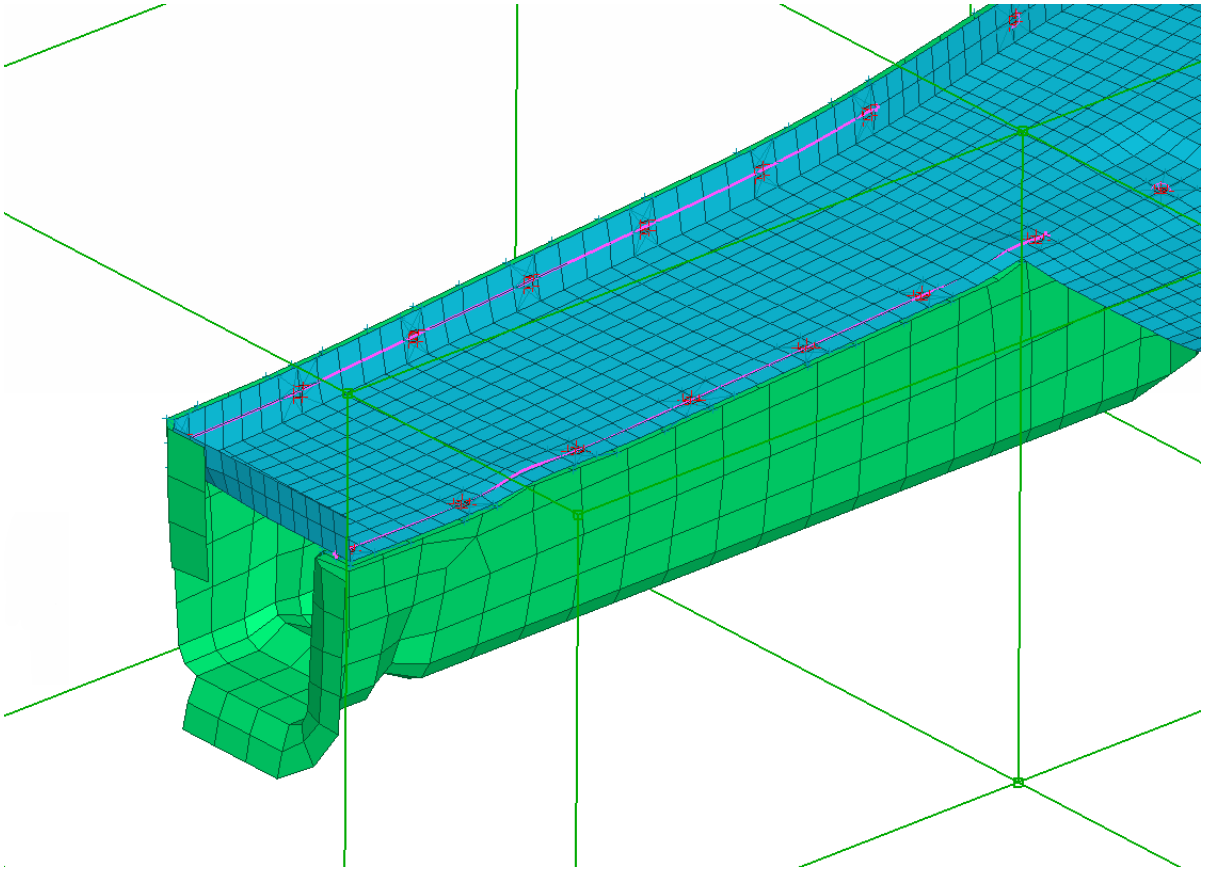
- Automated assembly tool

Ford Motor Company: Body CAE - Considerations for weld modeling while morphing



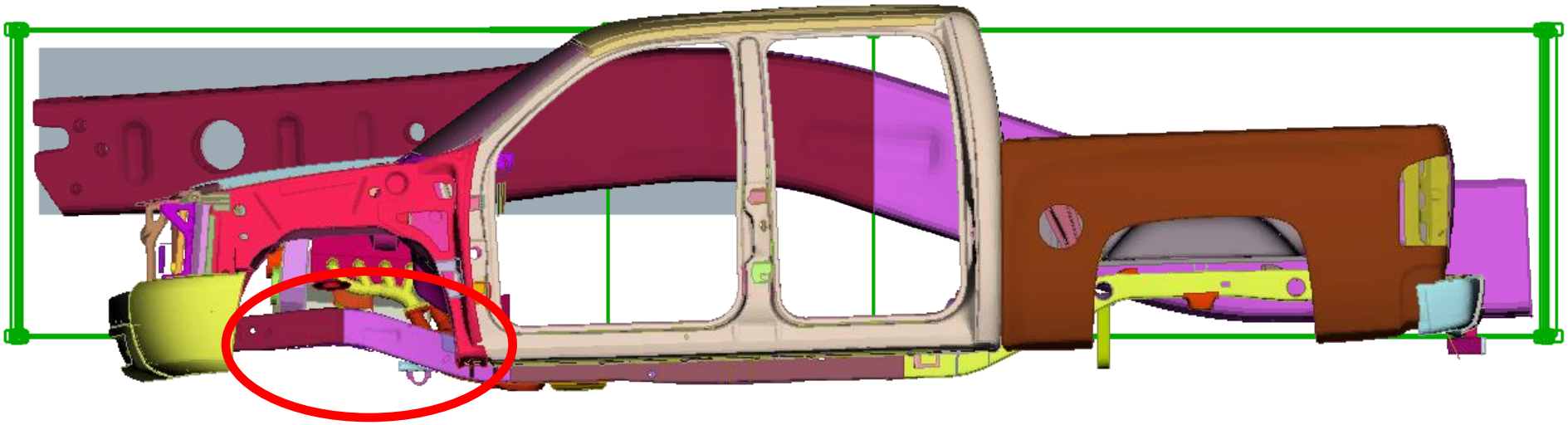
Ford Motor Company: Body CAE - Weld modeling while morphing

Connection lines and FE representations follow shape modification
FE representations re-applied to fix spotweld distance modification



Ford Motor Company: Body CAE – Tailor-welded-blanks weld modeling

Tailor welded blanks weld location is controlled as a design variable through morph parameter



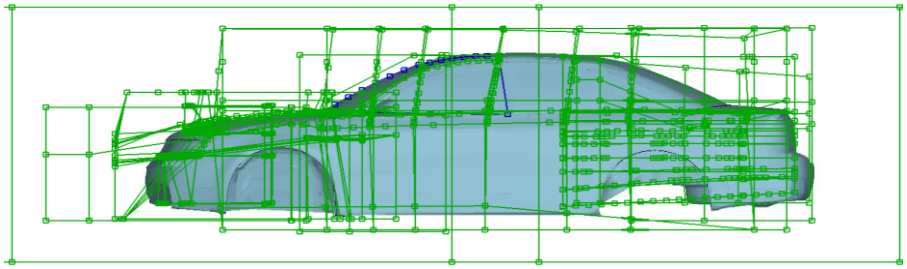
Use cases from

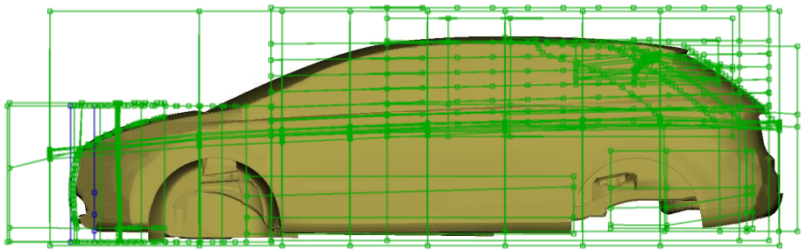
External aerodynamic applications

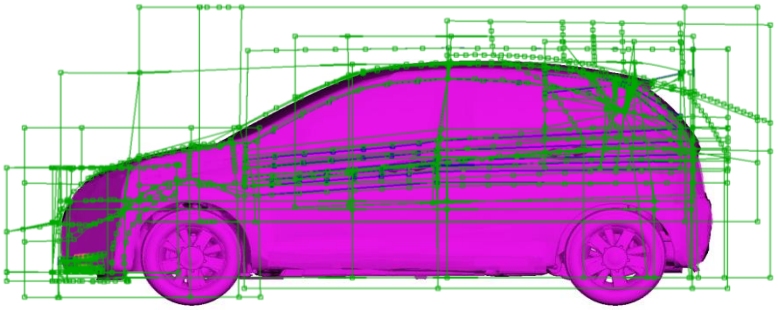
Key Enablers

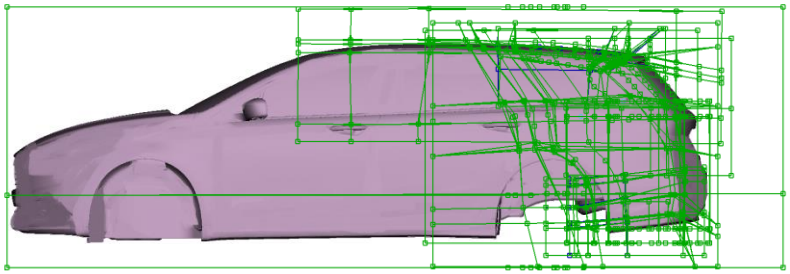
- Smooth surface morphing

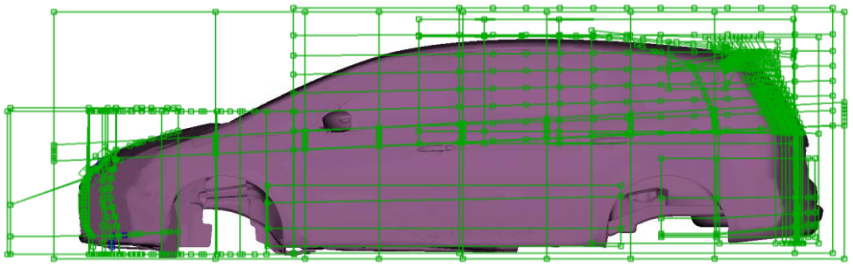
Ford Motor Company: External aerodynamics

