VR&D Products and Recent Updates

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October 2, 2018 | Plymouth, MI

Outline

- Introduction: Why use optimization?
- VR&D Products & New Features
  - VisualDOC
  - GENESIS
  - GTAM/GSAM
  - ESLDYNA
  - Design Studio
- Creo Topology Optimization Extension
- Summary

Introduction: Why Use Optimization?

To more efficiently and economically design products that are:

Safer, Lighter, Stiffer and Stronger

Complimentary Product Lines

Multidiscipline Design Optimization	Structural Analysis and Optimization
VisualDOC – GUI Based: Couple Optimization With Almost Any Analysis	GENESIS – Fully Integrated Linear Elastic Analysis and Optimization
DOT – General Purpose Optimizer	SMS – Very Fast Large Scale Eigenvalue Analysis
BIGDOT – Very Large Scale Optimizer	Design Studio – GUI to Create GENESIS Design Data and Post Process
DSCDOT –Discrete Variable Optimization	ESLDYNA – Equivalent Static Load Method Optimization with Nonlinear Analysis
VisualDOC Coupled with ANSYS Workbench	GTAM & GSAM – GENESIS Coupled with ANSYS Mechanical

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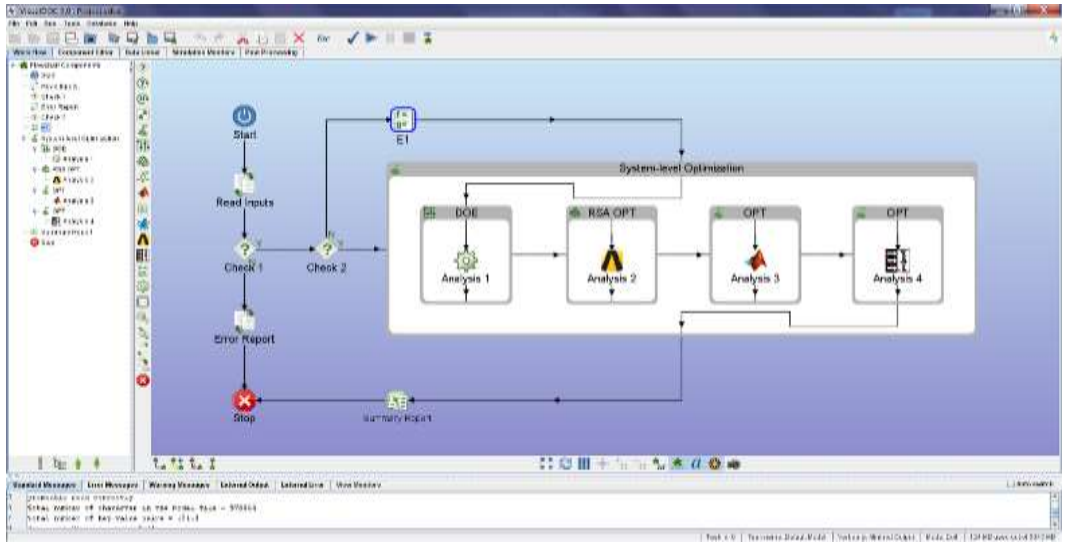
VisualDOC

- A general purpose multi-disciplinary design, optimization, design studies in a single simulation and process integration software
- Can add design modules to almost any analysis program (e.g. GENESIS, NASTRAN, ANSYS, LS-Dyna, FLUENT, STAR-CD, etc.)
- Multi-level/multiple disciplines



NOT a Collection of Public Domain Software

Our Software is Written by VR&D

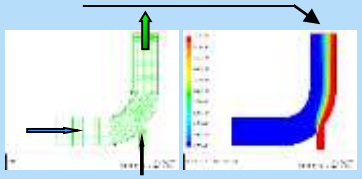
VisualDOC

- History

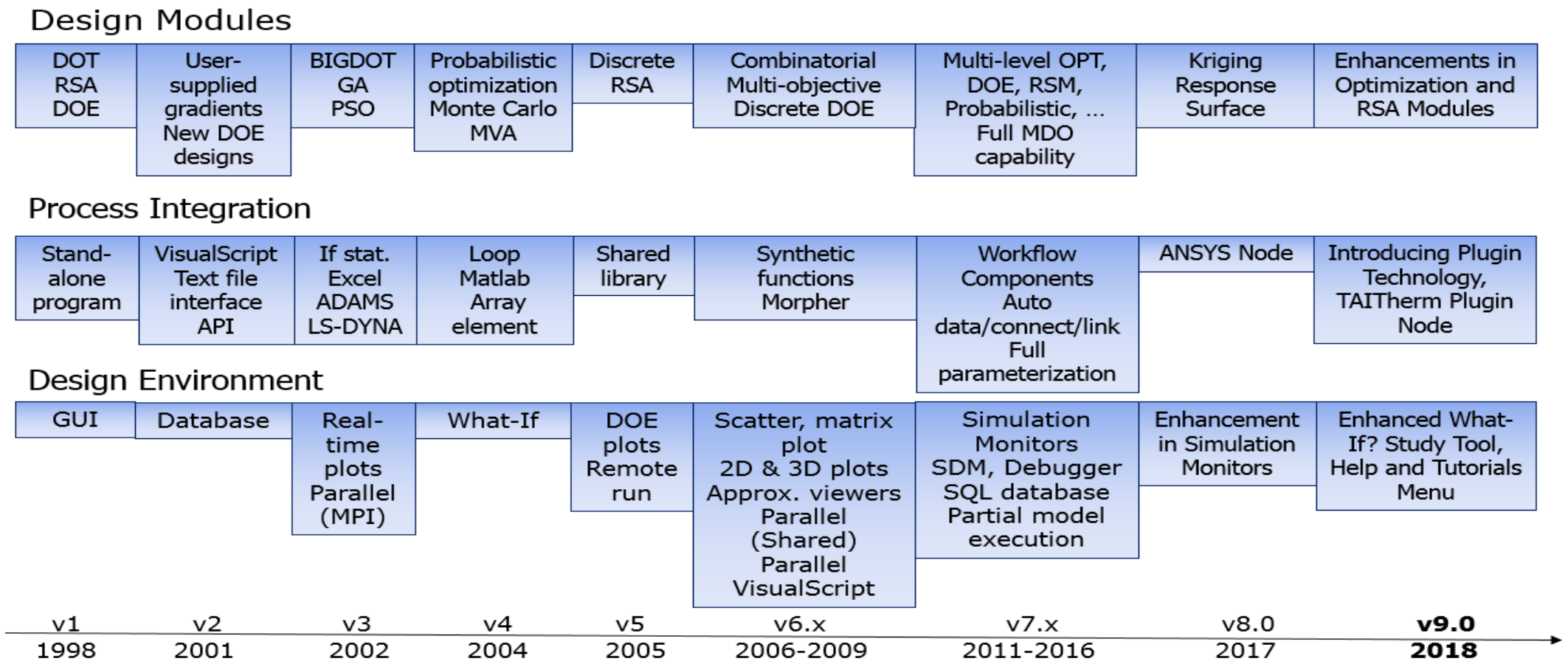
  1975; COPES Control Program for Engineering Synthesis

  1992; DOC Design Optimization Control

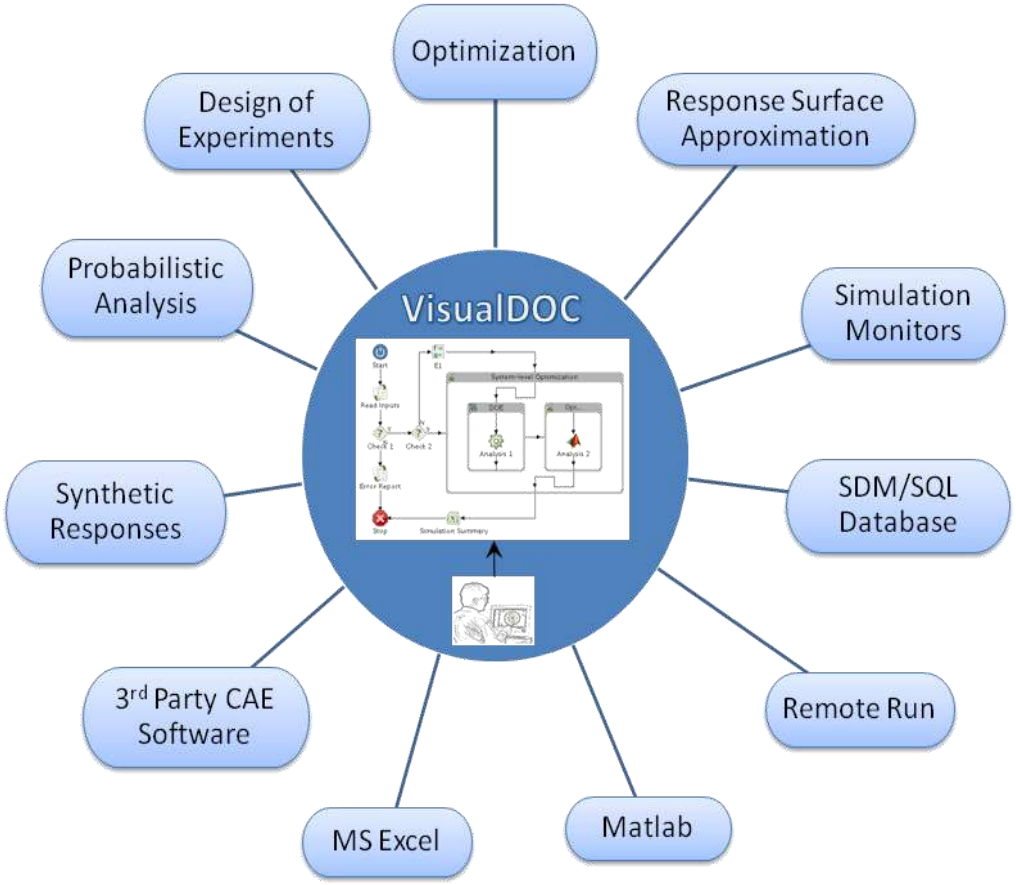
  1998; VisualDOC GUI Based Multidiscipline Design Optimization



