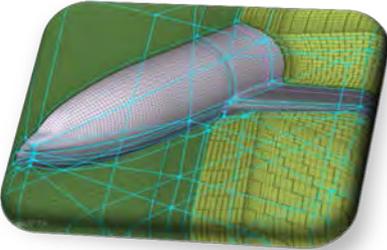# ANSA and META in AeroSpace Computational Mechanics
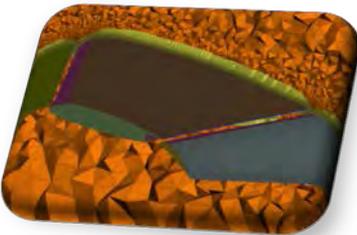
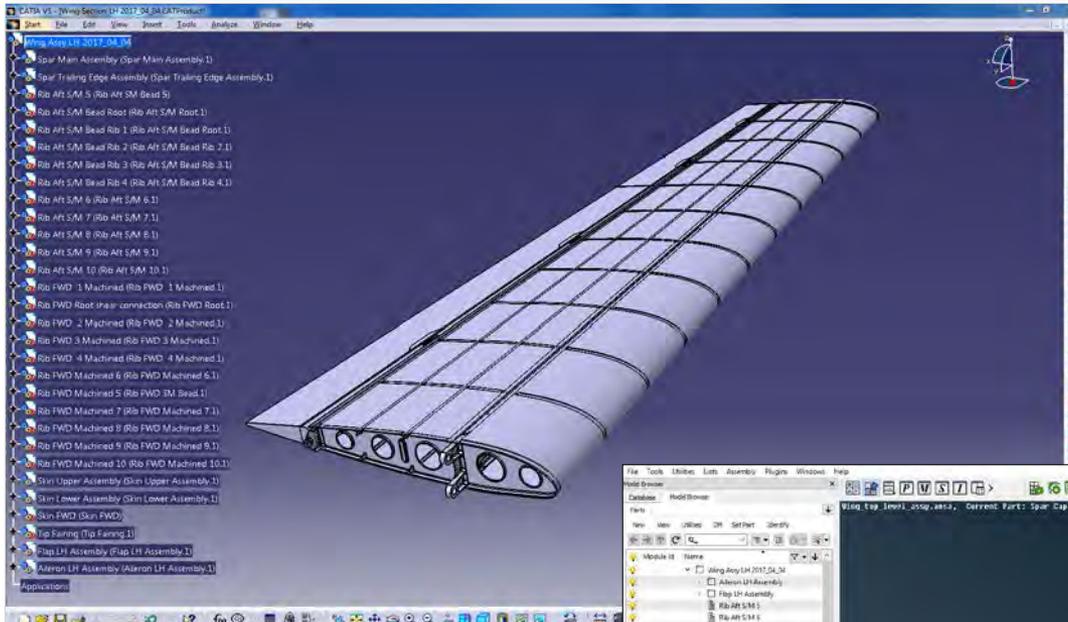physics on screen