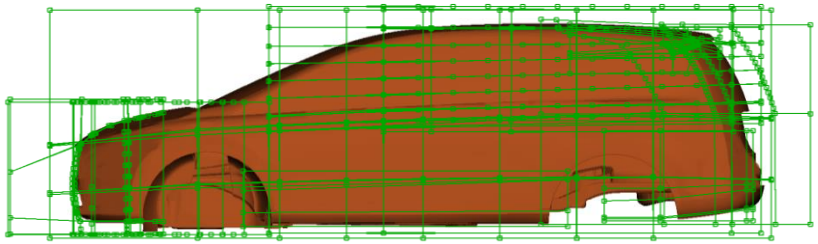




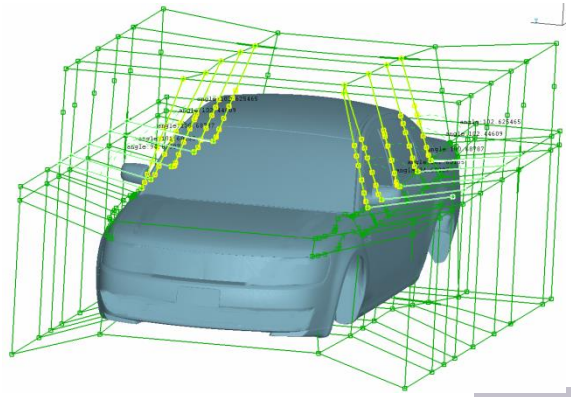




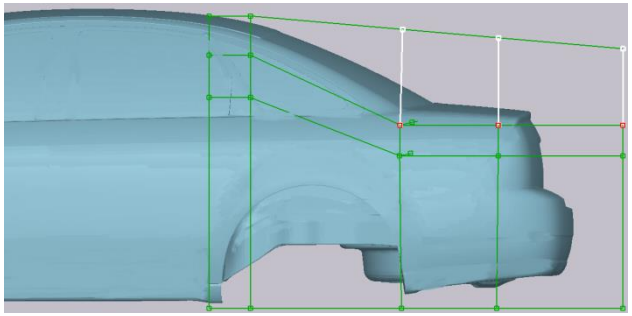




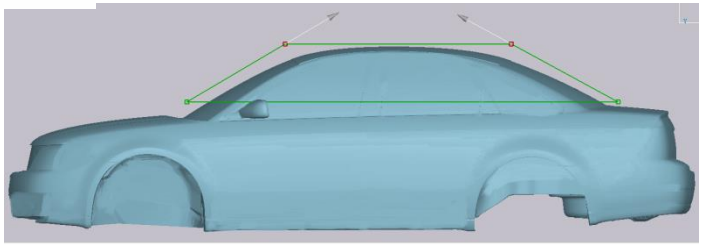
Ford Motor Company: External aerodynamics