Evolution of VisualDOC

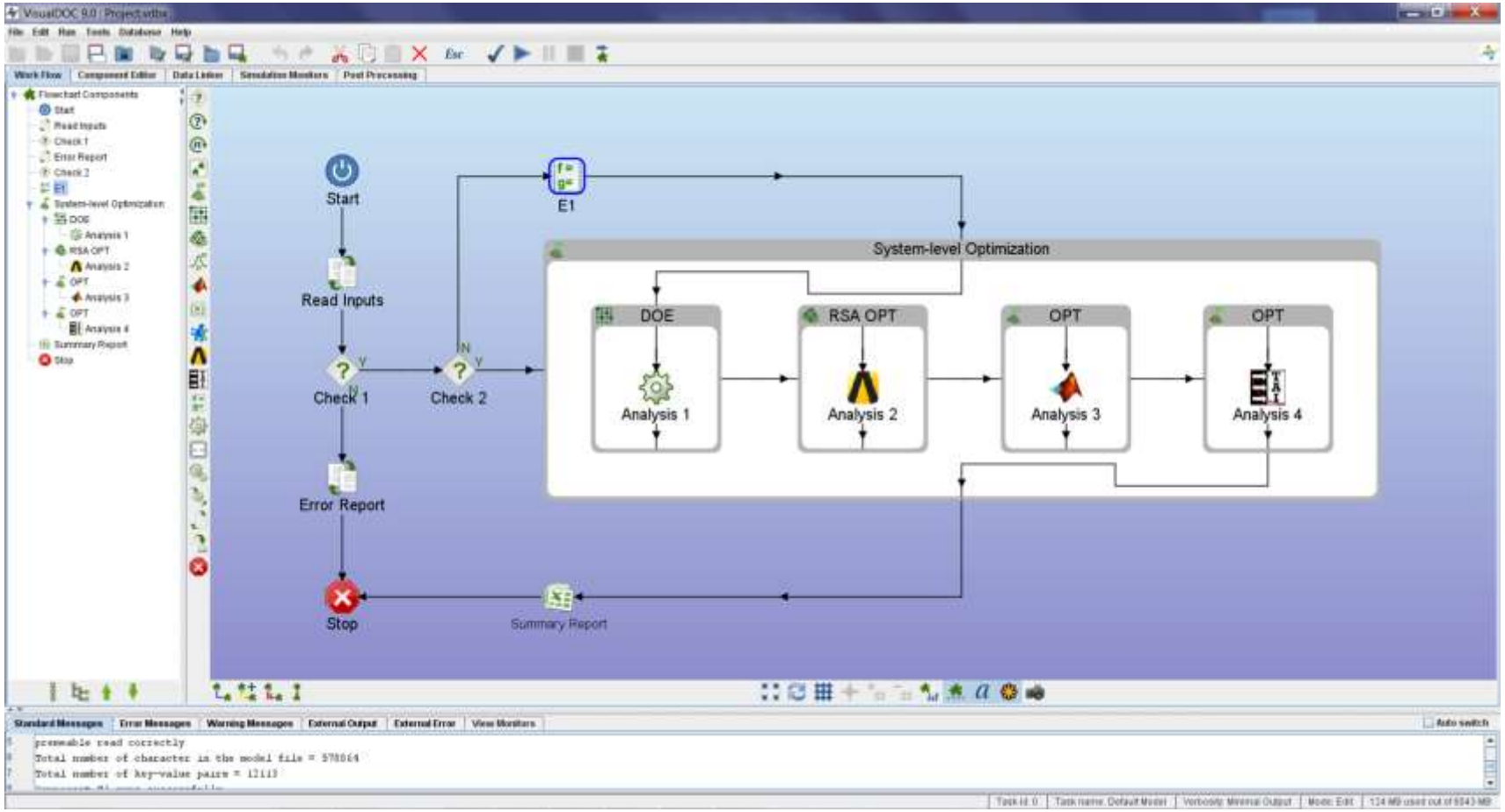


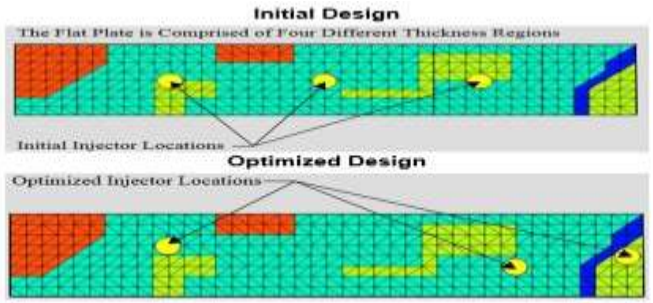
VisualDOC



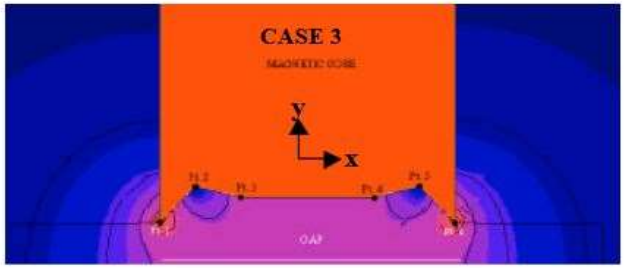
Components in VisualDOC

VisualDOC Interface

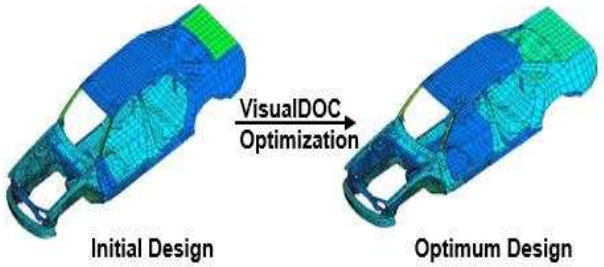




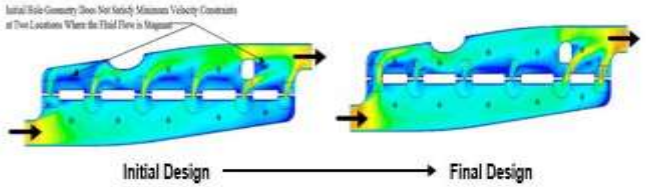
Polymer Injector Location Optimization



Magnetic Flux Gap Density Optimization - VisualDOC/FLUX2D

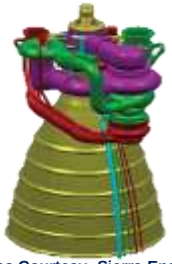


Structural Optimization – VisualDOC/GENESIS



Geometric Fluid Hole Location Optimization - VisualDOC/FLUENT

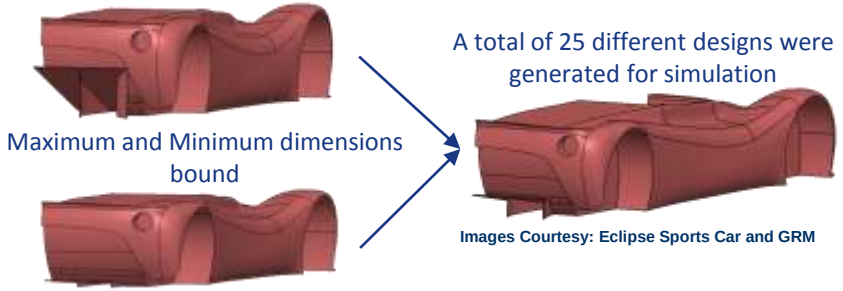
Applications



Images Courtesy: Sierra Engineering

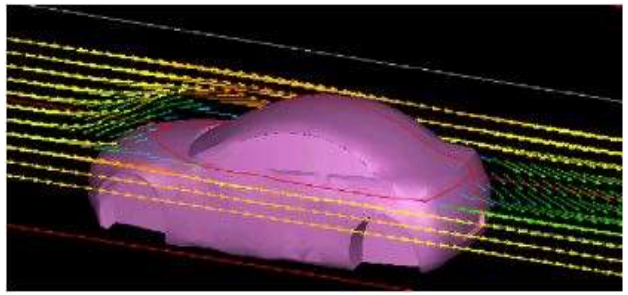
Rocket Nozzle Optimization

Turbomachinery Component Optimization – VisualDOC/CFX



Images Courtesy: Eclipse Sports Car and GRM

Diffuser Geometry Optimization



Aerodynamic shape Design of a Car Body – VisualDOC+ SC/Tetra + Think 3

Why VisualDOC?

Why is VisualDOC your best Choice?

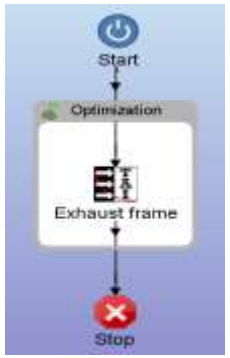
Many reasons. Here are just a few:

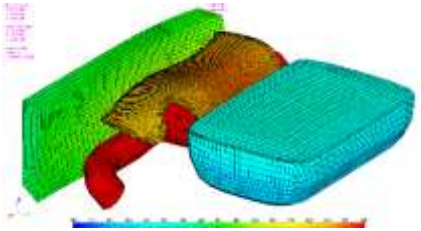
	Optimizers	Process Integration	DOE	Ease of Use	Real-time Design Monitors	Integration with VR&D Products
VisualDOC	DOT[1] BIGDOT[1]	Intuitive flowchart Automatic linkages Flexible components	13+ sampling designs	Comprehensive data checks Debug options Reusability of components	Monitors added/modified at any design stage, flexible in dimensions and chart types	Yes (GENESIS component)
Competitors	?	Most of them have rigid formats and manual links	Most of them offer limited DOE sampling	Most of them offer no debug options	Most of them have fixed format	Most of them not

[1] Developed by VR&D and Continuously Enhanced

VisualDOC 9.0 - New Features

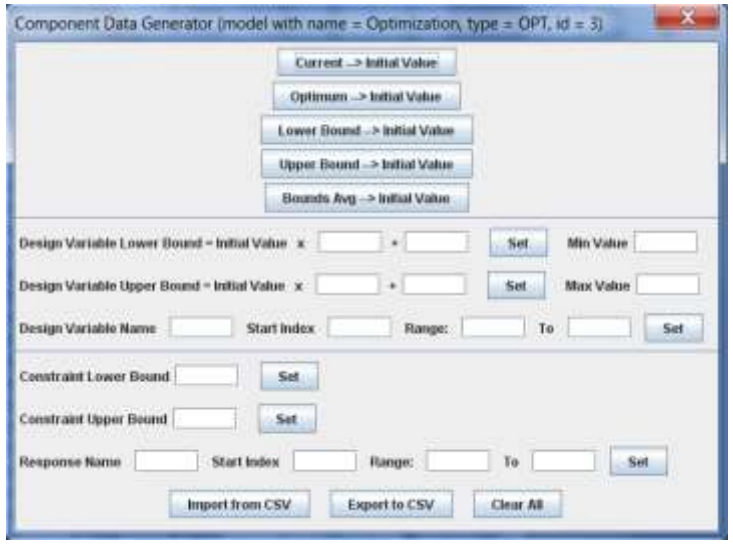
TAITherm Component





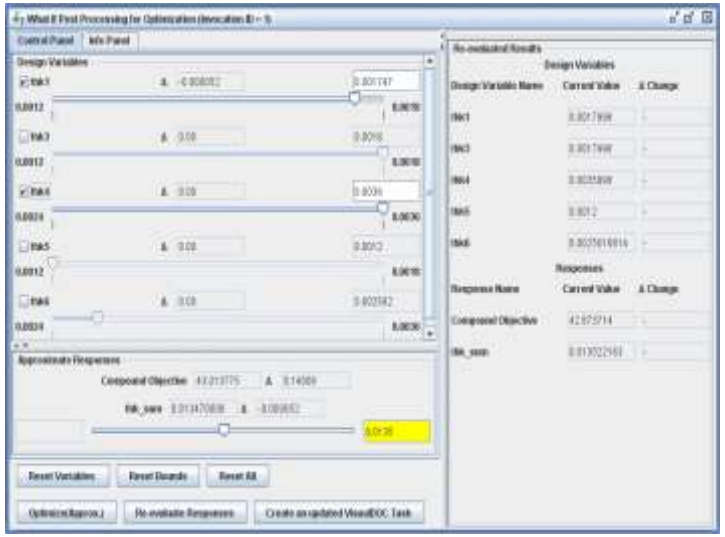
Exhaust Frame Optimization

Component Data Generator



- Create component data with few clicks.
- Set names of variables with few clicks.
- Import data from csv file
- Export component data and save it in csv format.

What-If? Study Tool



- Study the influence of small changes in optimization problem definition on the optimum results.
- Perform Approximate optimization.
- Run an actual analysis at the selected design point.

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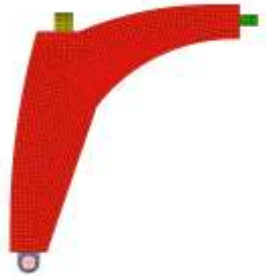
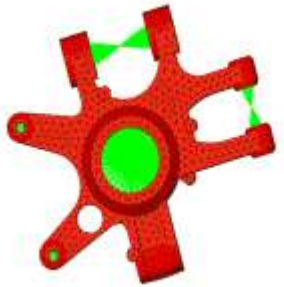
Strucutral Optimization Types in GENESIS