BETA
SIMULATION SOLUTIONS
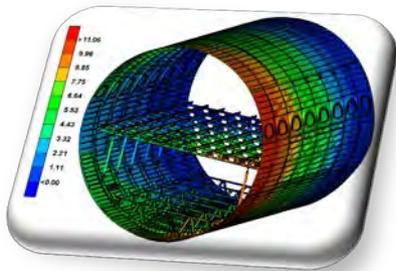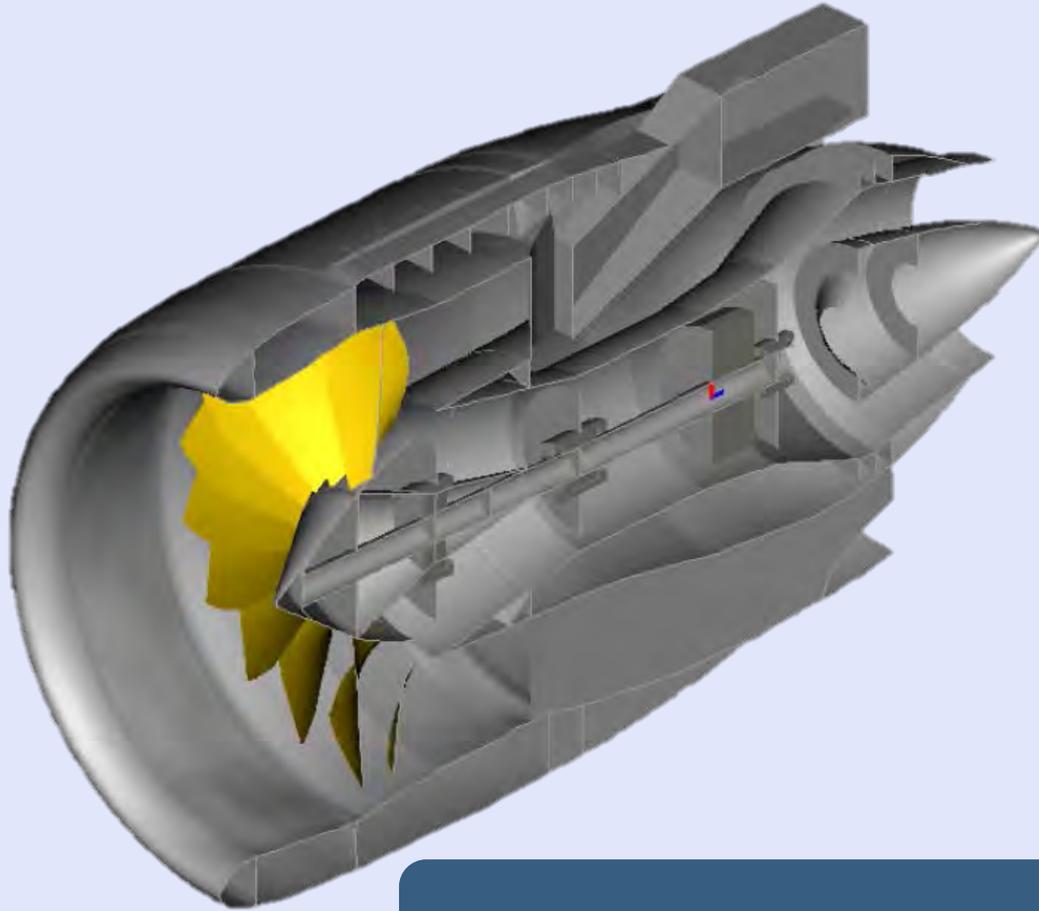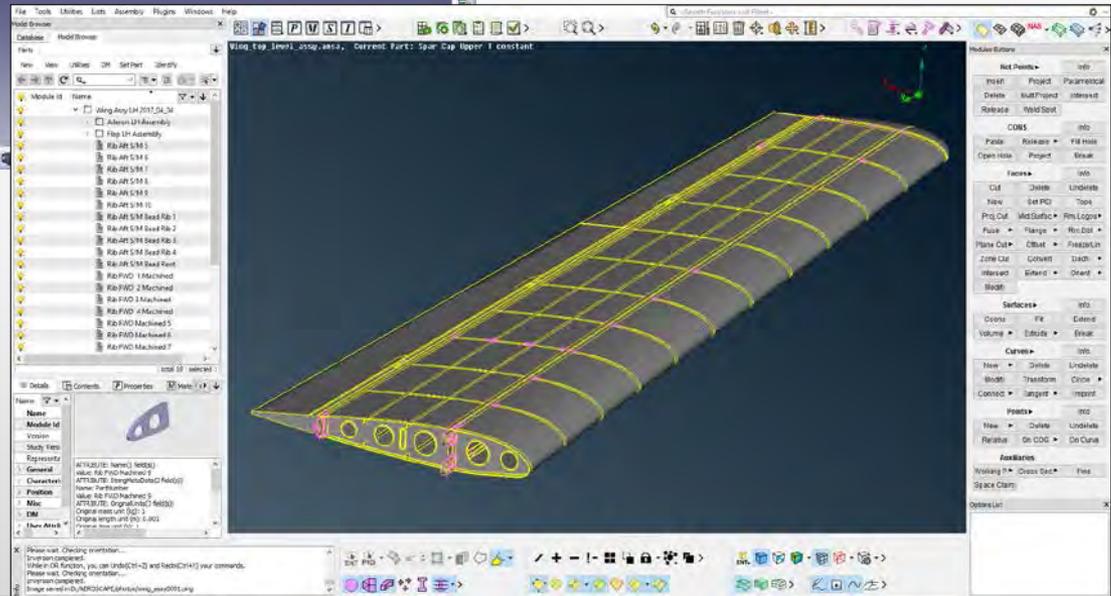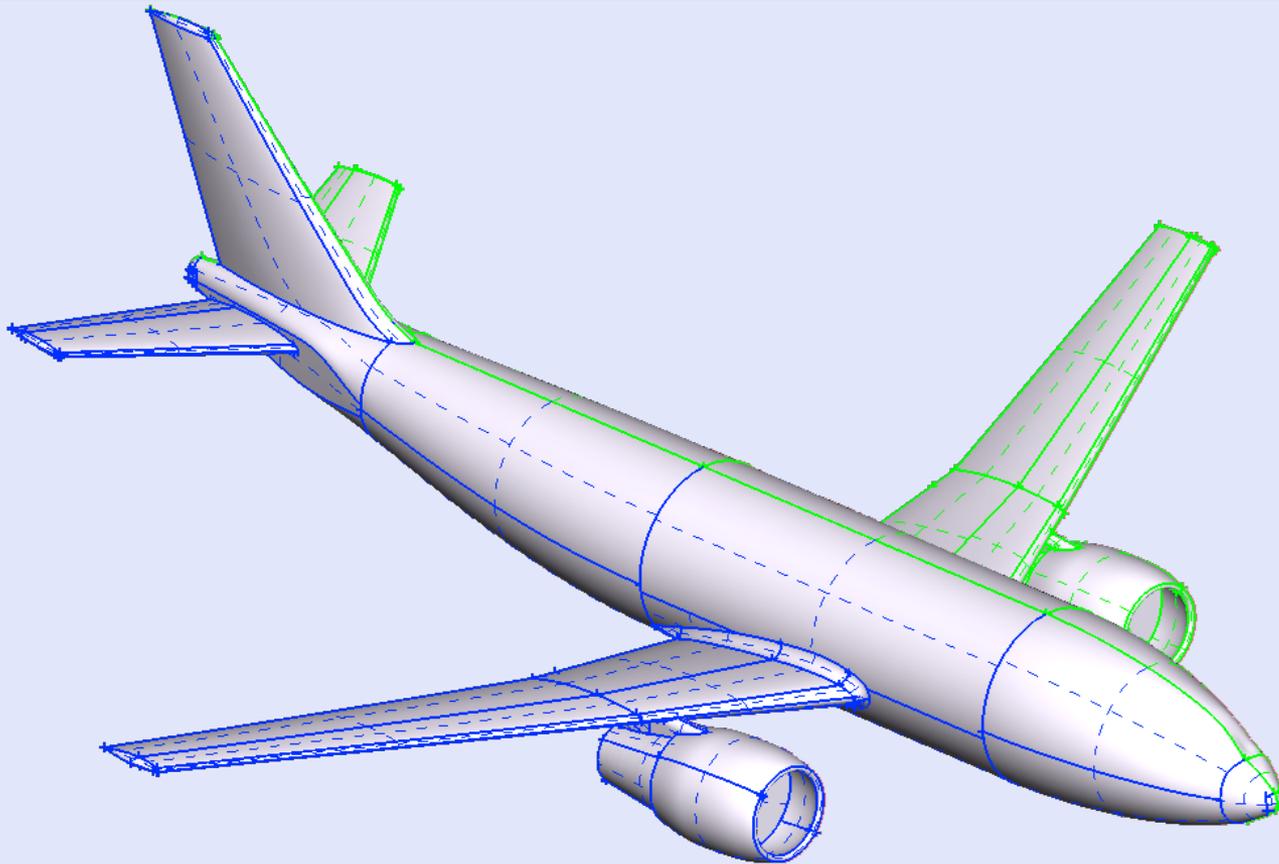
INTERFACES