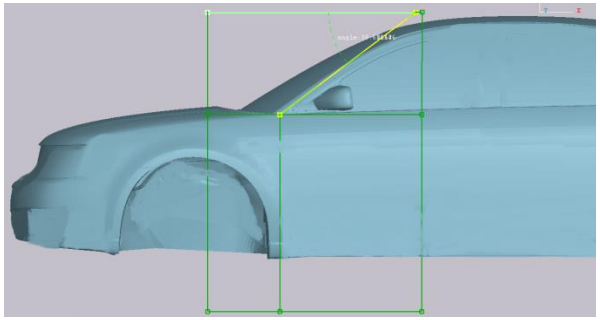
Tumble home



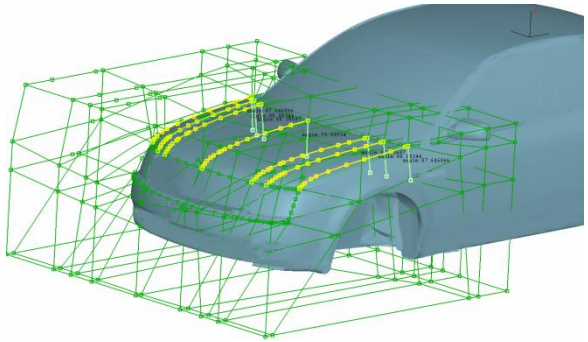
Decklid height



Roof height

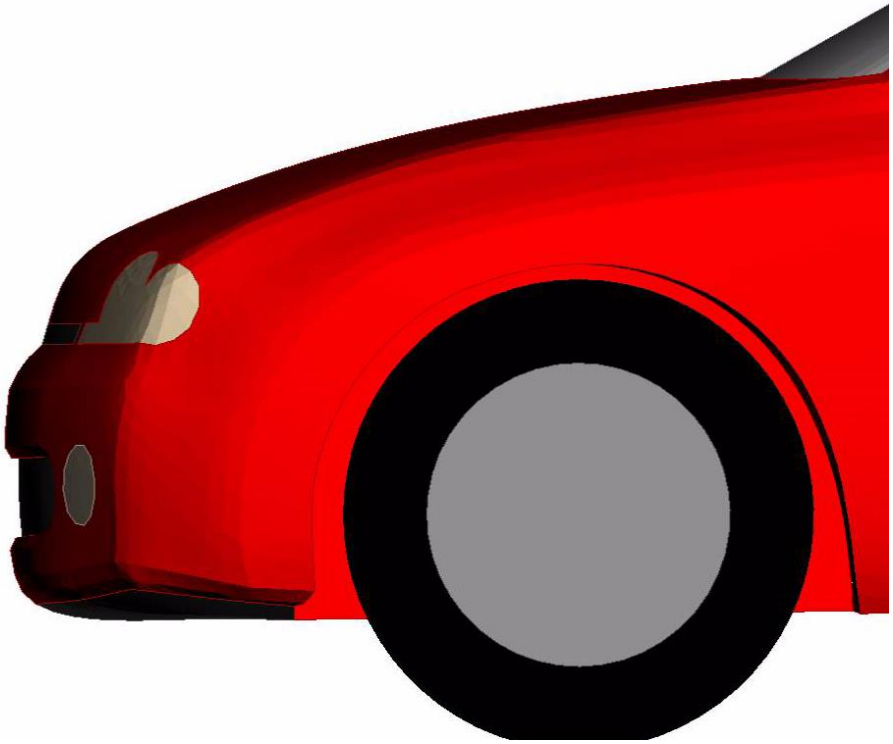


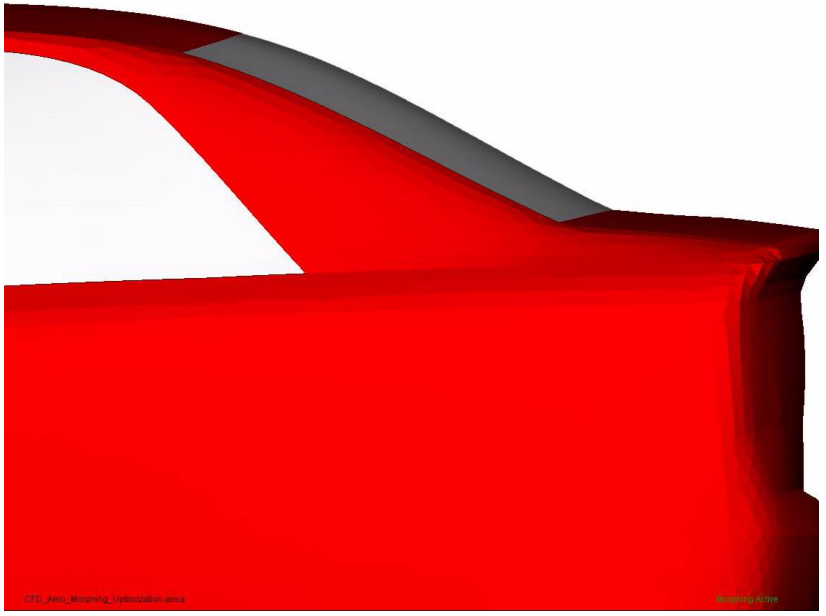
Windshield angle



Hood angle

Ford Motor Company: External aerodynamics





Aerodynamic shape optimization

Use cases from

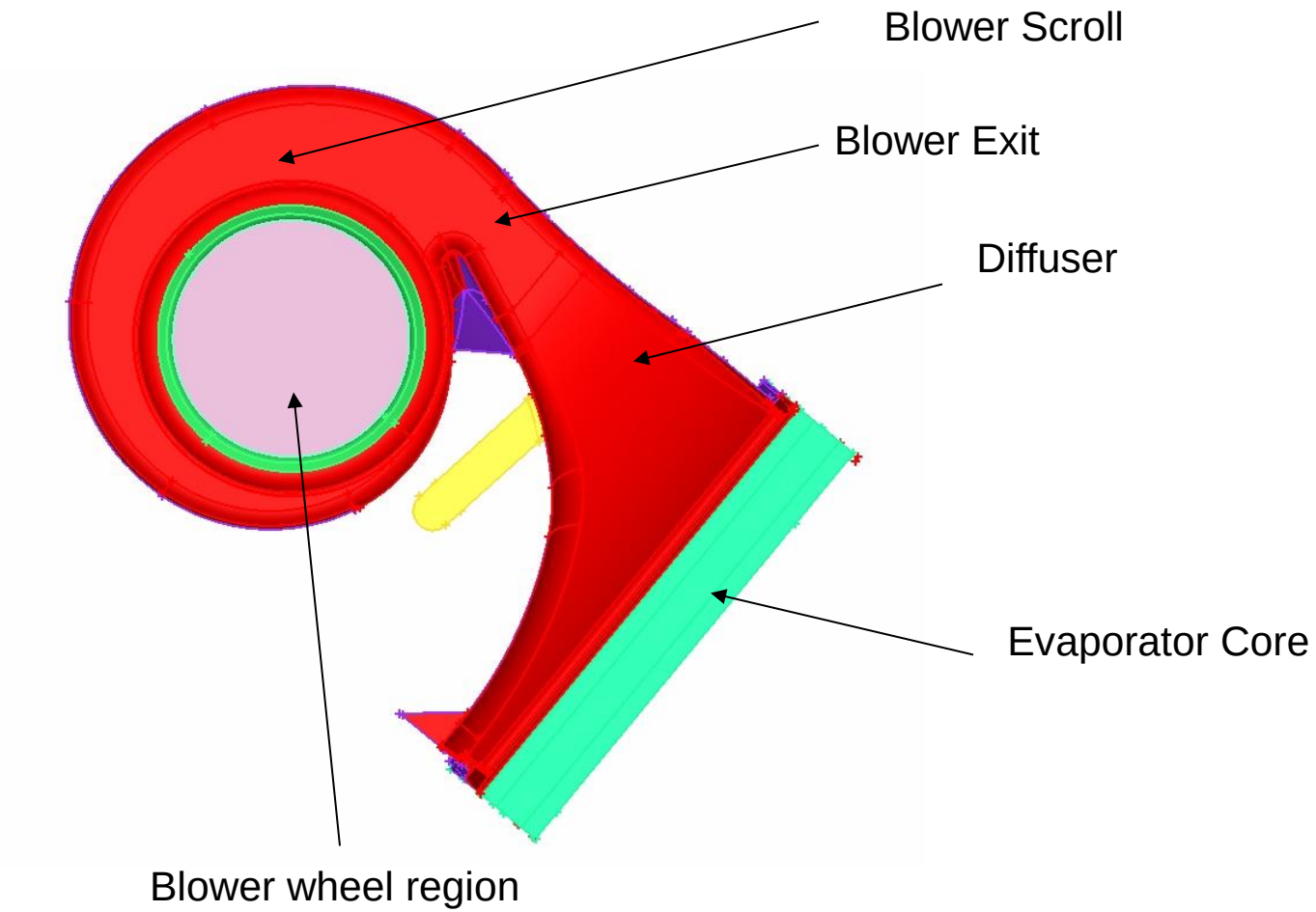
Climate control applications

Key Enablers

- Smooth surface morphing
- Shape change driven by mathematical function

ACH: Heat exchanger vane shape optimization

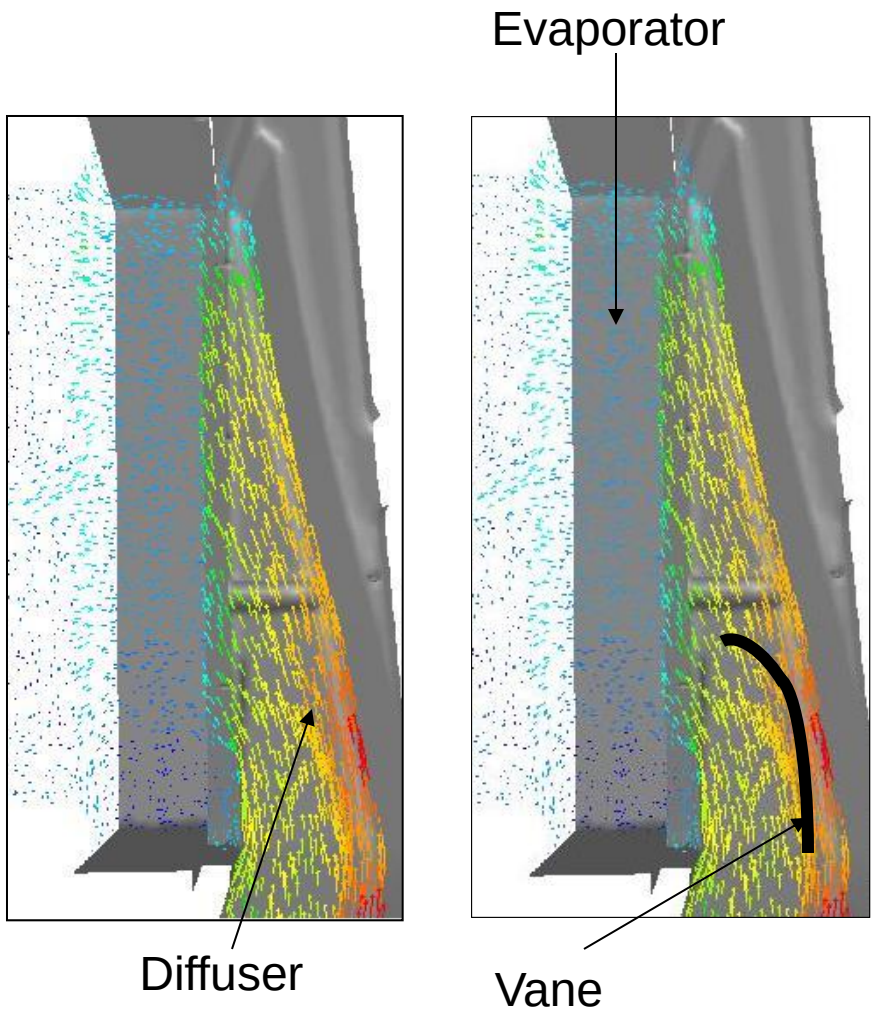
HVAC Diffuser Schematic



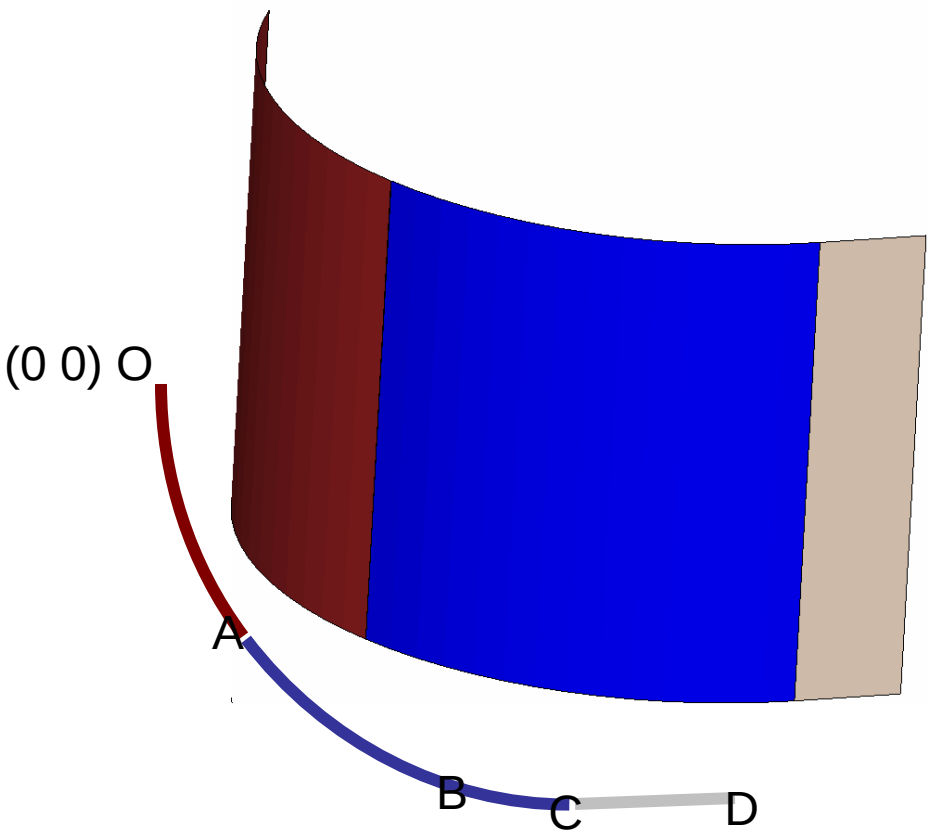
ACH: Heat exchanger vane shape optimization