Six Main Types in GENESIS and GSAM

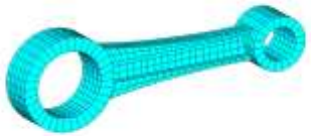


Topology Optimization

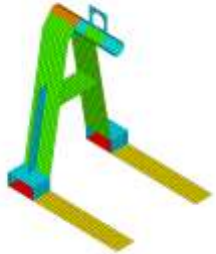
Topography Optimization



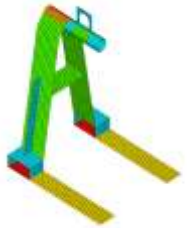
Shape Optimization



Freeform Optimization

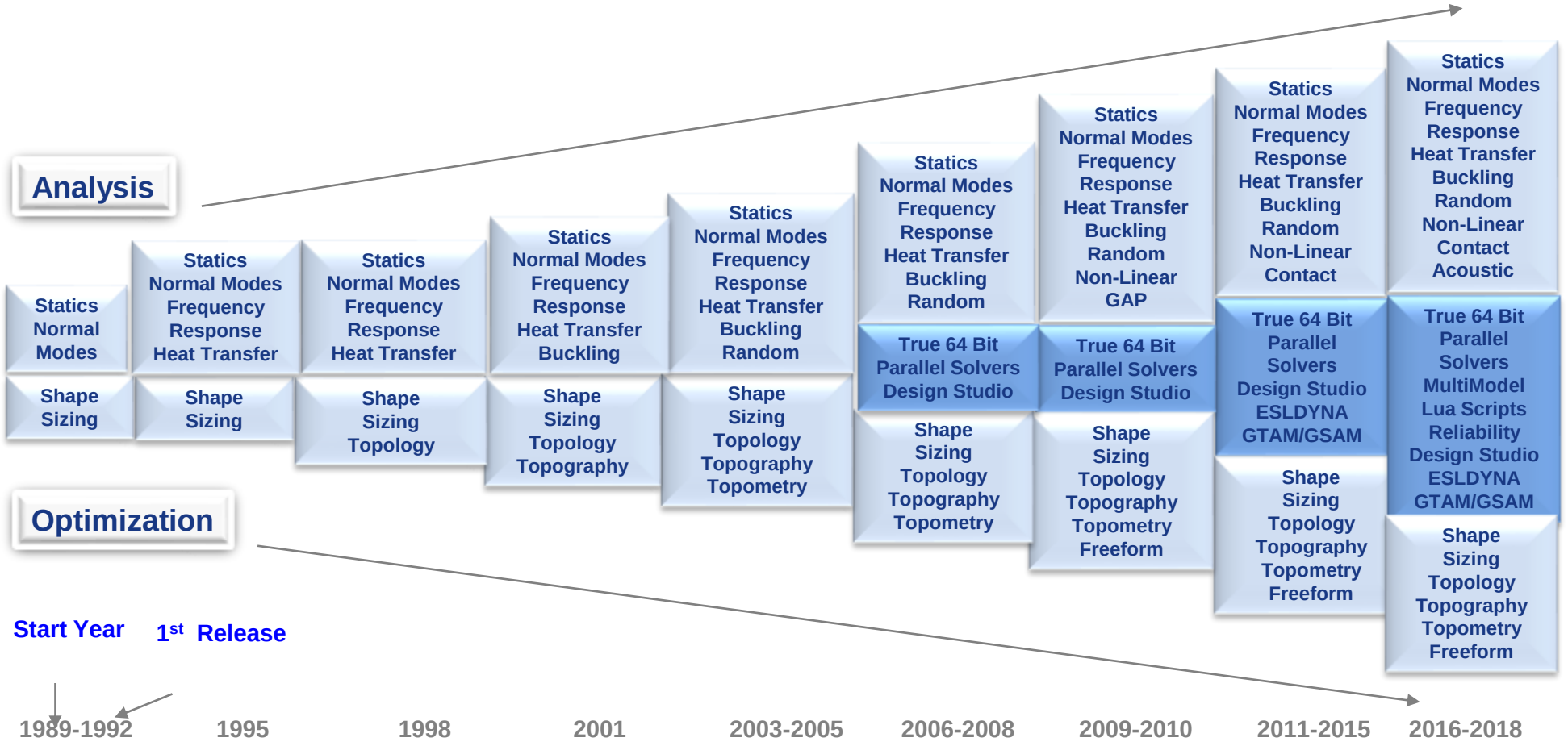


Sizing Optimization

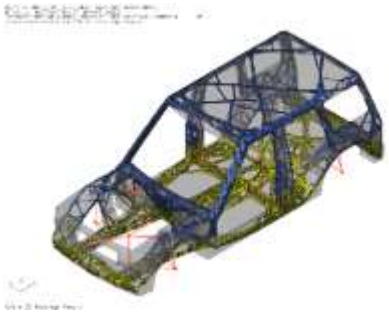


Topometry Optimization

GENESIS Evolution



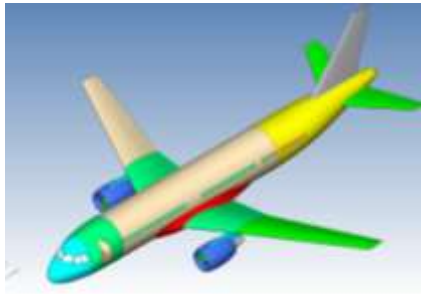
Engine Design



Car body Design

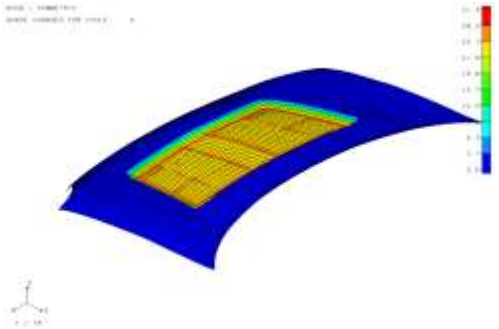
Support Structure

Applications



Airplane Components

Sport Equipment



Components

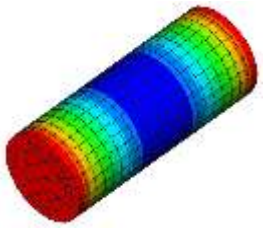
Why GENESIS?

	Optimizer	Approximations	Topometry	Freeform	Shape
GENESIS	DOT[1] BIGDOT[1] DSCDOT[1] STRDOT[1]	2nd Generation Invented by VR&D	Invented by VR&D	Fully Implemented	Built-in Domain Morphing with Distortion Control
Competitor 1	ADS[2]	1st Generation	Partially Borrowed	Not available	Only Raw Perturbations
Competitor 2	CONMIN[3]	Borrowed	Partially Borrowed	Partially Implemented	Only Raw Perturbations

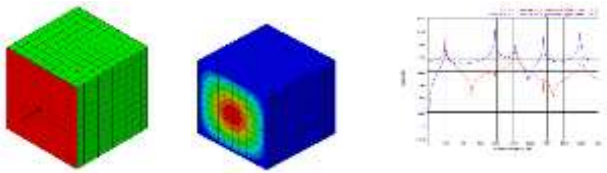
1 Developed by VR&D and Continuously Enhanced
2 Unsupported 1984 Research Code by Vanderplaats
3 Unsupported 1972 Research Code by Vanderplaats

GENESIS 17.0 - New Features

ANALYSIS

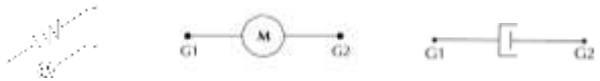


New Acoustic Eignesolver



New Fluid-Structure Interactin Solver

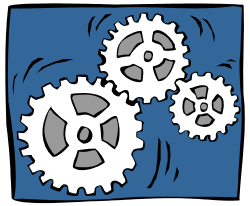
New Format



New Format for Scaler Elements

New Format for Heat Transfer Elements

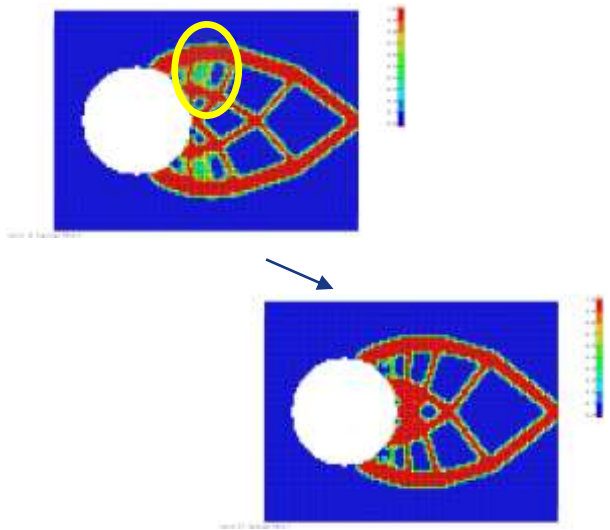
Optimization



New Optimizer: CMBDOT

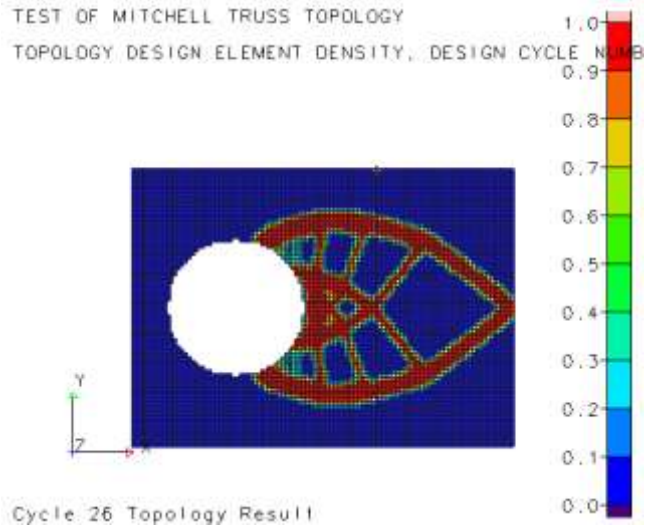
GENESIS 17.0 - New Features

New Progressive Rule



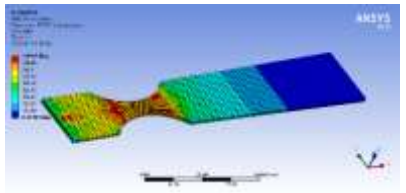
Interior Fuzziness eliminated

New Hybrid Method



Optimization

New Global Von mises Index



New Von mises PSD/RMS Random Responses: In GENESIS and GTAM/GSAM

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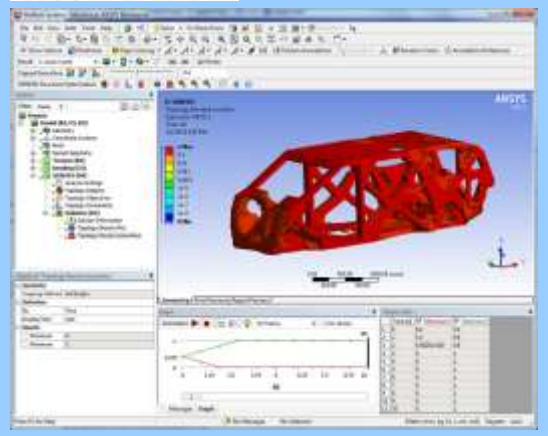
GENESIS Integration With ANSYS Mechanical