Interfaces

...to

- Ready-to-run solver input files
- CAD files
- Tessellated data
- META Product Tree

From...

- CAD & PDM data
- Keyword files
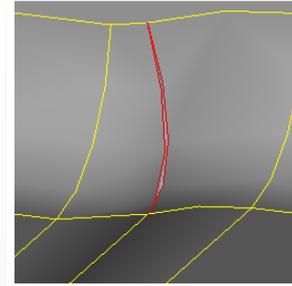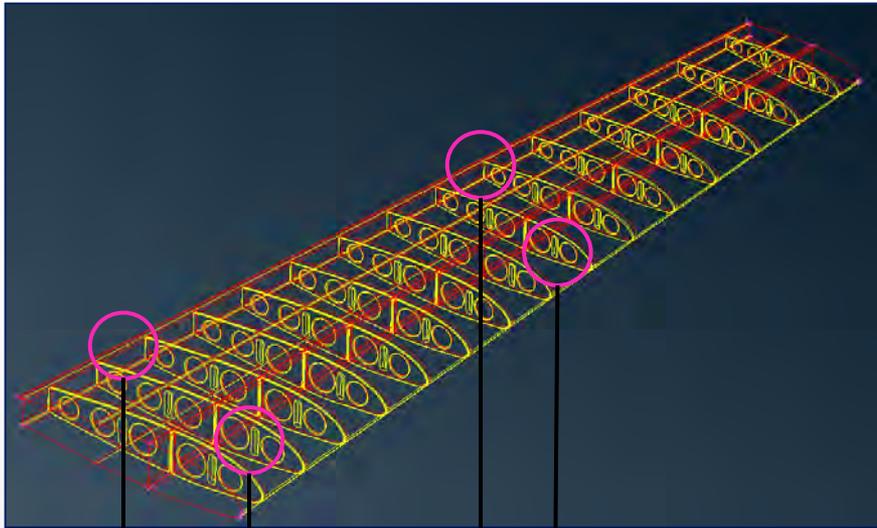- Tessellated data
- Other (e.g. Medina)