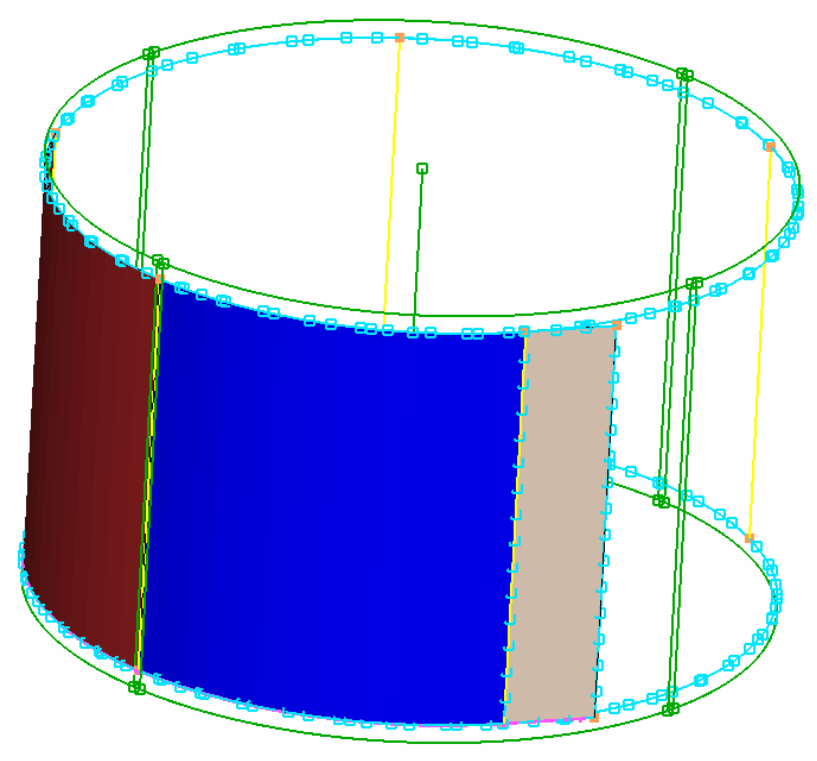
Objectives:

- To present an effective way to control flow in an automotive diffuser using guide “vanes”
- To develop a method to optimize the location and shape of a vane to:
  - Maximize Pressure Recovery
  - Maximize Evaporator Coverage

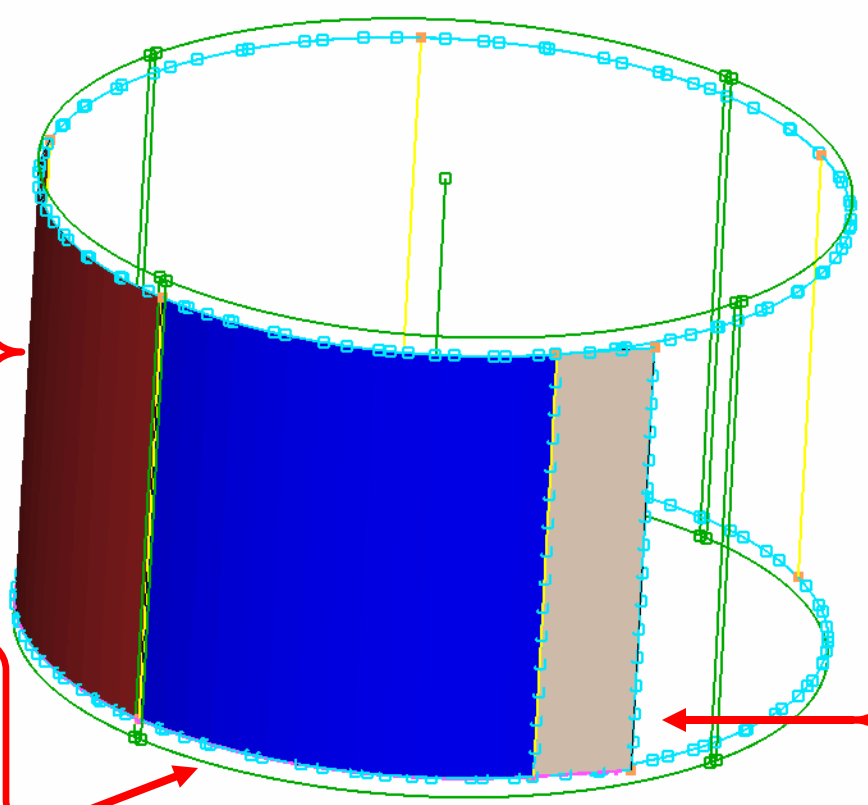


ANSA Parametric Base Model





ANSA Parametric Base Model



First segment

- Change radius
- Translate
- Change arc length

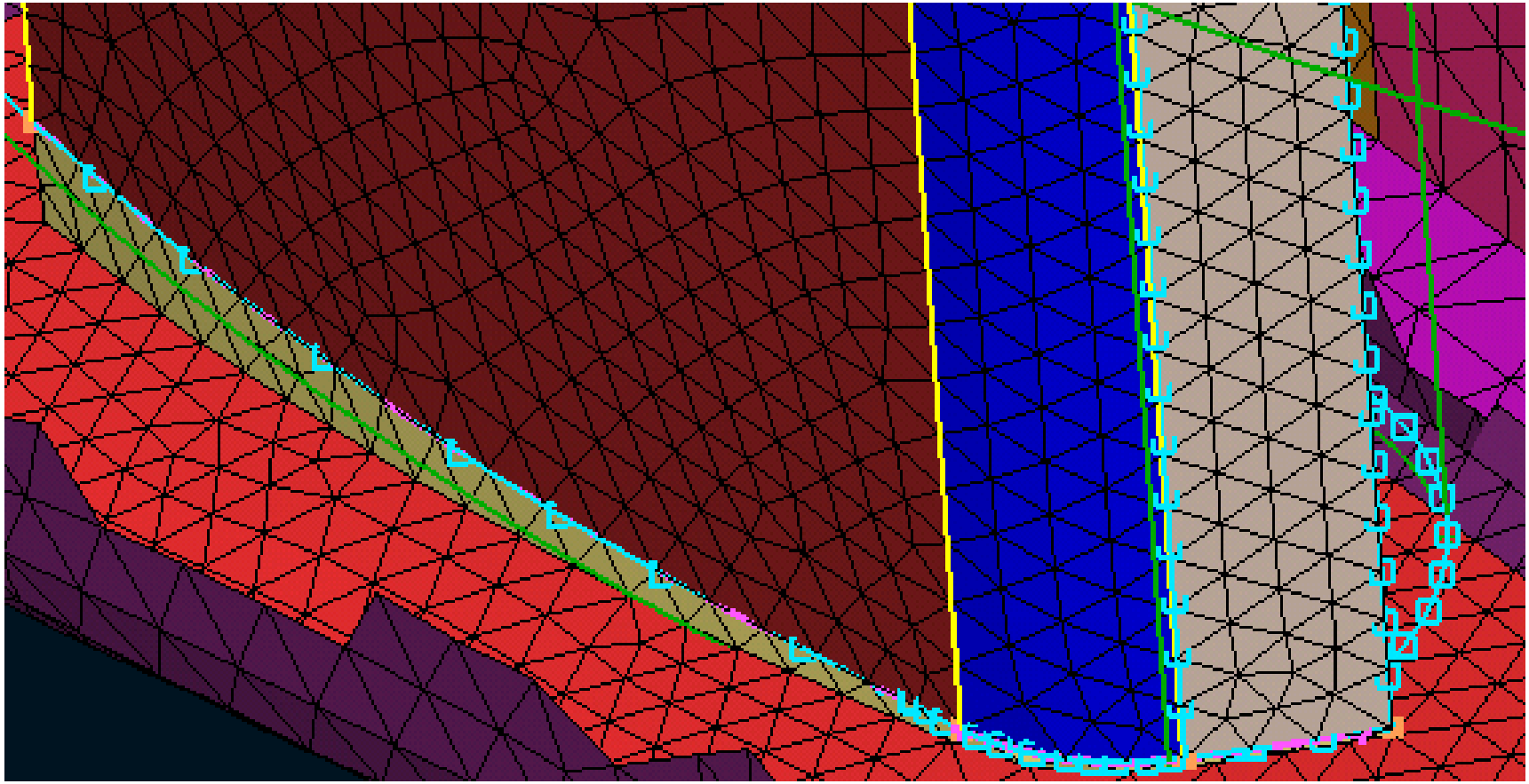
Second segment

- Change radius
- Rotate
- Translate
- Change arc length

Linear segment

- Translate
- Rotate
- Change length

Connecting morphed vanes to the base



All three vane segments are morphed, re-meshed, connected to each other and the diffuser surface in their final shape