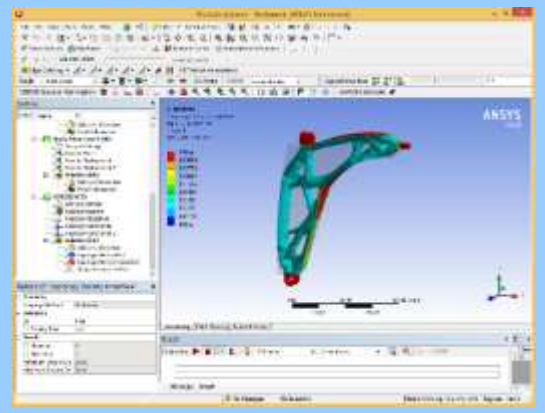
ANSYS



GTAM

GENESIS Topology Optimization for ANSYS Mechanical

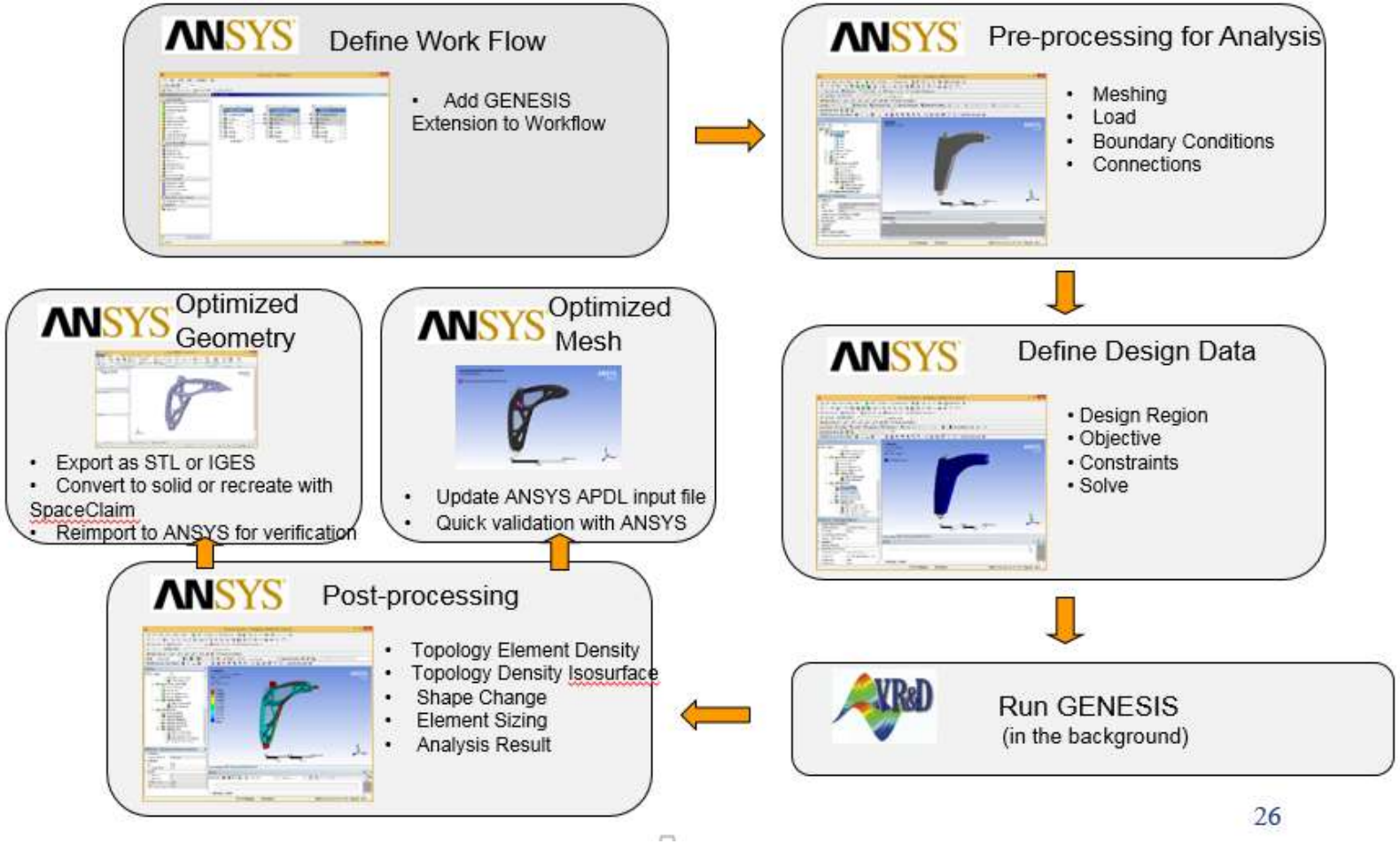
ANSYS



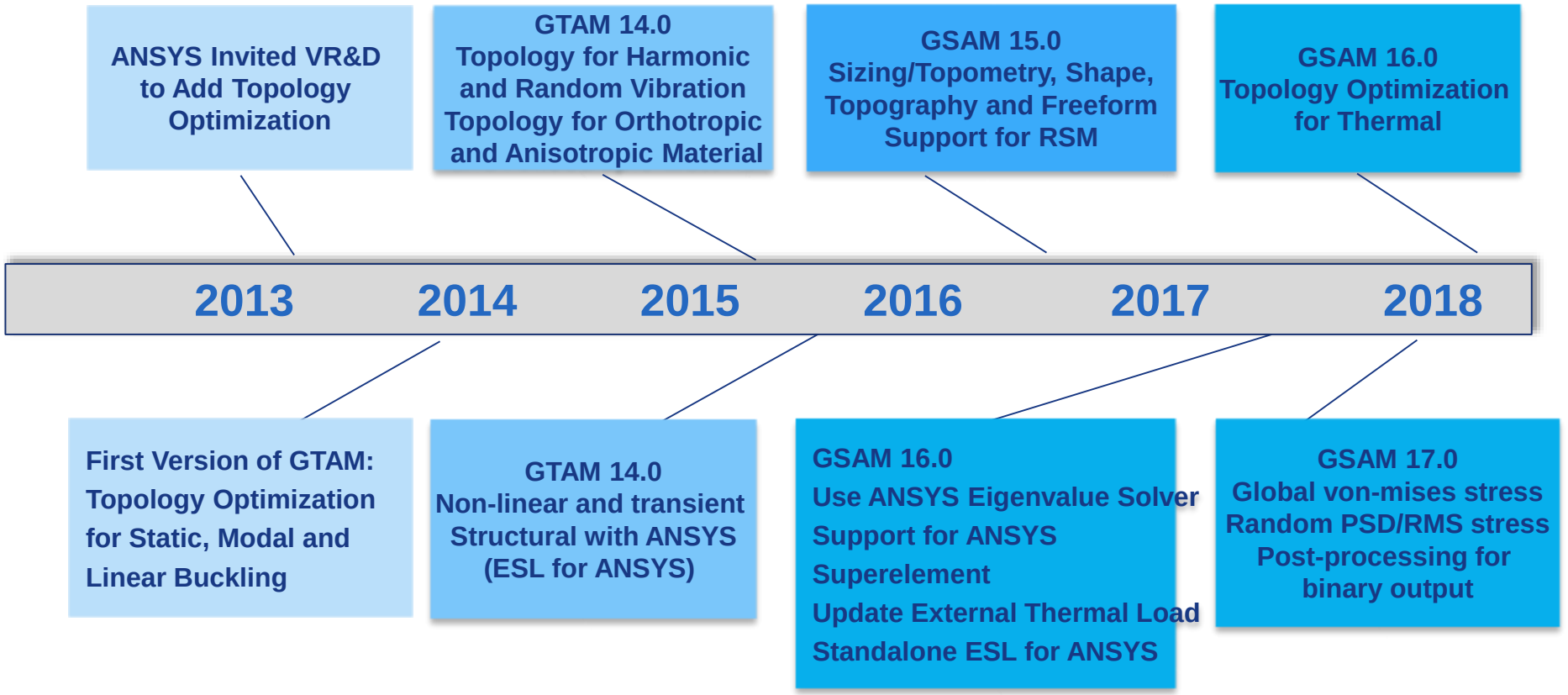
GSAM

GENESIS Structural Optimization for ANSYS Mechanical

GTAM/GSAM Process

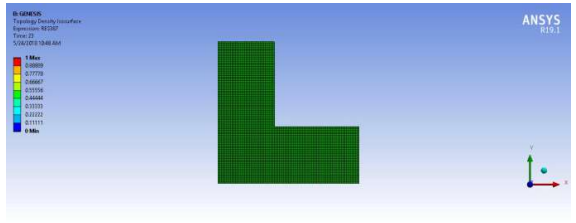


GSAM/GTAM Product History

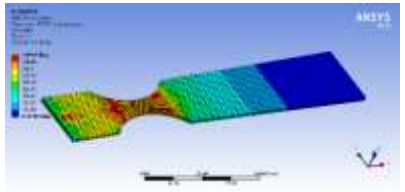


GTAM/GSAM 17.0 - New Features

ANALYSIS

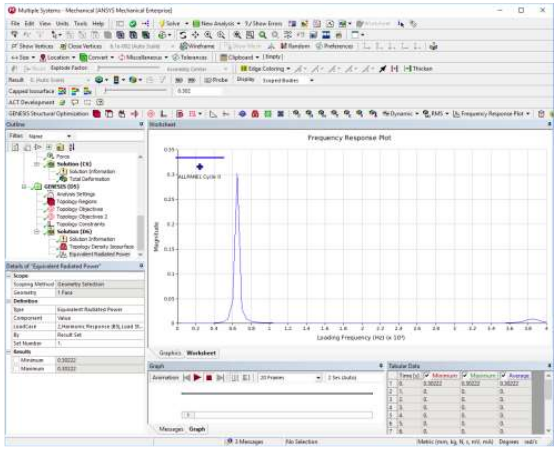


New Global von Misses Index



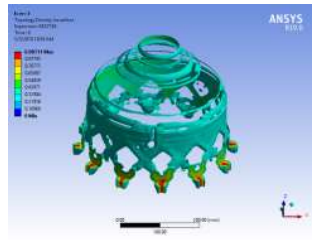
New Von mises PSD/RMS Random Responses

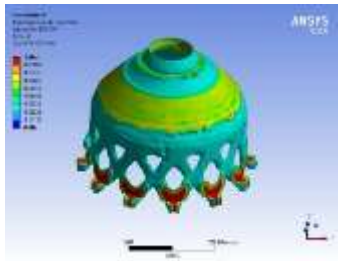
New Postprocessing



ERP

Optimization





New Topology Rule

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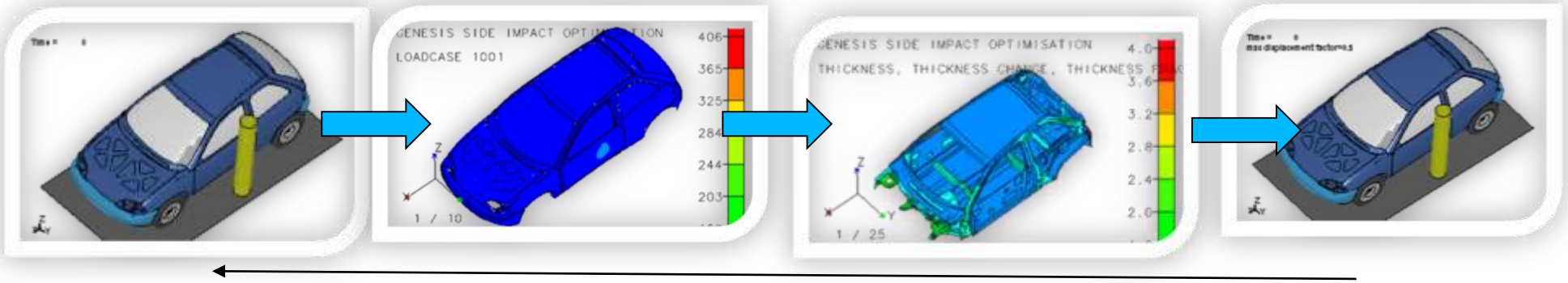
ESLDYNA

Extends GENESIS Optimization to LS-DYNA



Baseline Non-Linear Model(s)

GENESIS Interpretation of Non-Linear Model

GENESIS Optimization

Updated Non-Linear Solution

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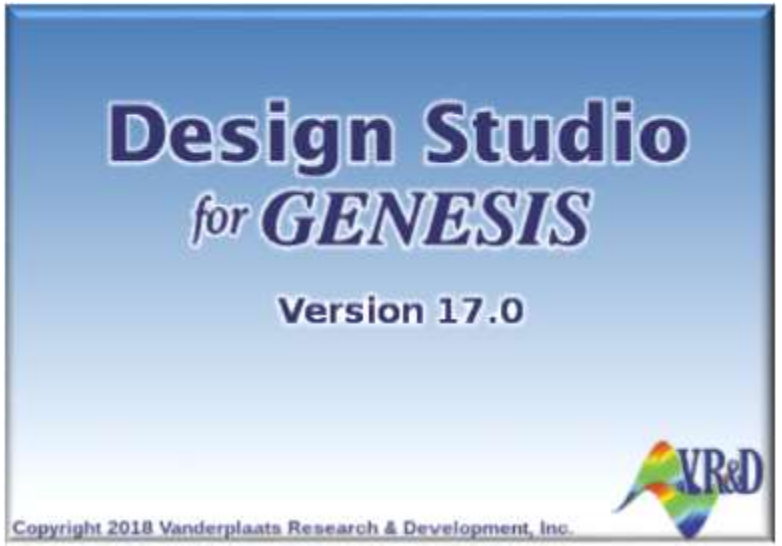
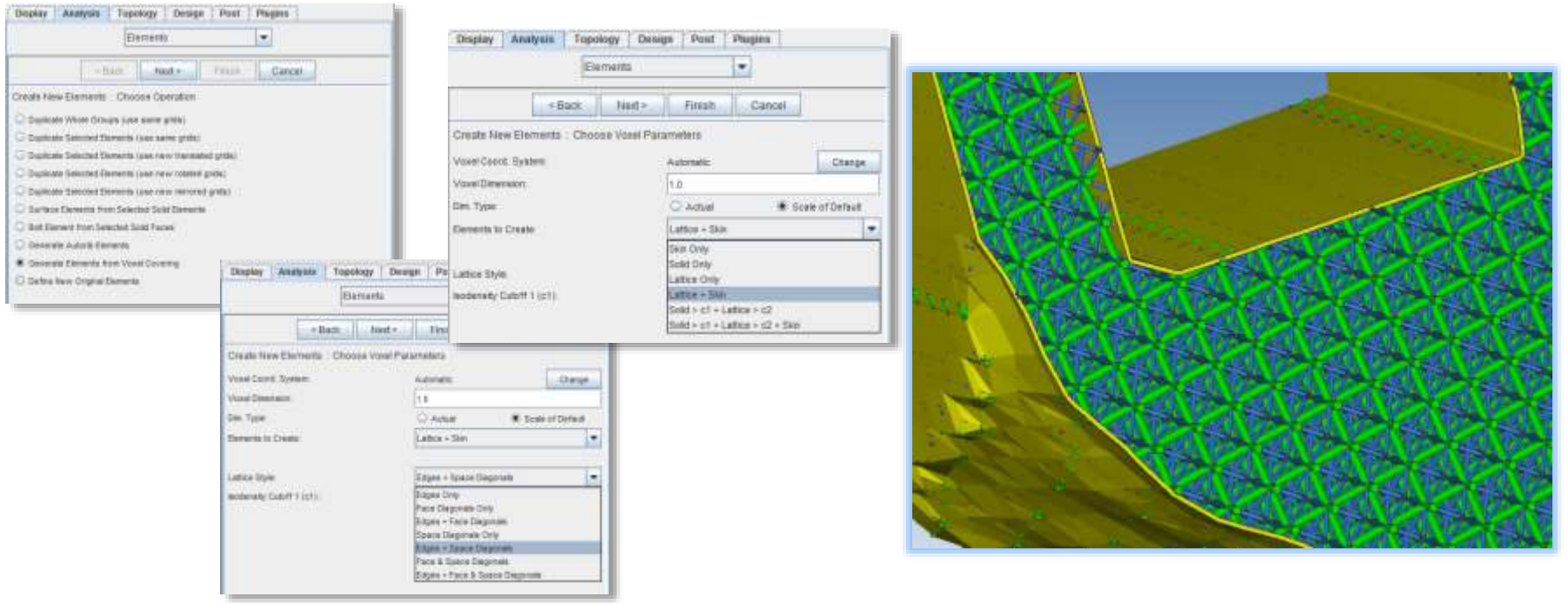
Design Studio Enhancements in 17.0

- Import/Export the View Catalog
- Pick Grids Along a Feature Line
- Renumber Item Edit Menu/Toolbar Button
- Create Elements from Voxel Covering
- Analysis Data Edit Enhancements
- Postprocessing Enhancements



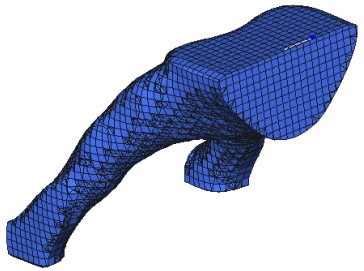
Create Elements from Voxel Covering

- Create Solid Elements and/or Lattice Bars
- Can Use Topology Result

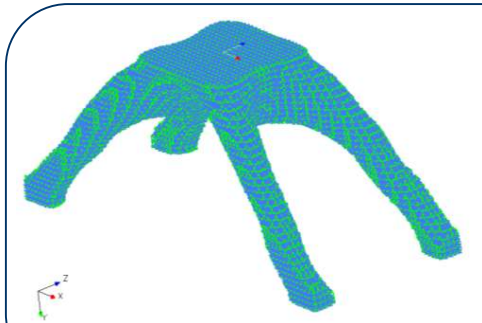


Lattice and/or Shell and/or Solid Topology Results

Skin mesh created

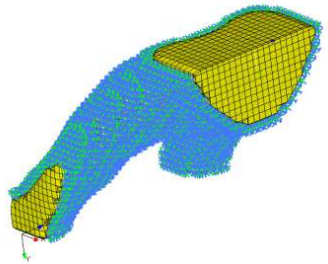


Solid mesh created

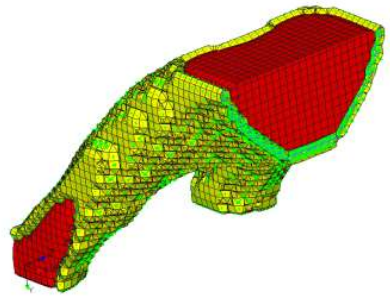


Lattice mesh created

Skin and lattice mesh created



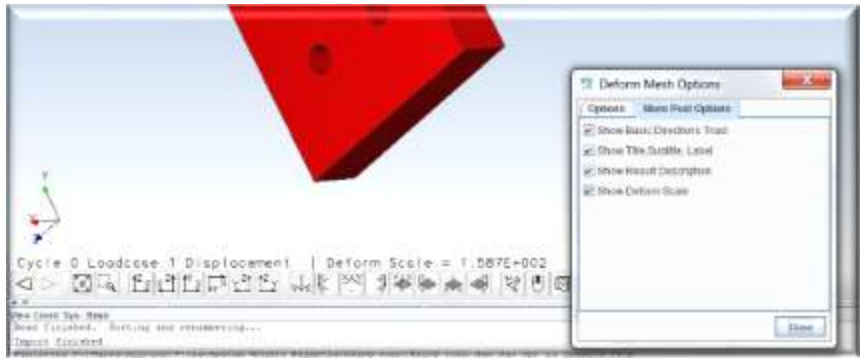
Solid and lattice mesh created

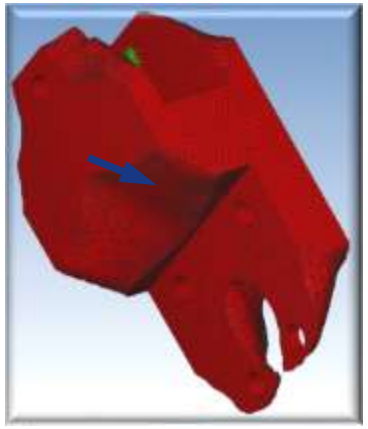


Skin & shell and solid mesh created

Postprocessing Enhancements

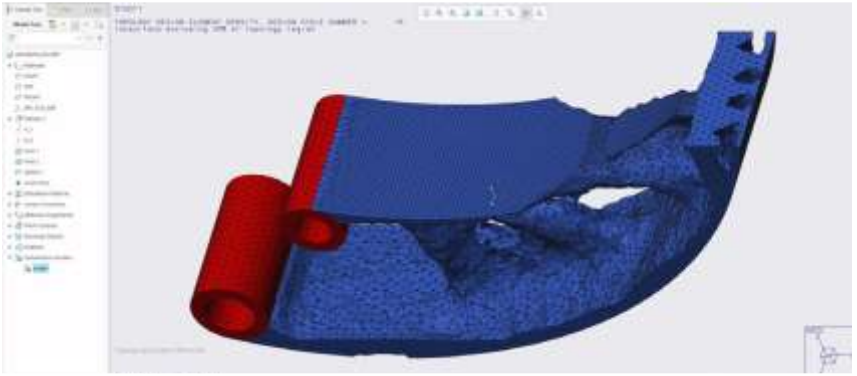
- Deform Scale in Viewport
- New Synthetic Result Functions
- Pick Feature Bounded Surface in Color Mesh
- Show/Hide Chart Windows