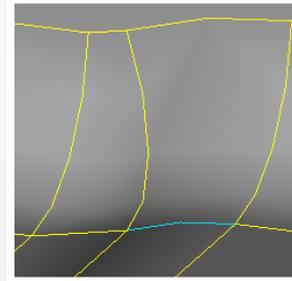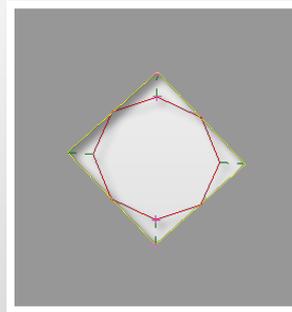**GEOMETRY**

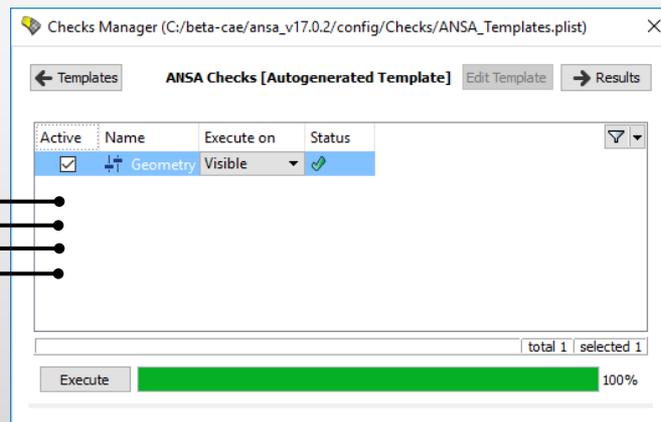# Geometry Checks
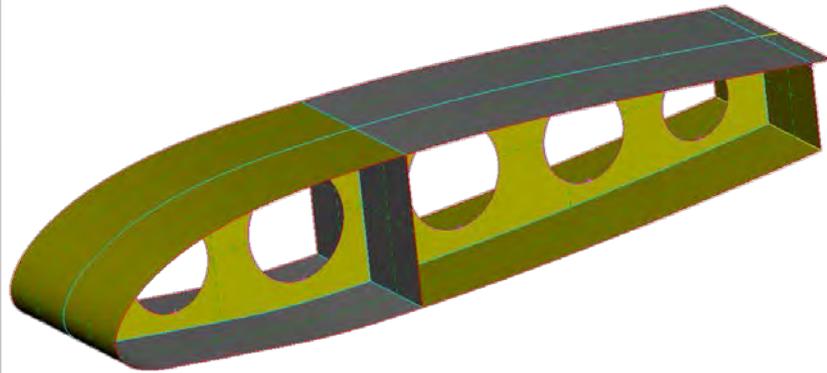
Geometry check for:

- Free Edges
- Cracks
- Overlap Faces
- Needle Faces
- Triple Edges
- Collapsed Edges
- Distorted Faces
- Unmeshed Areas