Use cases from

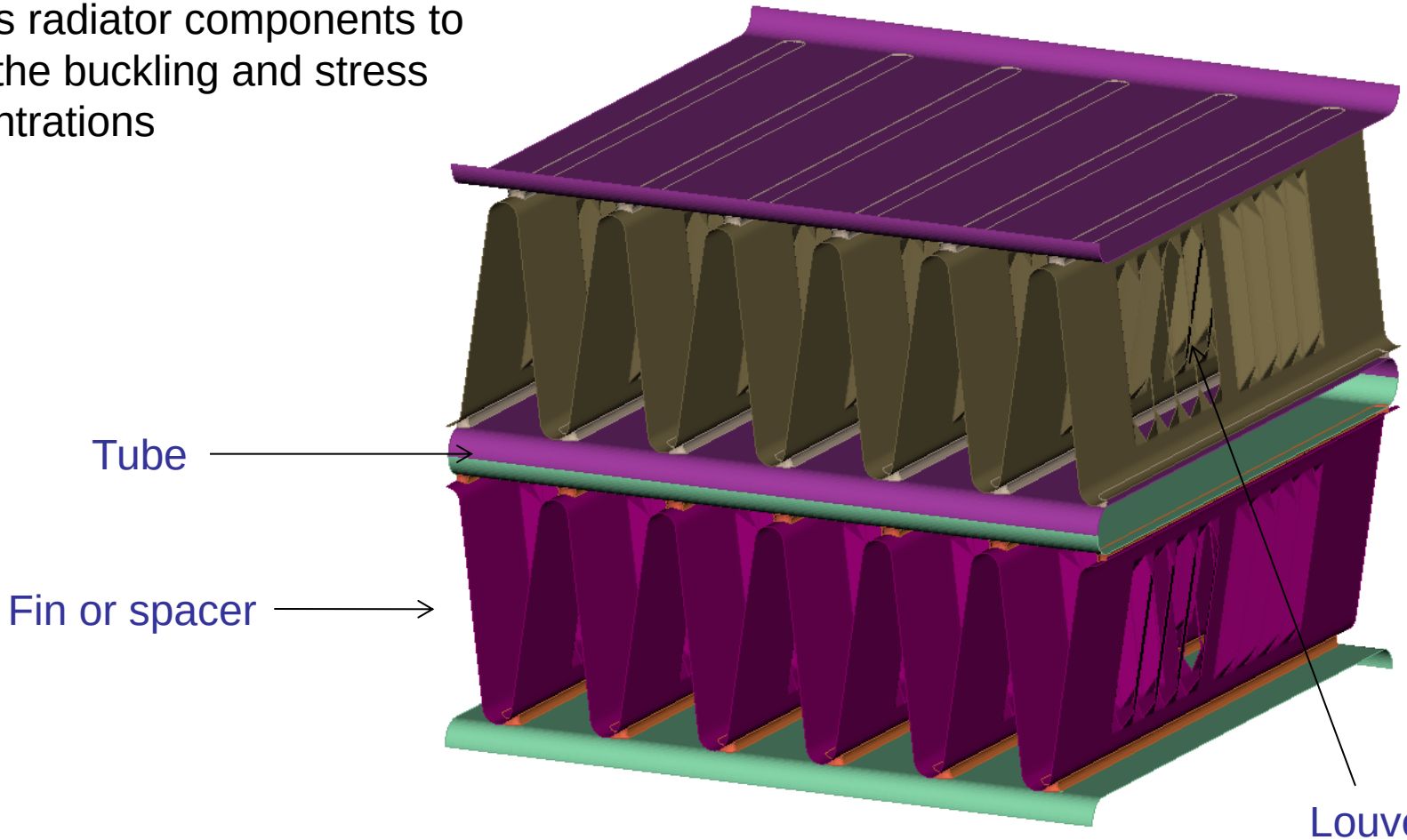
Powertrain installations applications

Key Enablers

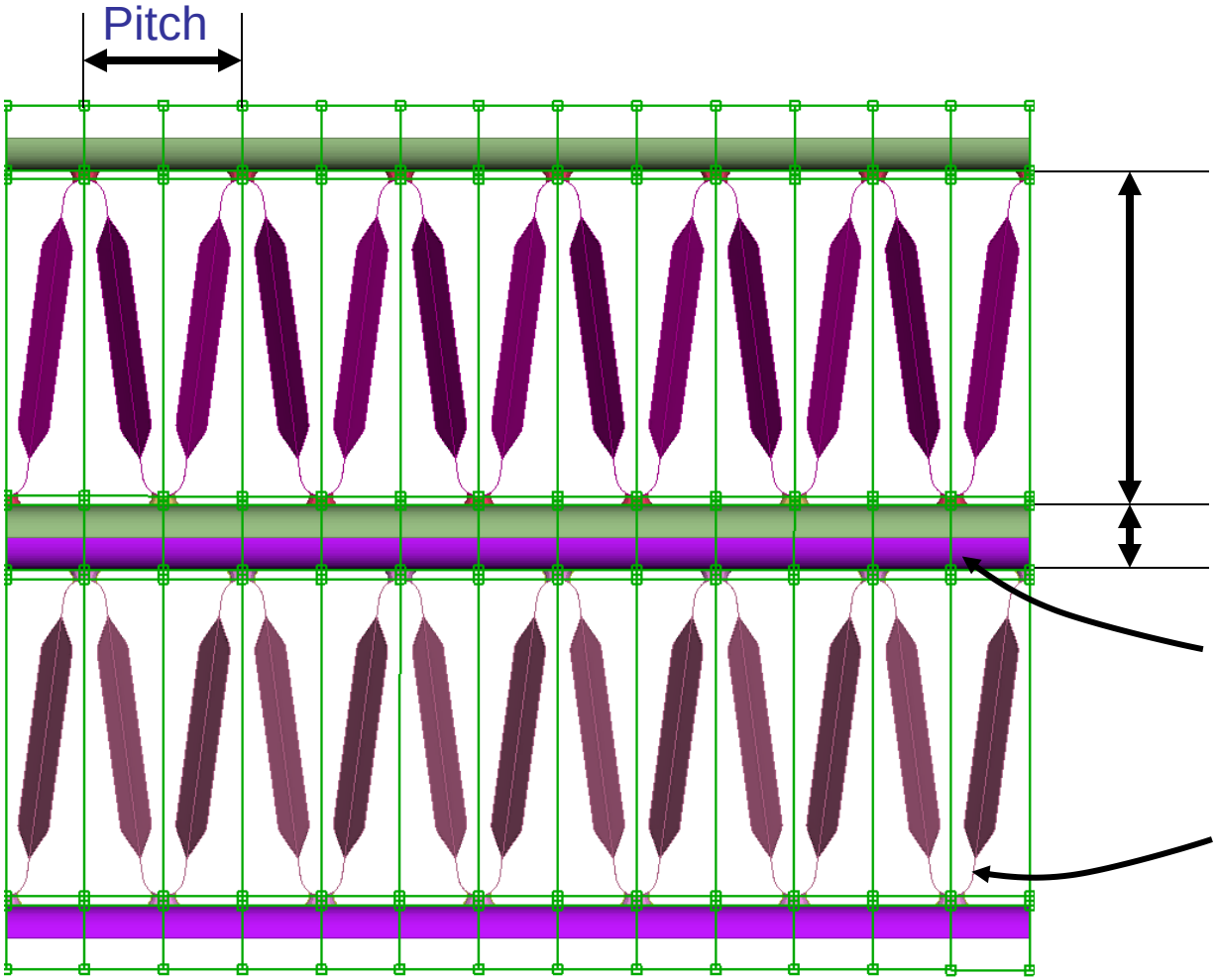
- Modular based input of discrete design variables
- Functionality to support extracting desired post-processing results
- Direct integration with META Post processor
- Coupling with commercial optimization software

Radiator Shape Optimization

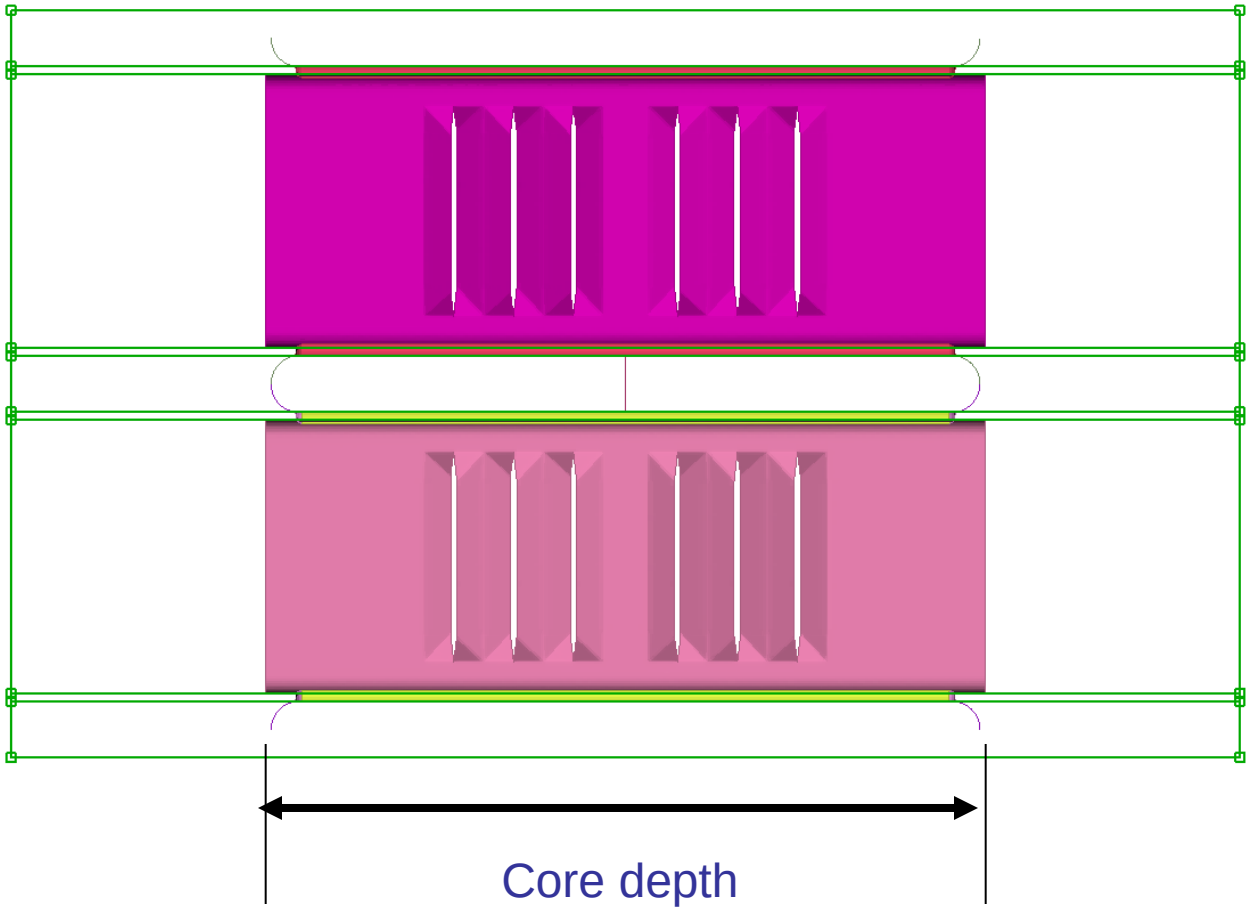
Objectives: Optimizing shape of various radiator components to avoid the buckling and stress concentrations