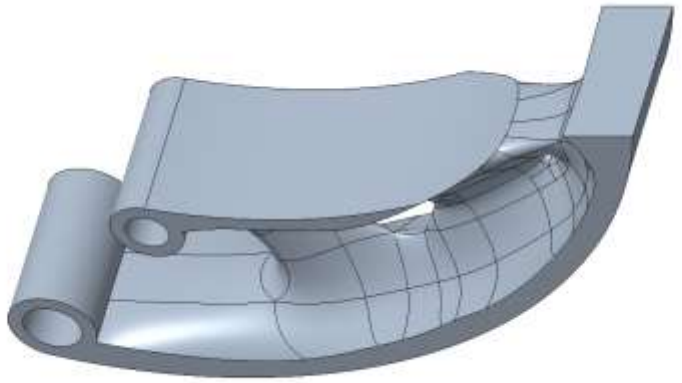




Creo Topology Optimization Extension (PTC)

- Features and Benefits
  - Ease-of-use, including the familiar Creo UI and workflow
  - Fast optimization set-up
  - Rapidly convert topology optimization results into rich CAD data
  - Define manufacturing constraints for additive as well as traditional manufacturing process
  - Structural, modal, and thermal analysis





The standard output of the Topology Optimization can be converted to a solid model in the form of a Creo freestyle feature. STL format is another option.

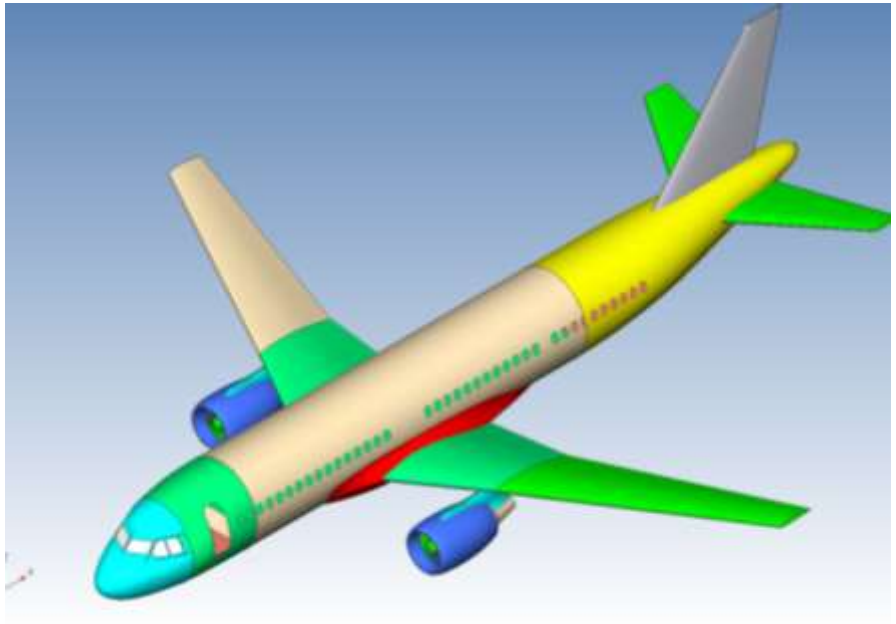
Summary

- VR&D has a powerful and robust portfolio of optimization products
- VisualDOC provides extensive MDO capabilities that can be used with practically any analysis program
- GENESIS/GTAM/GSAM/ESLDYNA can efficiently solve large scale structural optimization problems
- Design Studio is a powerful GUI for GENESIS

Concluding Remarks

- VR&D Products are Continuously Being Improved for Functionality
- Numerous User-Requested Features has been Added and Described

Thank You



Appendix

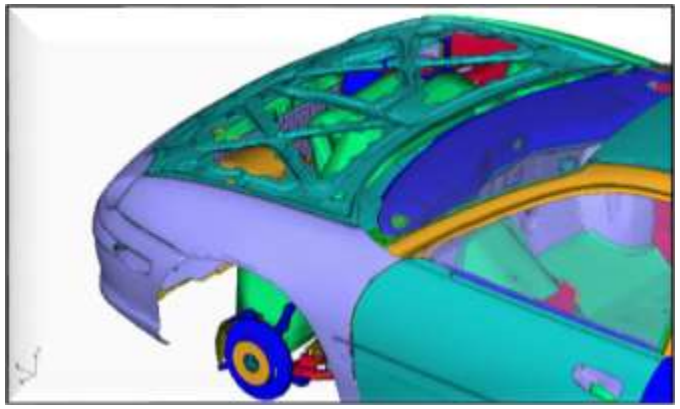
- Additional Slides

Complimentary Product Lines

Multidiscipline Design Optimization	Structural Analysis and Optimization
VisualDOC – GUI Based: Couple Optimization With Almost Any Analysis	GENESIS – Fully Integrated Linear Elastic Analysis and Optimization
DOT – General Purpose Optimizer	SMS – Very Fast Large Scale Eigenvalue Analysis
BIGDOT – Very Large Scale Optimizer	Design Studio – GUI to Create GENESIS Design Data and Post Process
DSCDOT –Discrete Variable Optimization	ESLDYNA – Equivalent Static Load Method Optimization with Nonlinear Analysis
VisualDOC Coupled with ANSYS Workbench	GTAM & GSAM – GENESIS Coupled with ANSYS Mechanical

SMS - A Fast Eigenvalue Solver

	Eigenvalue Method	Elapsed Time (seconds)	Disk Usage (Gb)	Speed-up
NASTRAN	Lanczos	26370	29	1
GENESIS	SMS	1485	16	18



Over 18 Times Faster than NASTRAN Lanczos

Built-in GENESIS
Available in DMAPs for MSC/NASTRAN

Speed-up of 10 x typical for most applications

Complimentary Product Lines

Multidiscipline Design Optimization	Structural Analysis and Optimization
VisualDOC – GUI Based: Couple Optimization With Almost Any Analysis	GENESIS – Fully Integrated Linear Elastic Analysis and Optimization
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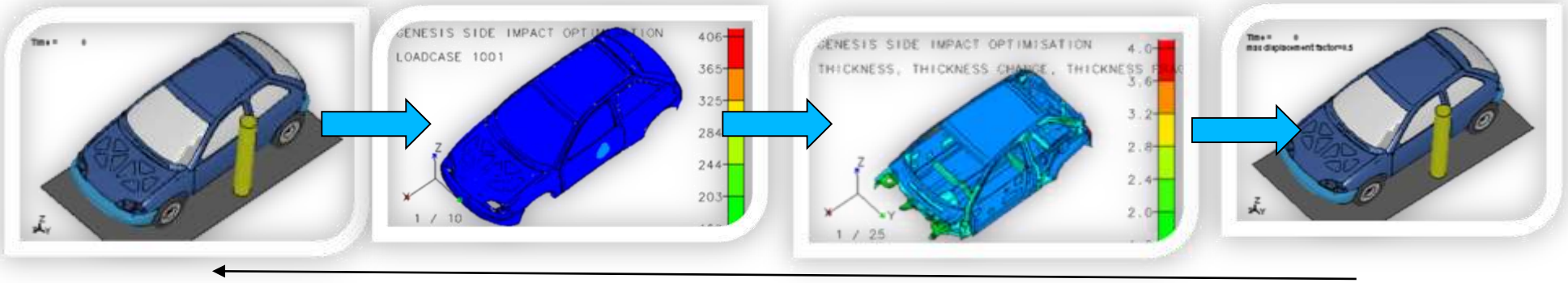
VisualDOC Coupled with ANSYS Workbench	GTAM & GSAM – GENESIS Coupled with ANSYS Mechanical

ESLDYNA

Extends GENESIS Optimization to LS-DYNA



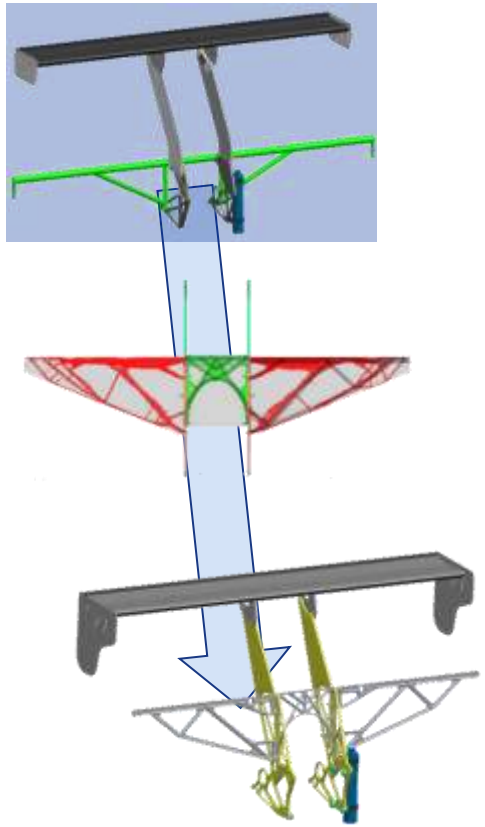
Baseline Non-Linear Model(s)