Cracks

Needle Faces

Distorted Faces

Geometry

Geometry
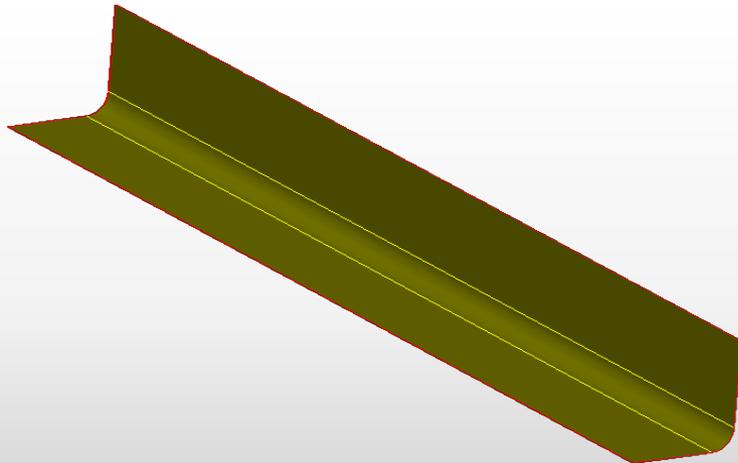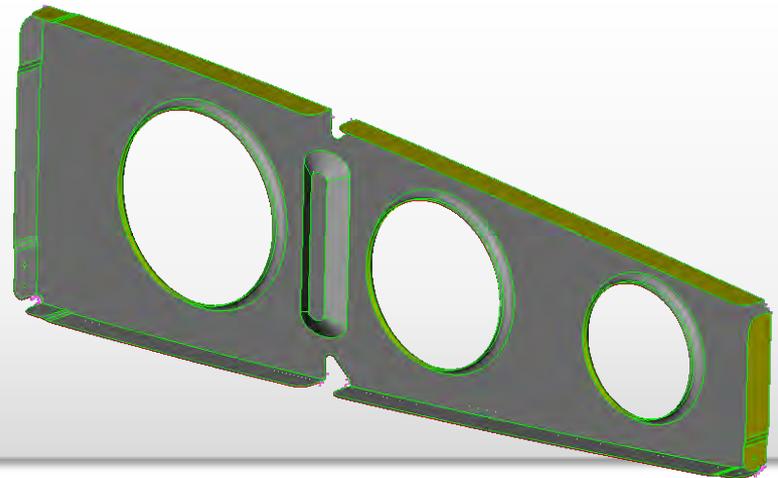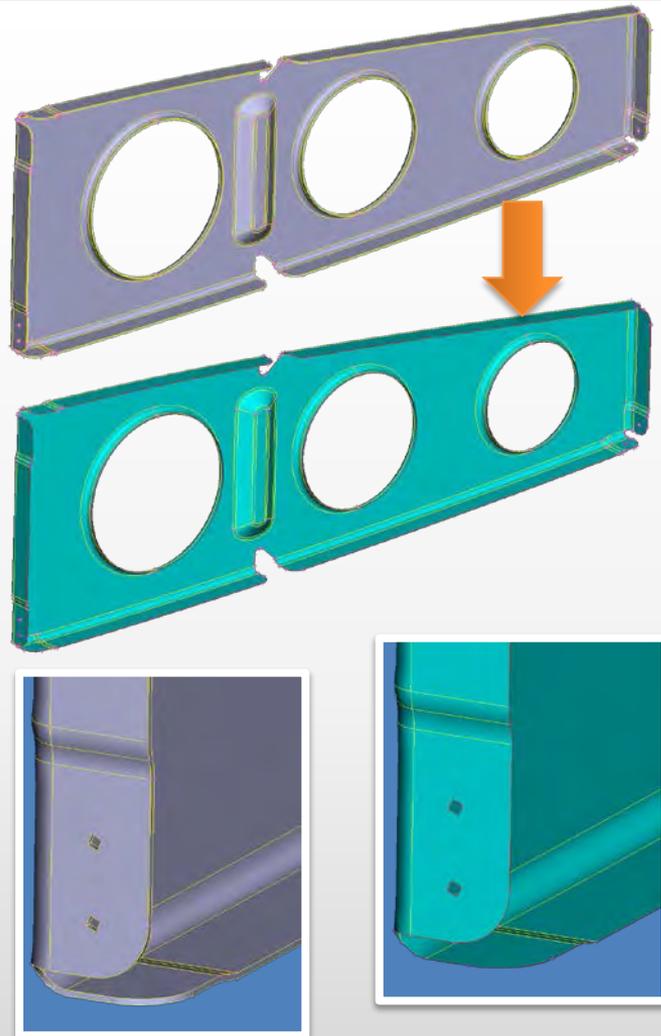
Geometry

- Fully automated process
- Assign nodal thickness
- Identification of ribs - base
- Assign properties according to element thickness