Continuous design variables



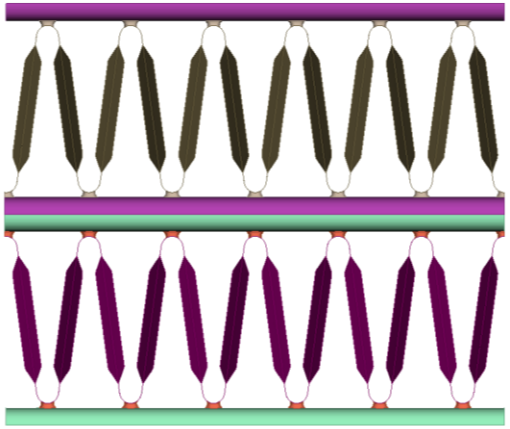
Continuous design variables



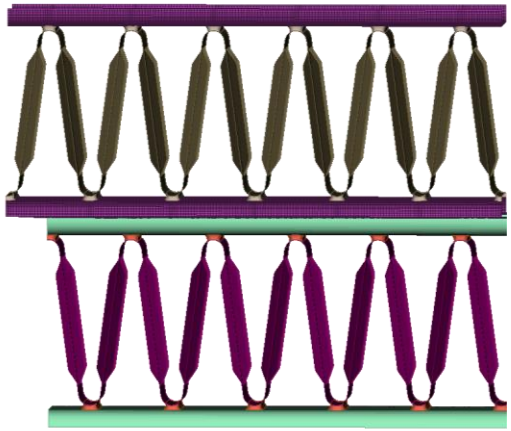
Discrete design variables

Configuration

Head-to-head

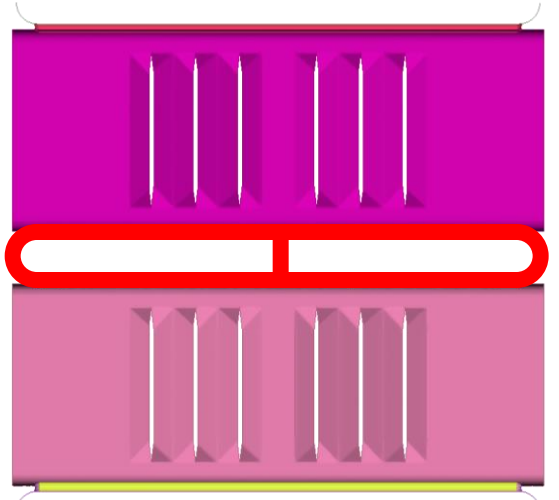


Shifted



Louvers

Yes Tube



Double tube

No

Single tube

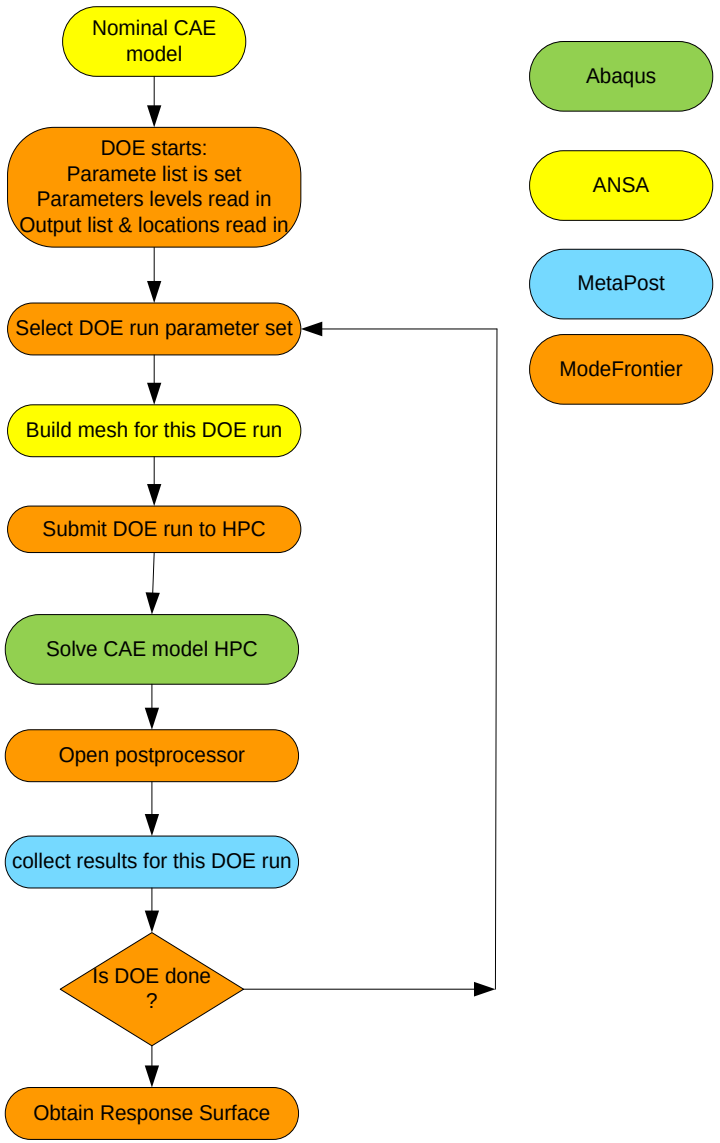
DOE Work flow

First the base model with morphing setup is prepared in ANSA

Then, the DOE workflow is created and run in ModeFrontier.

ModeFrontier coordinates the automatic execution of all the stages and the data transfer and execution of all the steps.

Obviously, each step is implemented and proved-out independently ahead of time.



Use cases from

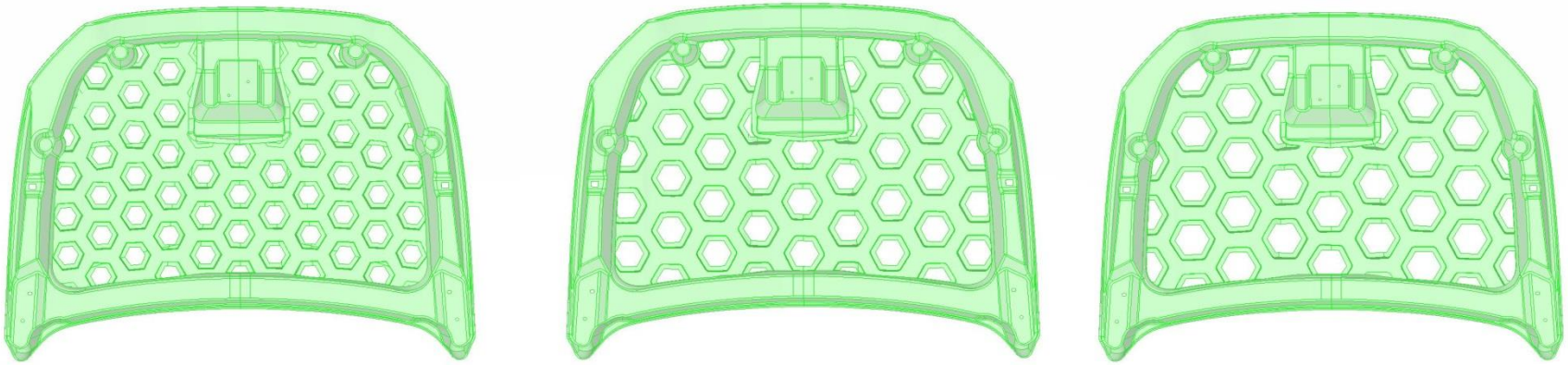
Closures applications

Key Enablers

- Integrated environment for multidisciplinary optimization
- Geometry morphing

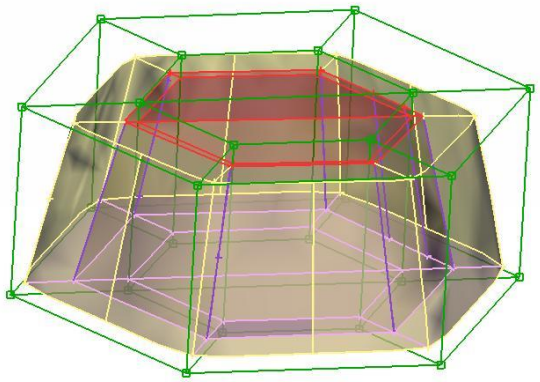
Ford Motor Company: Hood optimization – Closures