GENESIS Interpretation of Non-Linear Model

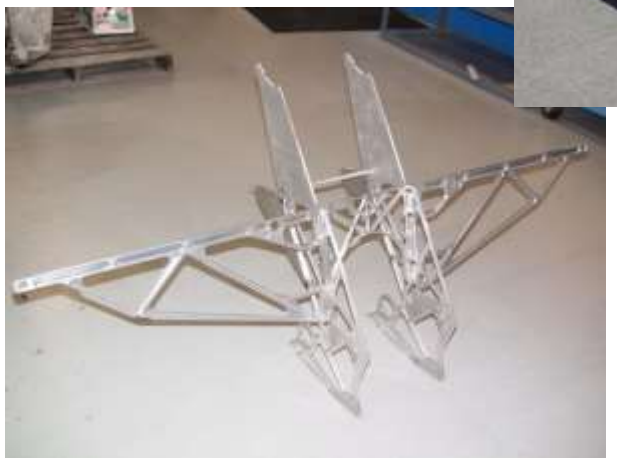
GENESIS Optimization

Updated Non-Linear Solution

Wing Frame Topology Optimization



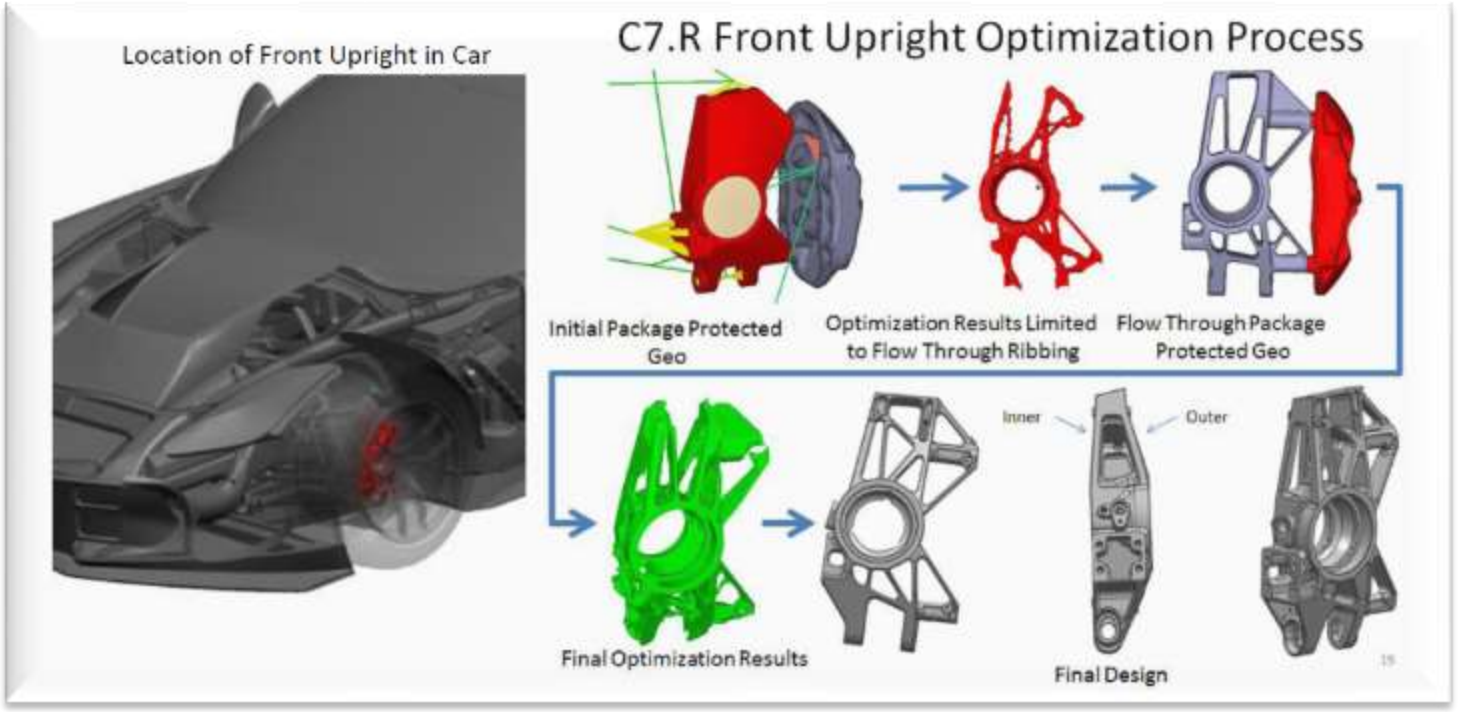
2012 Corvette
Daytona Prototype



Estimated Mass savings: 33%

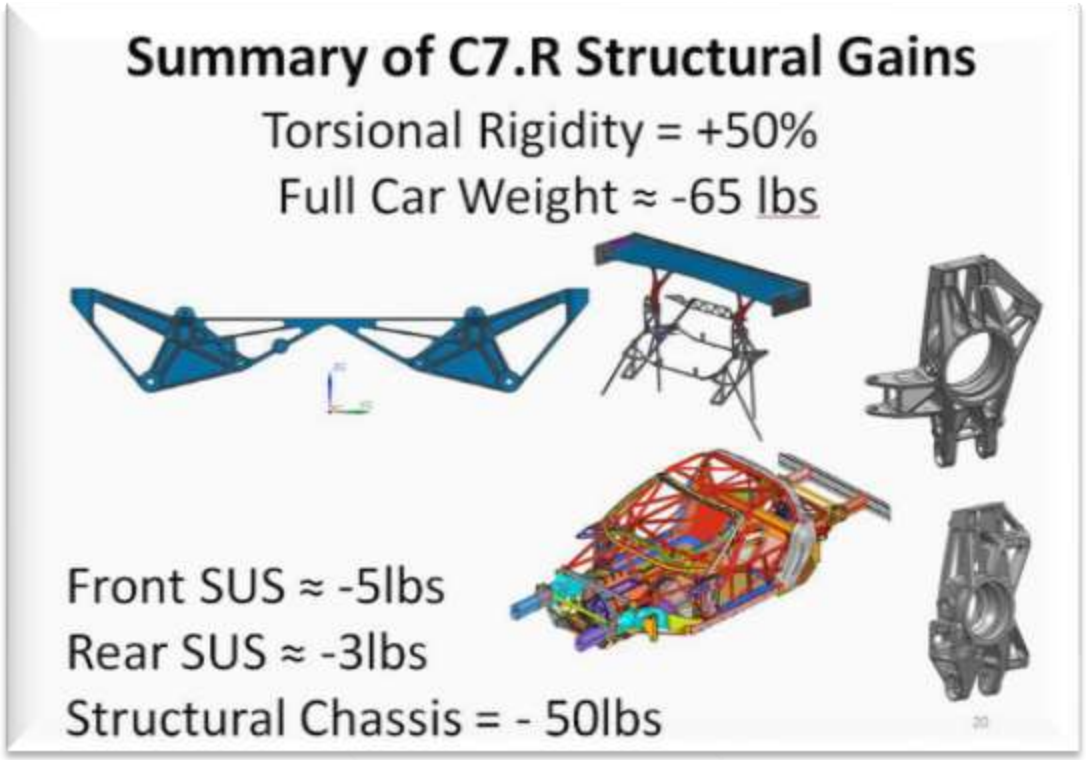
PRATT & MILLER

Corvette Racing C7.R Front Upright



(Courtesy of Pratt & Miller Engineering)

Corvette Racing C7.R Front Upright



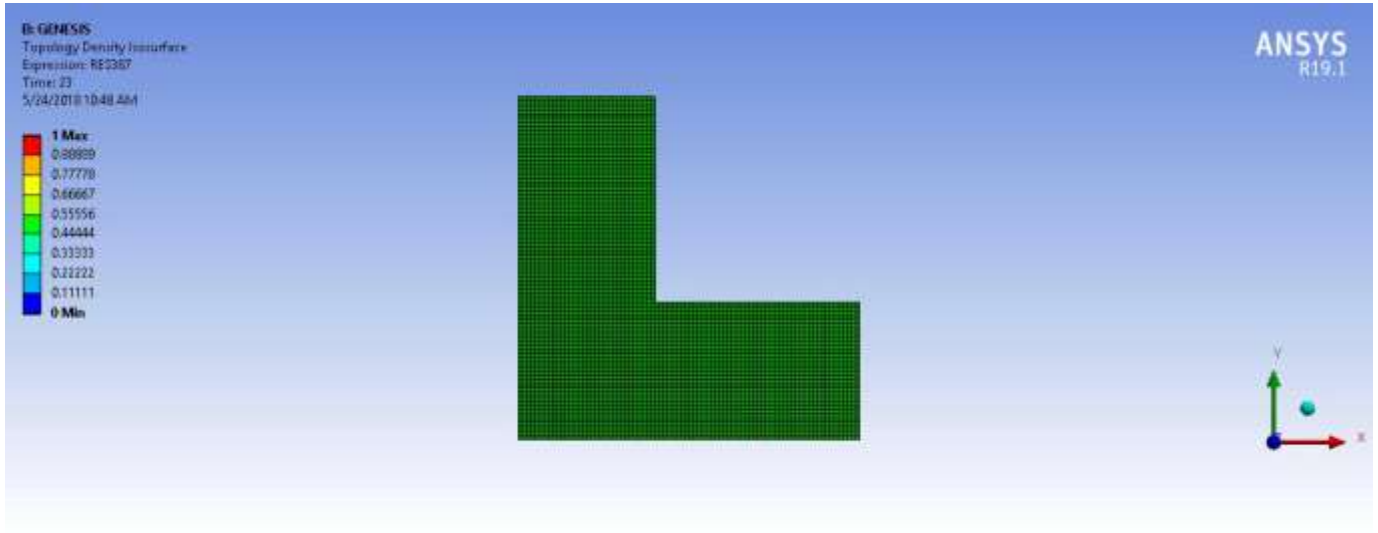
(Courtesy of Pratt & Miller Engineering)

New Features in GSAM/GTAM v17.0

- New Global von Mises Stress Response
- New RMS/PSD Stress Responses for Random Vibration
- Write only Loadcases Referred by Optimization
- Support Post-processing for Binary OUTPUT2 Format
- Support Post-processing for More Result Types
- Support Importing Results for All Design Cycles

Structural Optimization Enhancement

- New Global von Mises Stress Response
  - The new VMINDEX response allows the user to economically and efficiently impose von mises stress constraints in topology and other types of optimization



Structural Optimization Enhancement

- New Global von Mises Stress Response
  - Upper bound for von mises index response is typically set as 1.0
  - This constraint uses the yield strength on material as the stress limit
  - Impose on all geometries with the given material
  - Loadcase dependent

Properties of Outline Row 3: Structural Steel

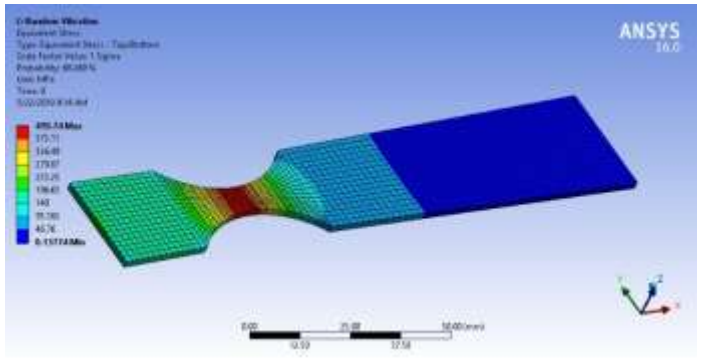
	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	2.8E-09	tonne mm^-3		
4	Isotropic Secant Coefficient of Thermal Expansion				
6	Isotropic Elasticity				
12	Alternating Stress Mean Stress	Tabular			
16	Strain-Life Parameters				
24	Tensile Yield Strength	120	MPa		
25	Compressive Yield Strength	120	MPa		
26	Tensile Ultimate Strength	4.6E+08	Pa		
27	Compressive Ultimate Strength	0	Pa		
28	Isotropic Thermal Conductivity	60.5	W m^-1 C^-1		

Structural Optimization Enhancement

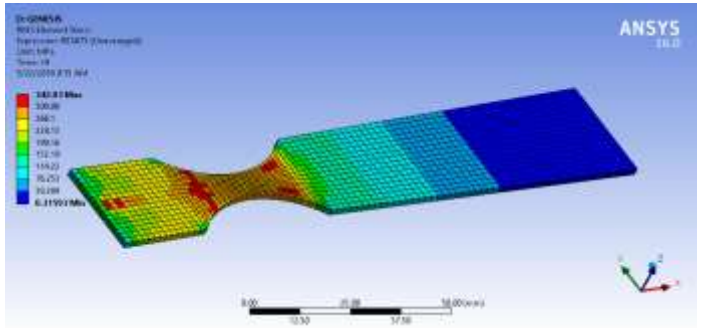
- Random Stress Responses
  - The Power Spectral Density (PSD) stresses and the Root Mean Square (RMS) stress responses are now available for all shell and solid elements.
  - The type of stresses are all stress tensor components (Normal-x, Normal-y, Shear xy, etc). For RMS stress, the user can also design for von Mises stress

Structural Optimization Enhancement

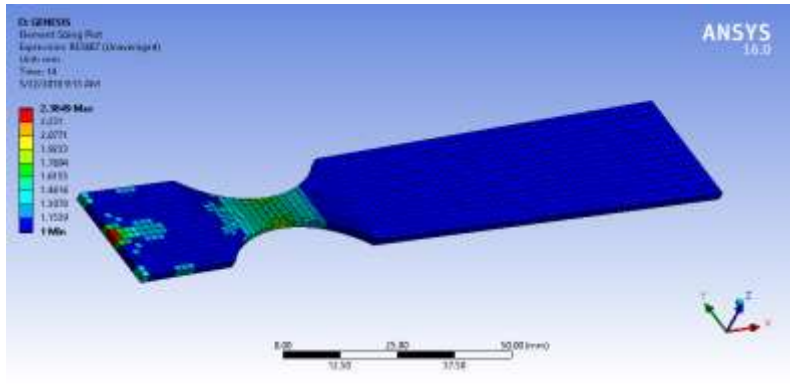
- Example: Topometry optimization to reduce Random RMS Stress



RMS von mises stress = 419 MPa in the original model



RMS von mises stress = 342 MPa in the optimized model

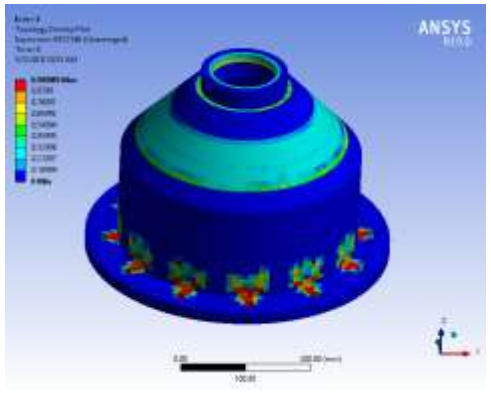


Shell thickness distribution

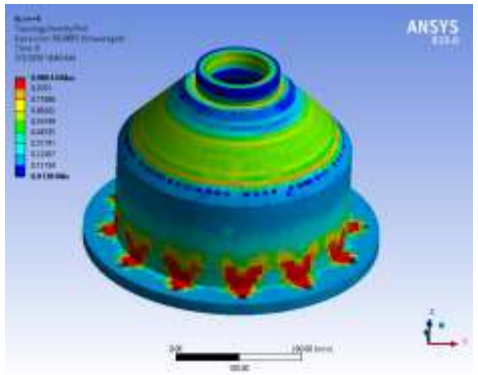
Export optimized geometry

Structural Optimization Enhancement

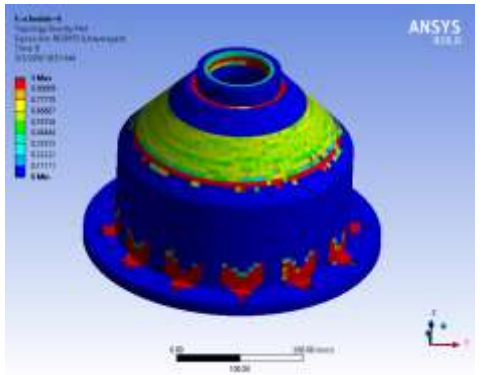
- New Progressive Rule for Topology Optimization