Geometry

Isolate

Flanges, Ribs, Radius, Washers, Skin, Exterior, Logos, etc...
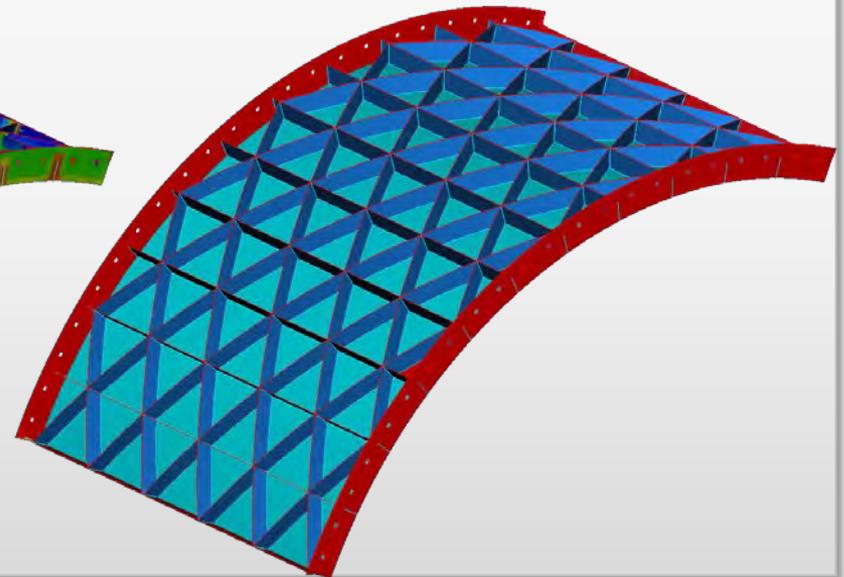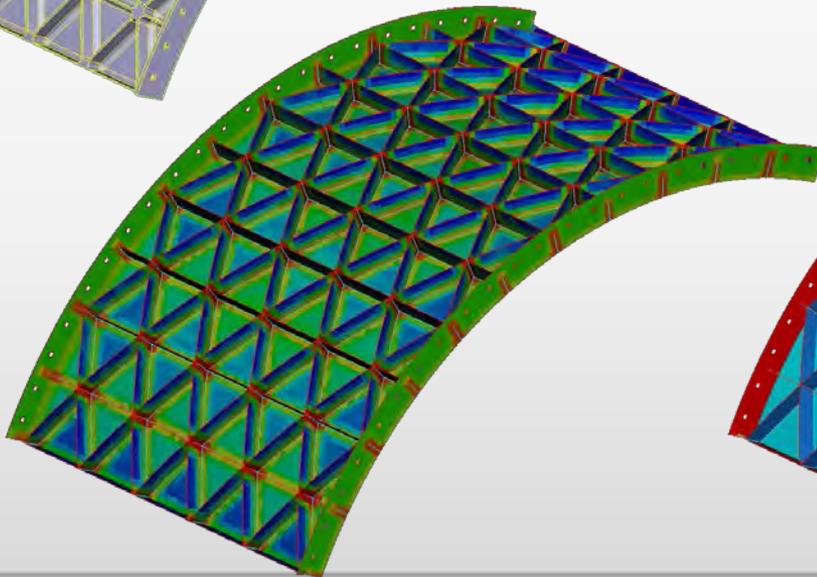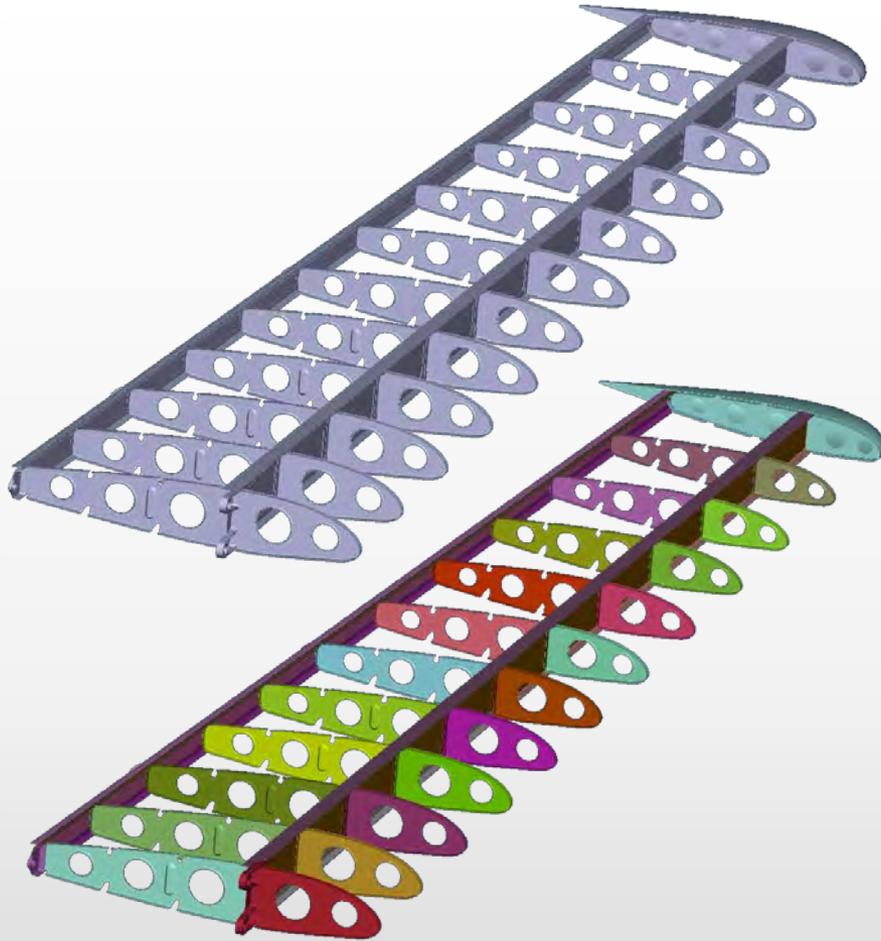
Isolate Ribs