Automated process for generating multiple Hood Inner designs



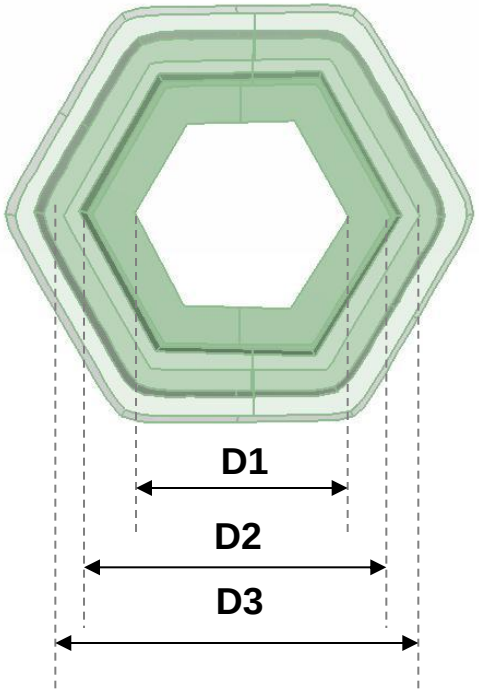
The design variable was to control the size and spread of the honeycomb pattern by its diameter and pitch.

Ford Motor Company: Hood optimization – Closures



Morphing- Controlling Model Shape

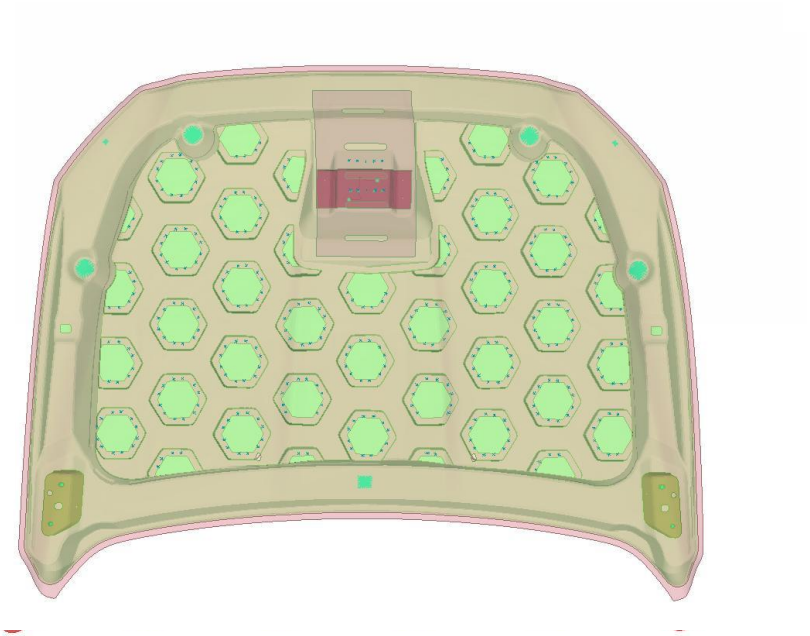
A base honeycomb geometry structure is used as a template which is morphed to a new size as per the input.



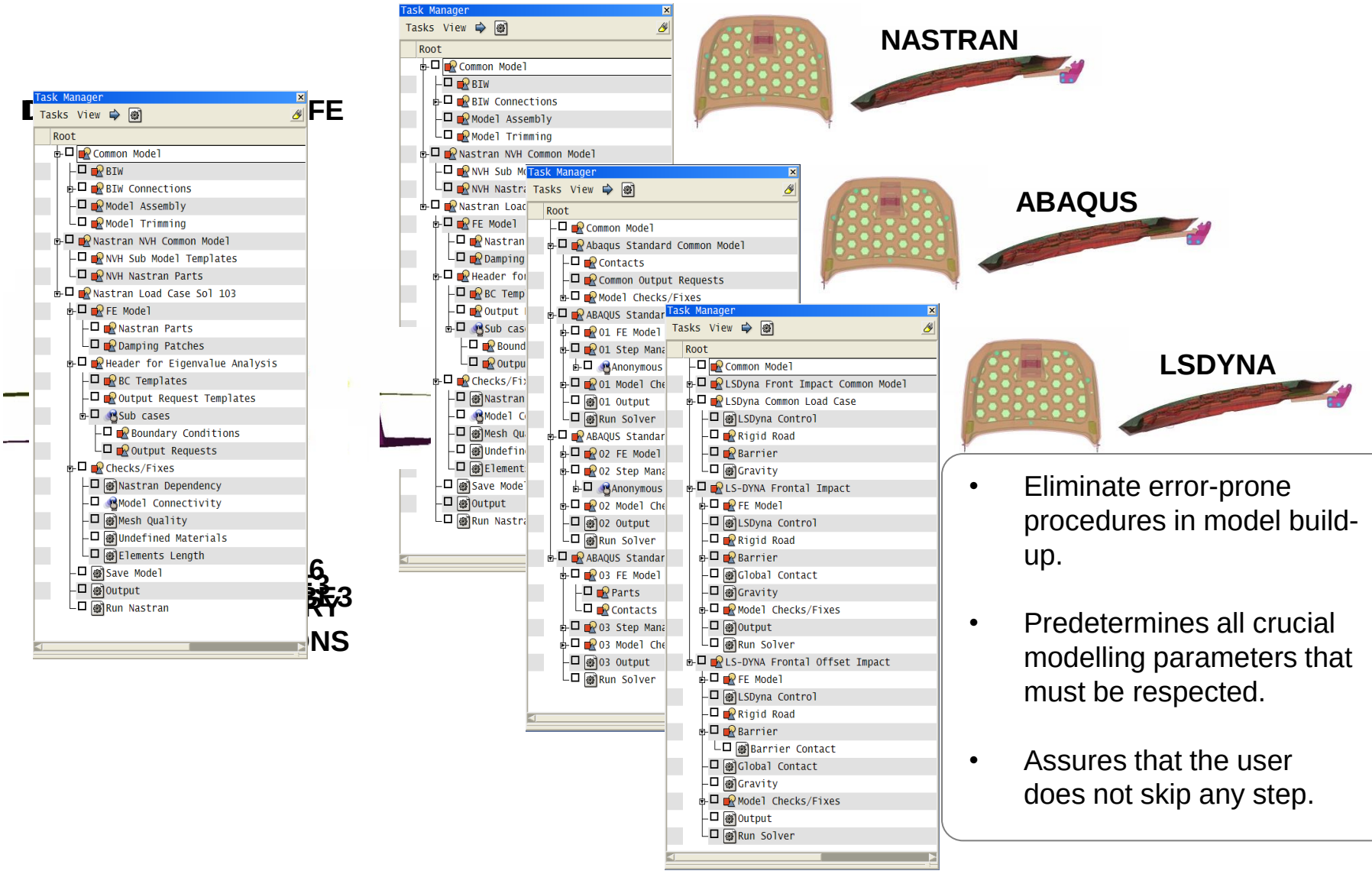
Ford Motor Company: Hood optimization – Closures

Scripting- Automation and Customization

```
def main()
{
        //This function creates the honeycomb pattern based on the pitch(p) and angle(a) inputted by the user
        //*****************************************************************************************************
        //pitch = UserInput("SPECIFY PITCH", p);
        p=200;
        n=p;
        nc=p;
        //angle = UserInput("SPECIFY ANGLE", a);
        a=30;
        rad = DegToRad(a);
        opp = (Sin(rad)*p);
        adj = (Cos(rad)*p);
        //Print(adj);
        adj1 = 0;
        c1 = (660/adj);
        c2 = Atoi(c1);
    clmns= c2+1;
        //Print(clmns);
        // calculating the z-displacment for the slope
        //teta= DegToRad(17);
        rows = Atoi(400/p);
        r=rows;
        pattern[0] = GetPartFromModuleId("101");
        //pattern = CollectEntities(NASTRAN,pat,"FACE",0);
        nearestnode[0] = GetEntity( NASTRAN, "PSHELL", 9998);
        point1[1]= GetEntity( NASTRAN, "POINT", 1);
        point2[2]= GetEntity( NASTRAN, "POINT", 2);
        point3[3]= GetEntity( NASTRAN, "POINT", 3);
        GetEntityCardValues(NASTRAN, point1[1], "X", ix1, "Y", iy1,"Z",iz1);
        GetEntityCardValues(NASTRAN, point2[2], "X", ix2, "Y", iy2,"Z",iz2);
        GetEntityCardValues(NASTRAN, point3[3], "X", ix3, "Y", iy3,"Z",iz3);
        // collecting the 1st vectors of origin points for GeoTransform
        ivx1= (Atof(ix2)-Atof(ix1));
        ivy1= (Atof(iy2)-Atof(iy1));
```



Task Manager – Automated tool for building Multi Disciplinary models



- Eliminate error-prone procedures in model build-up.
- Predetermines all crucial modelling parameters that must be respected.
- Assures that the user does not skip any step.