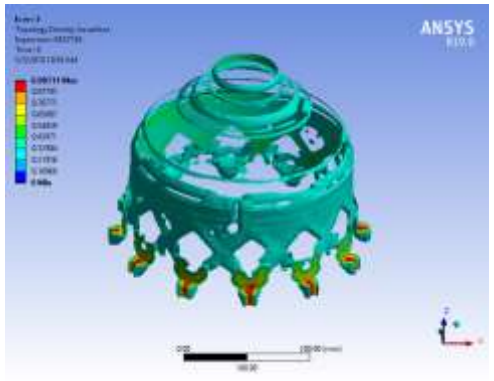
Rv1= 3

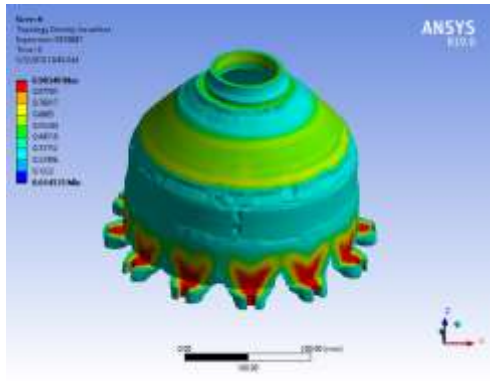


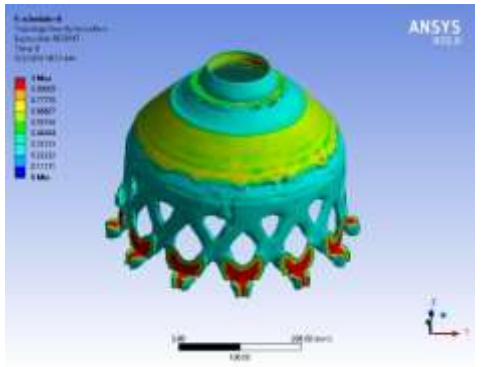
Rv1= 6



Built-in progressive schedule 6







Post-processing Enhancement

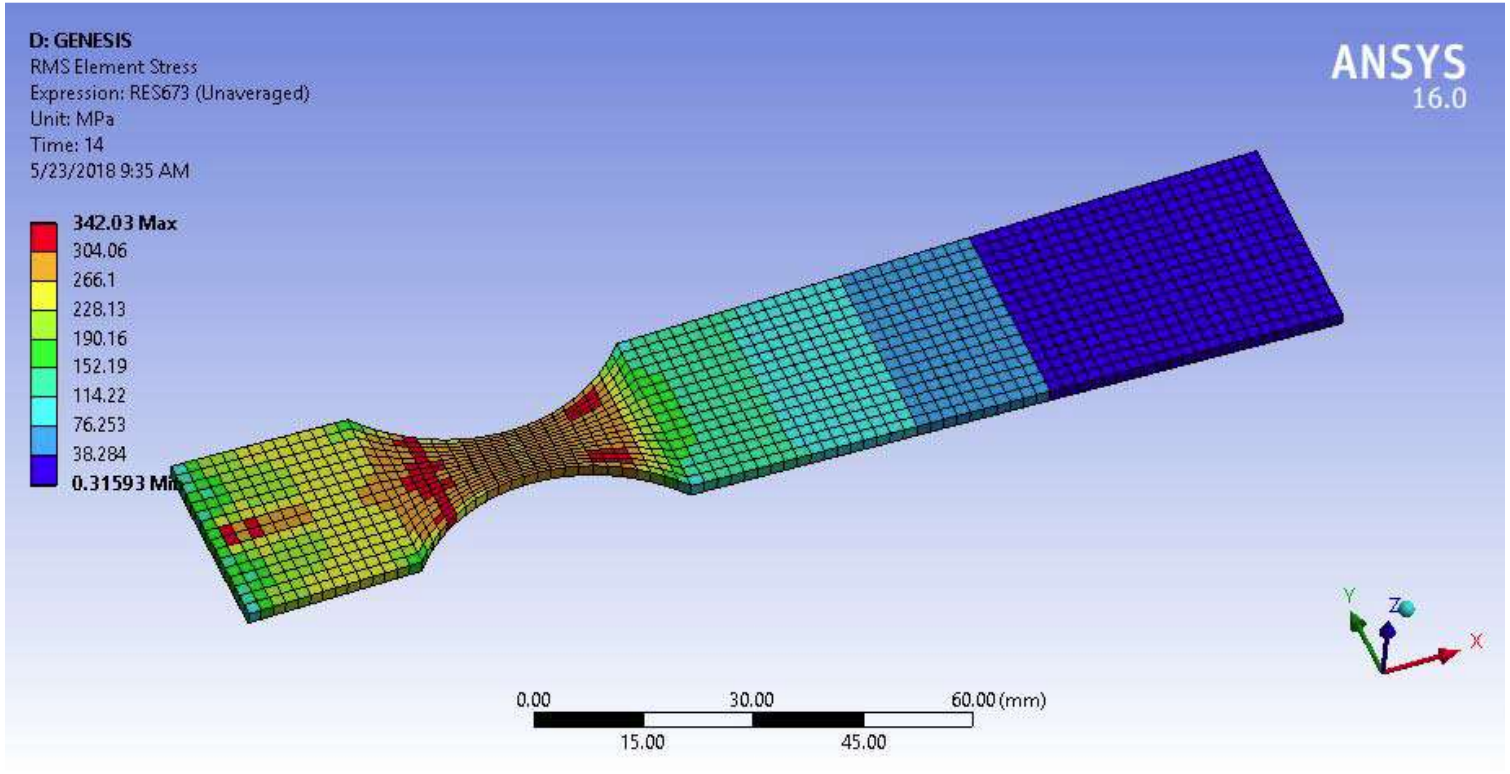
- Support Post-processing for Binary OUTPUT2 Format
  - Now the default format for output files is set as binary OUTPUT2
  - This will help reduce the output file size and improve the speed for post-processing

Post-processing Enhancement

- Support Post-processing for More Result Types
  - Reaction force contour plot
  - Dynamic displacement/velocity/acceleration/stress contour plot
  - RMS displacement/velocity/acceleration/stress contour plot
  - Frequency response chart plot for dynamic/PSD displacement, velocity, acceleration, stress and ERP

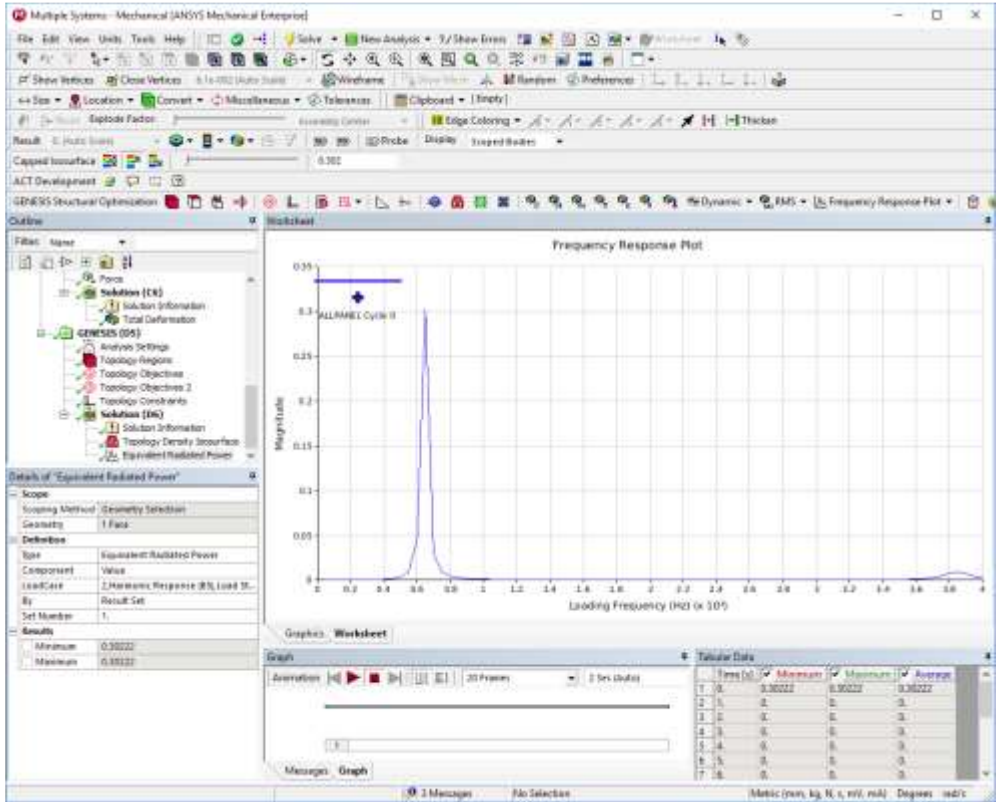
Post-processing Enhancement

- Example: RMS von mises stress



Post-processing Enhancement

- Example: ERP frequency response plot



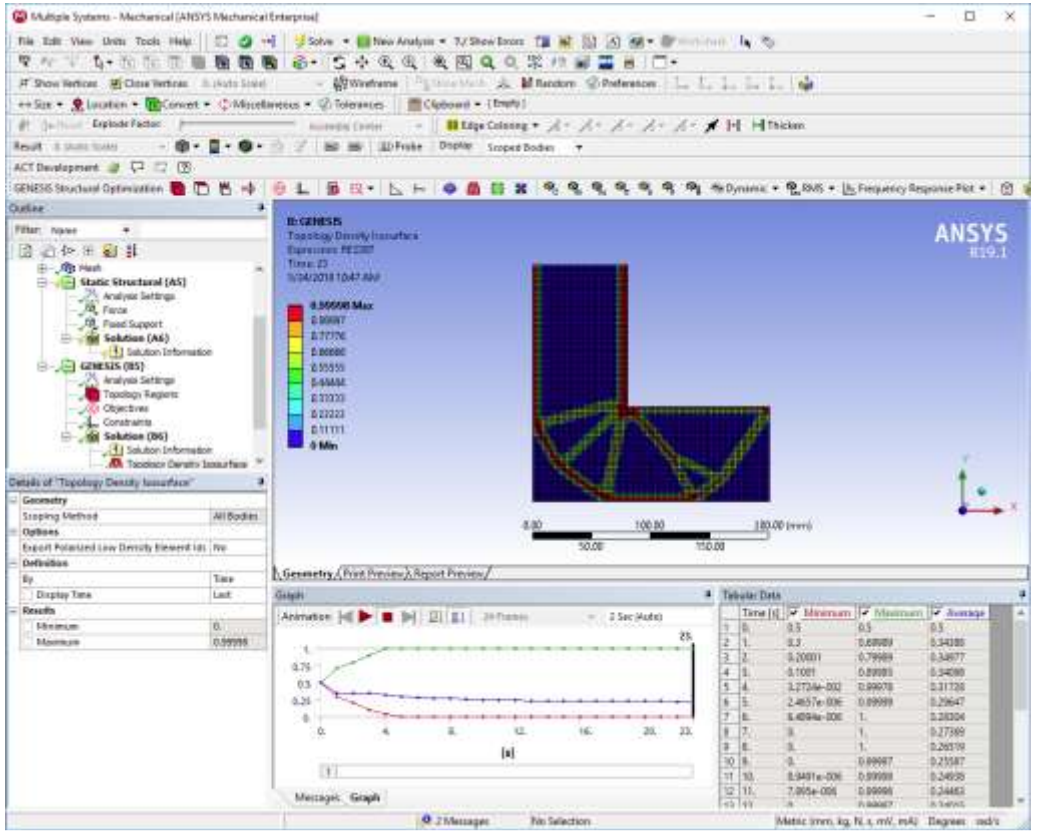
Post-processing Enhancement

- Support Importing Results for All Design Cycles
  - By default, the optimization results at all design cycles will be imported when post-processing.
  - The user can view an animation or view the results at each design cycle by going through all result sets
  - When viewing the animation, two options
    - Distributed

      Type in the total number of result sets as number of frames
      - For example, optimization ends at cycle 15, there are total 16 result sets including cycle 0
    - Result sets