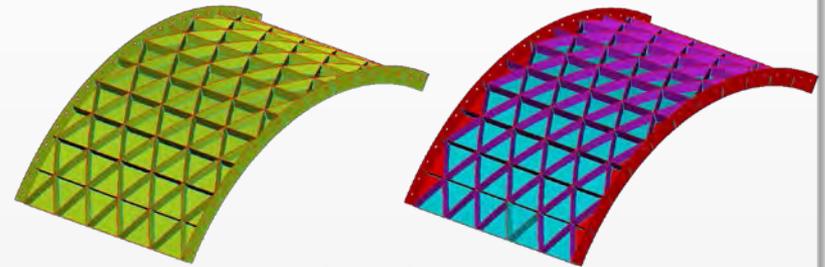
Isolate Connectivity Groups
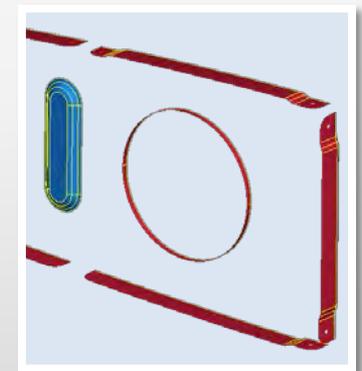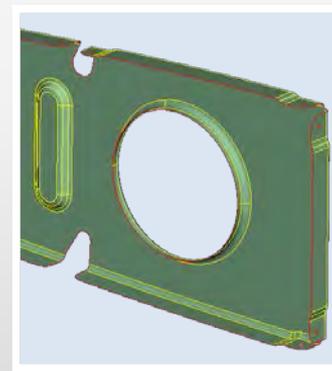
Isolate Flanges and Logos
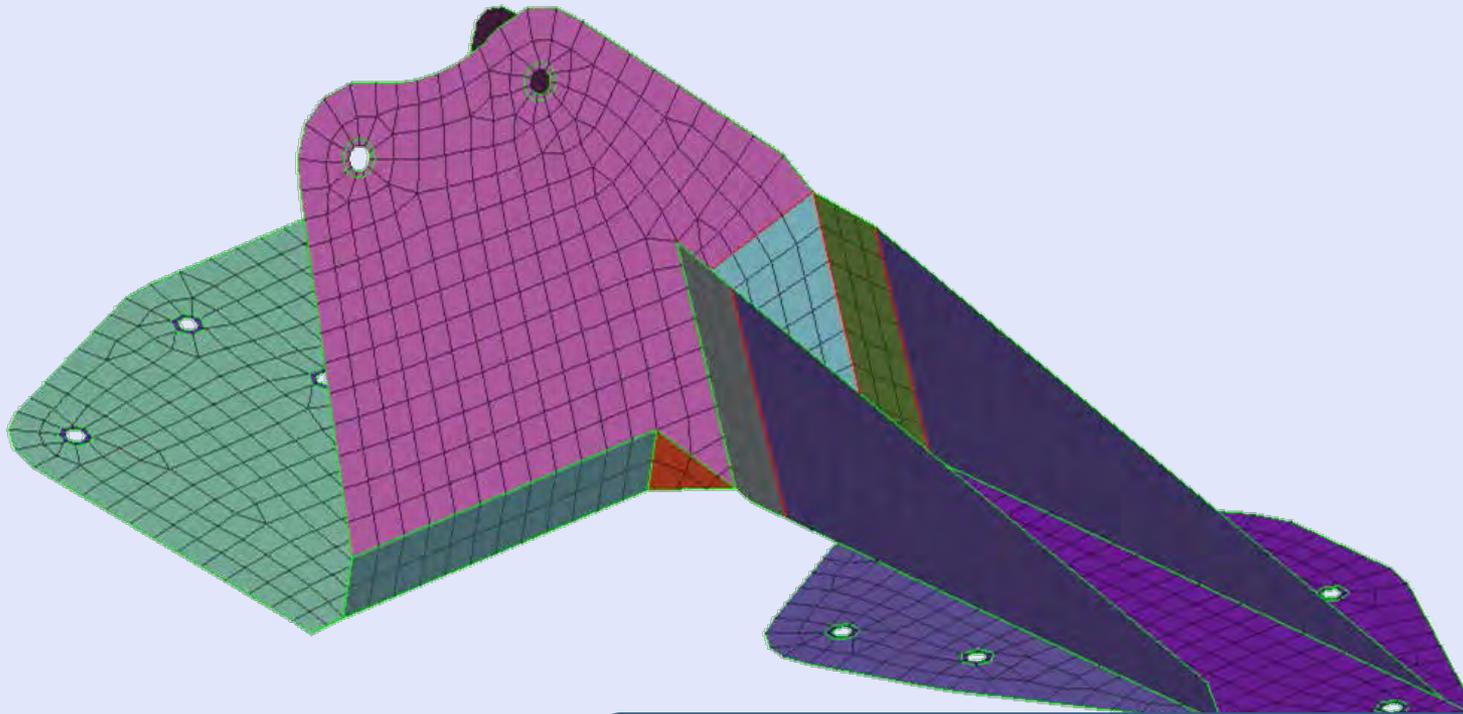
SHELL MESH