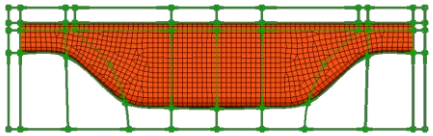
Optimization process template

Optimization task

Key Enablers

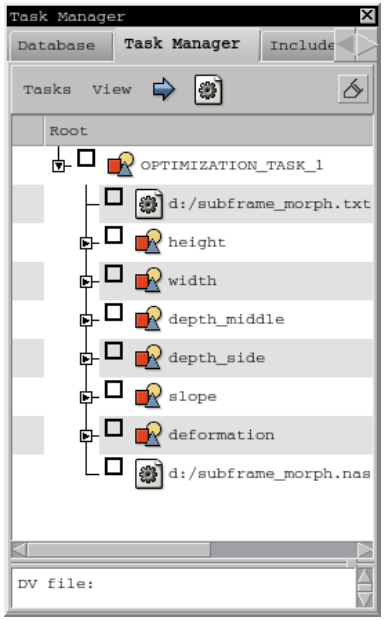
- Automated process

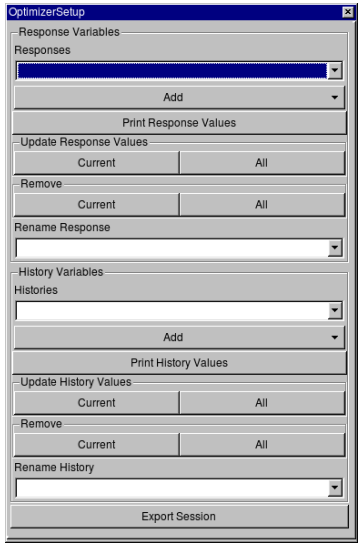
Optimization loop



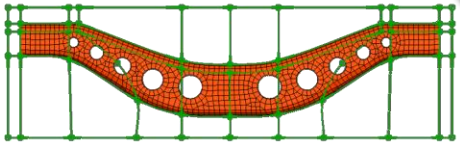
OPTIMIZER

ANSA Optimization Task

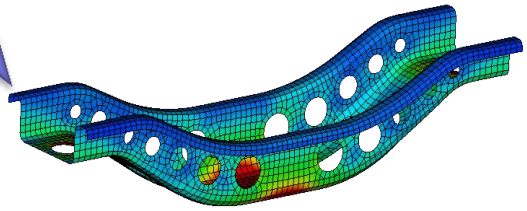




µETA Optimizer Setup



SOLVER



Coupling with optimization software

modeFRONTIER
the multi-objective optimization and design environment

Isight SIMULIA

HEEDS

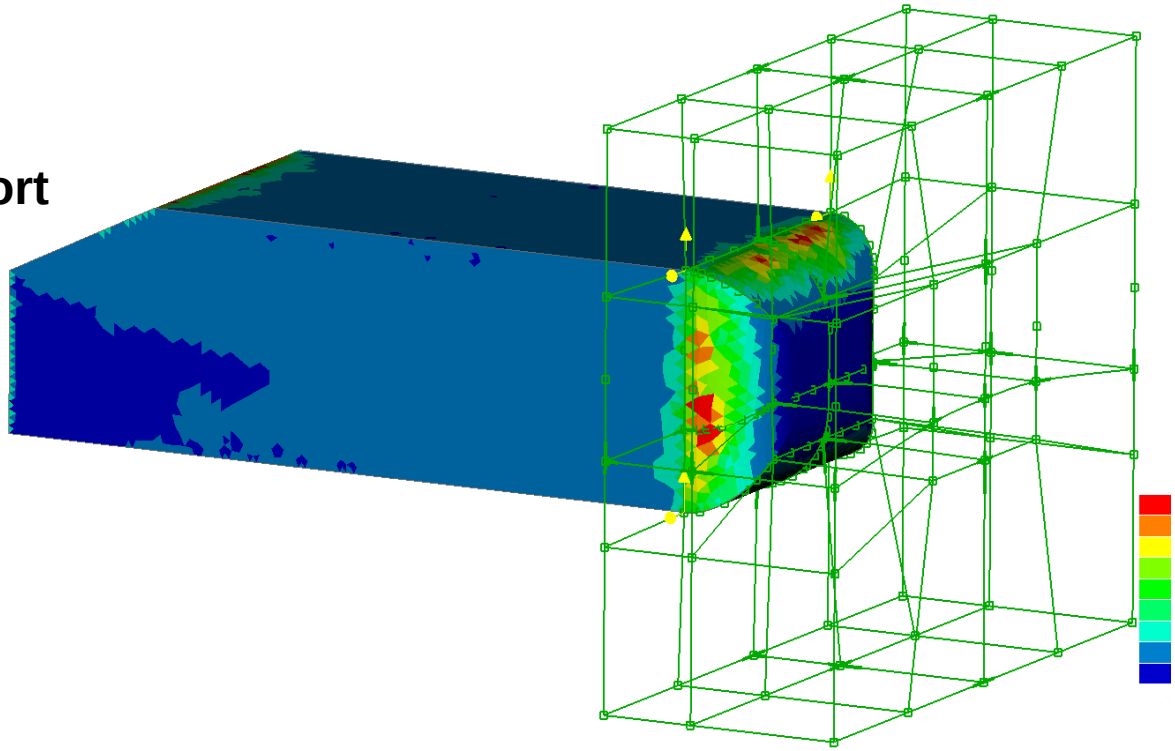
LS-OPT LSTC Livermore Software Technology Corporation

Key Enablers

- **Easy interface for coupling with optimization software**

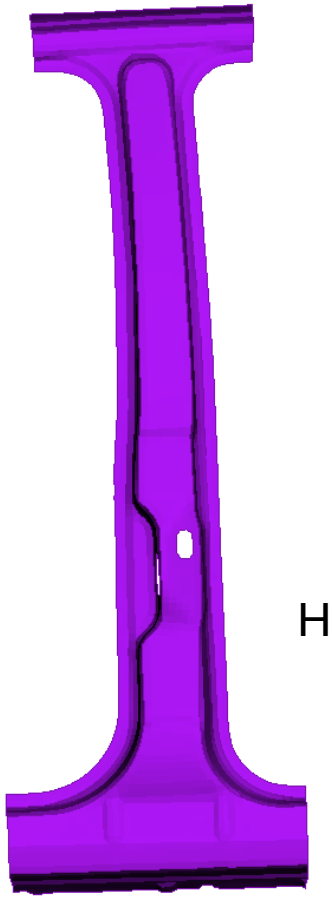
Current and future projects

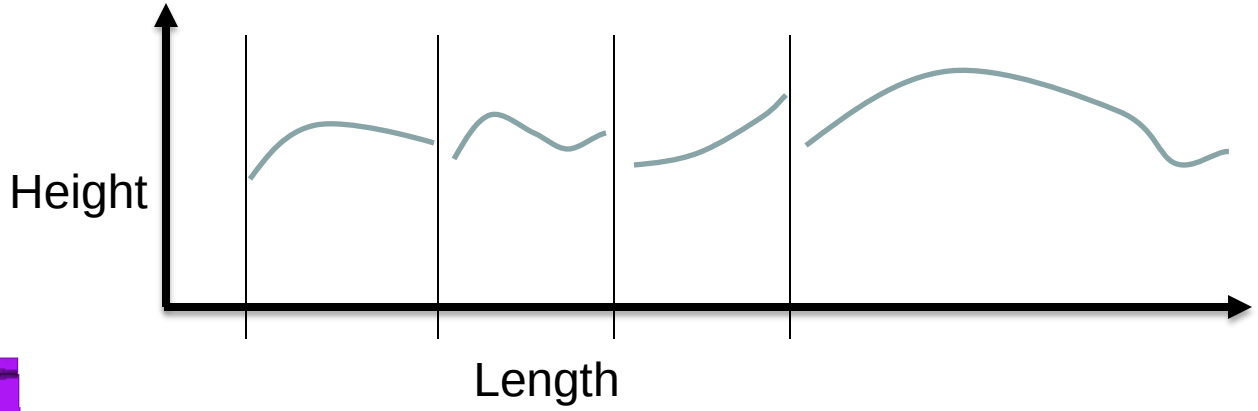
- **Sensitivity based morphing**
- **Direct / Box free morphing**
- **More adjoint solvers support**



Current and future projects

- **Shape change driven by complex mathematical expressions**





Summary

- Current status of the simulation technology in automotive applications
- Shape, gauge, materials, welds, topology etc. optimization
- Future development to make the process user friendly
- Optimization as a standard process in product development

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