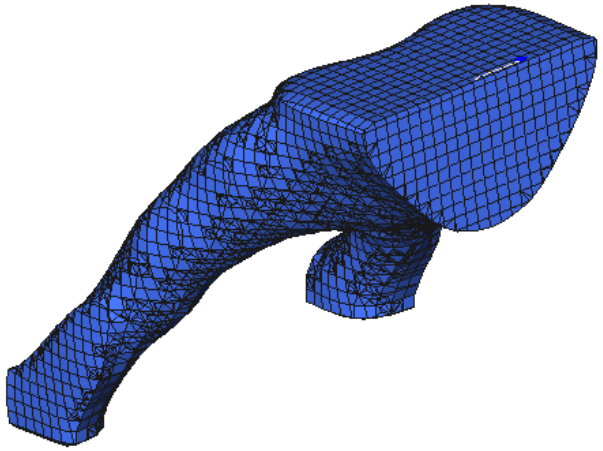
Post-processing Enhancement

- Support Importing Results for All Design Cycles



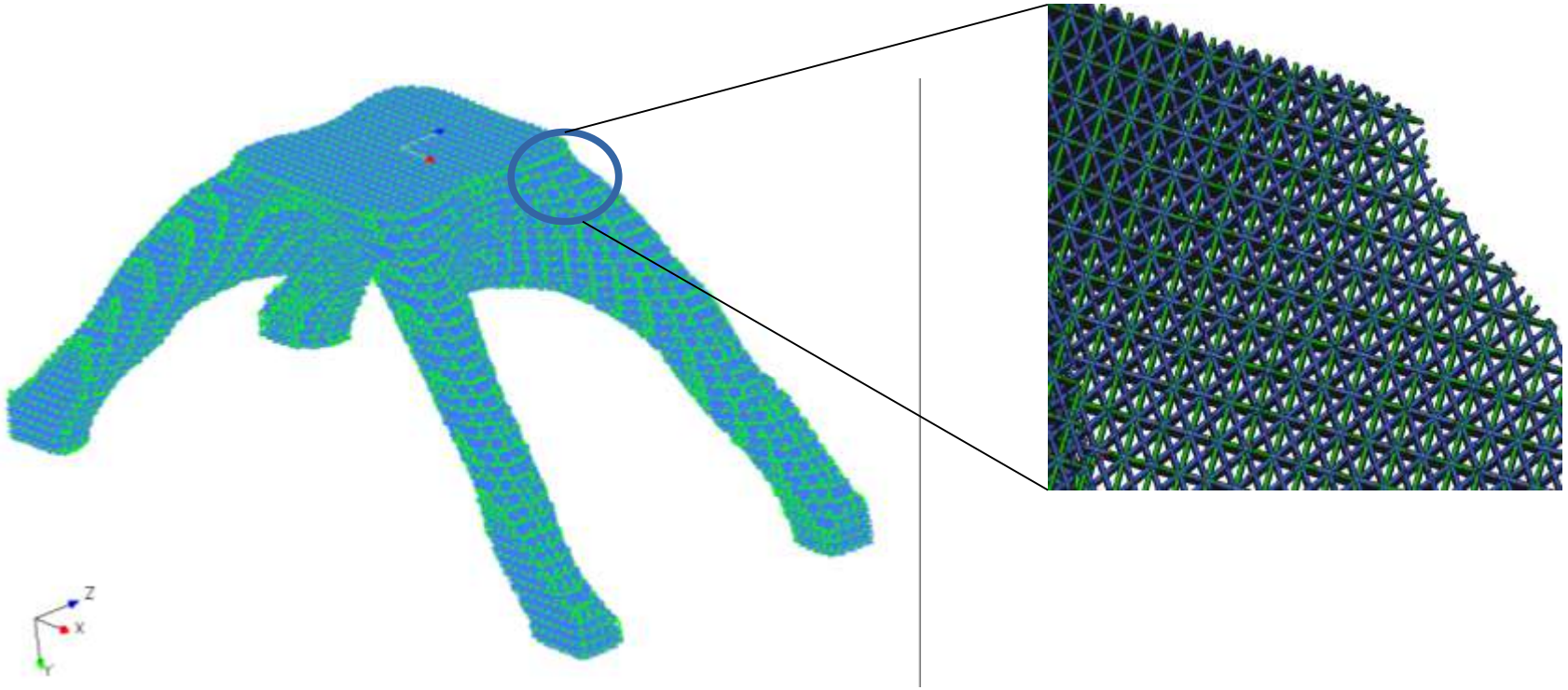
Solid only Mesh from Topology Result

Solid mesh created



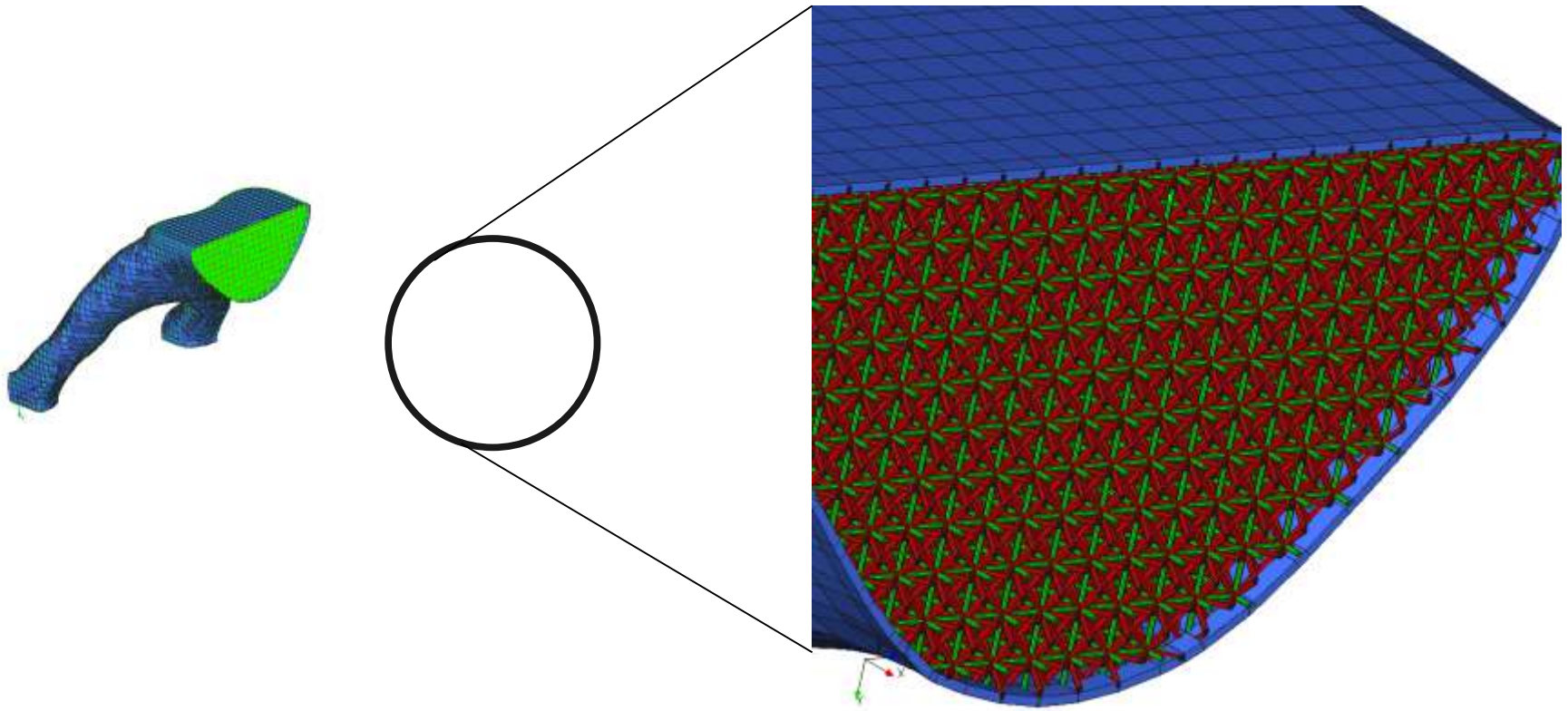
Cut section of the solid mesh created

Lattice only Mesh from Topology Result



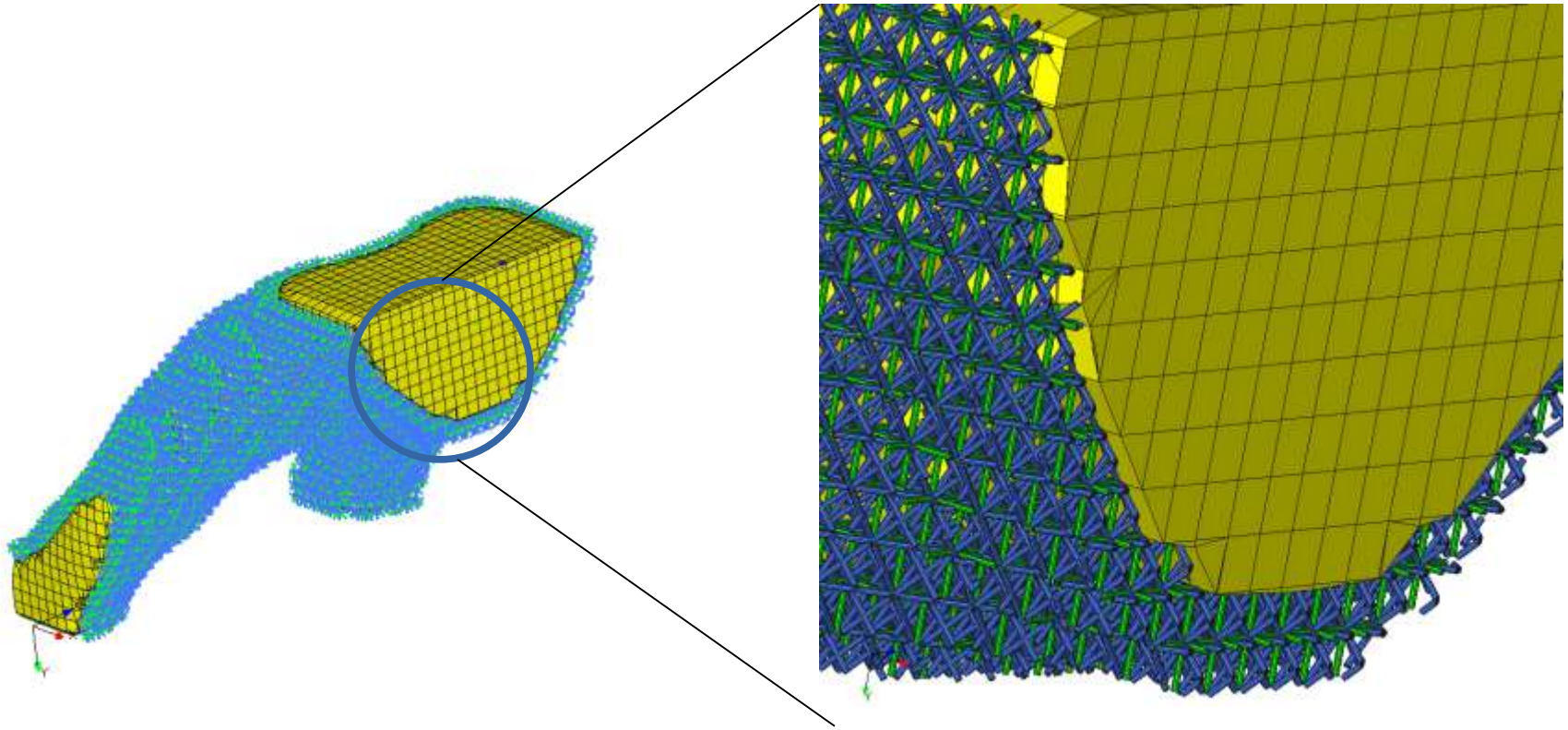
Lattice mesh created

Lattice+Skin Mesh from Topology Result



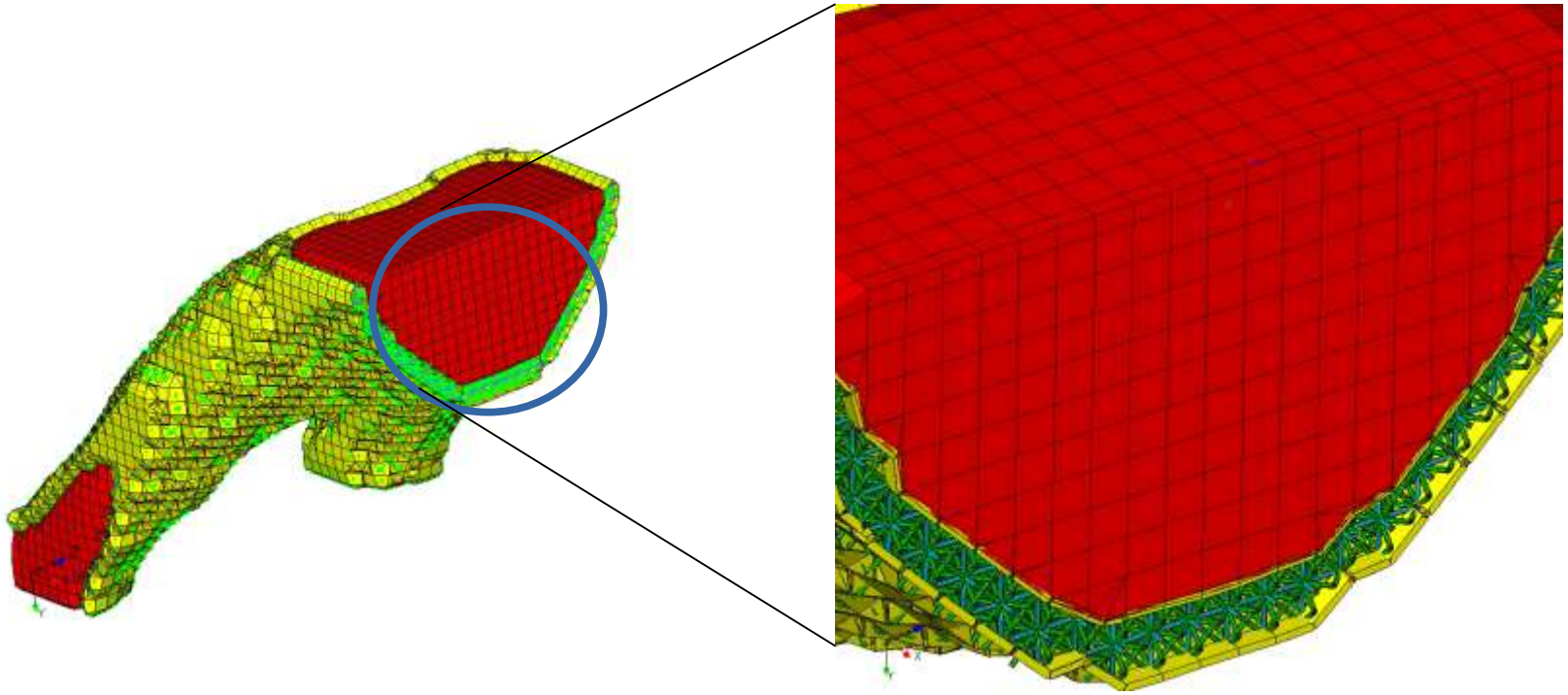
Cut section of the lattice+skin mesh created

Lattice+Solid Mesh from Topology Result



Cut section of the lattice+solid mesh created

Lattice+Skin+Solid mesh from topology result



Cut section of the lattice+skin+solid mesh created