Shell Meshing Types

Surface Meshing

Structural Mesh for Solid components

CFD Meshing
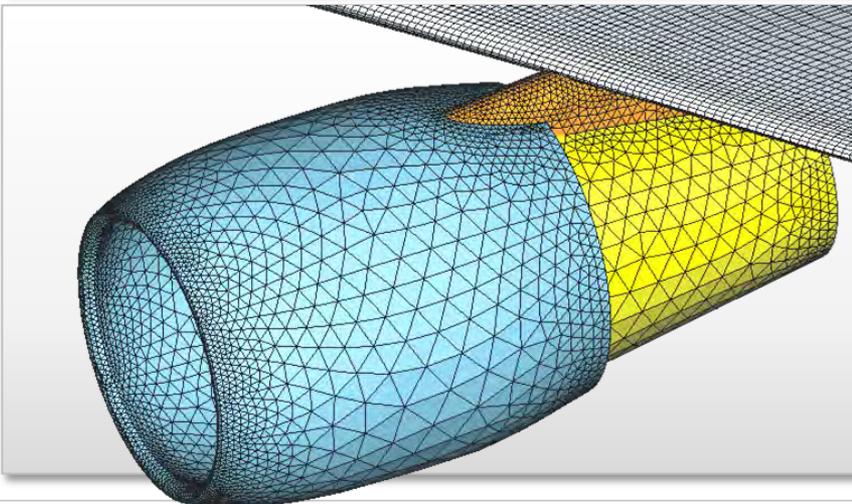
Wrapping
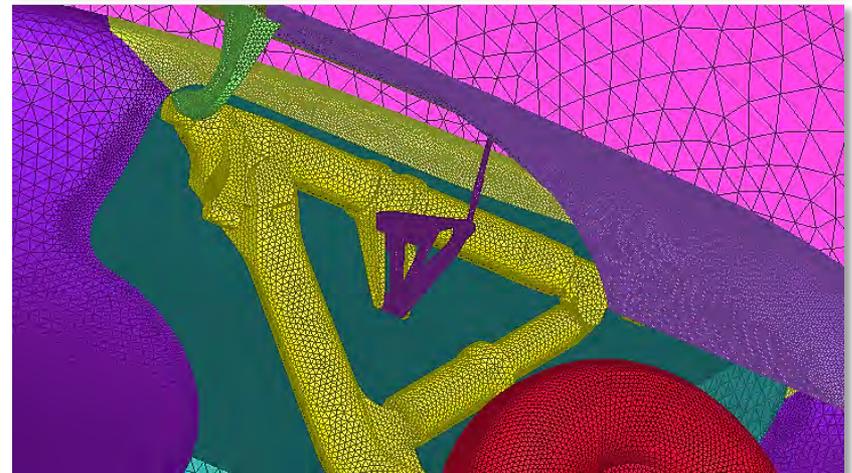
Shell Meshing

Quality Improvement

🟨	Aspect
🟩	Skewness
🟦	Warping
🟦	Taper
🟥	Min Length
🟥	Max Length
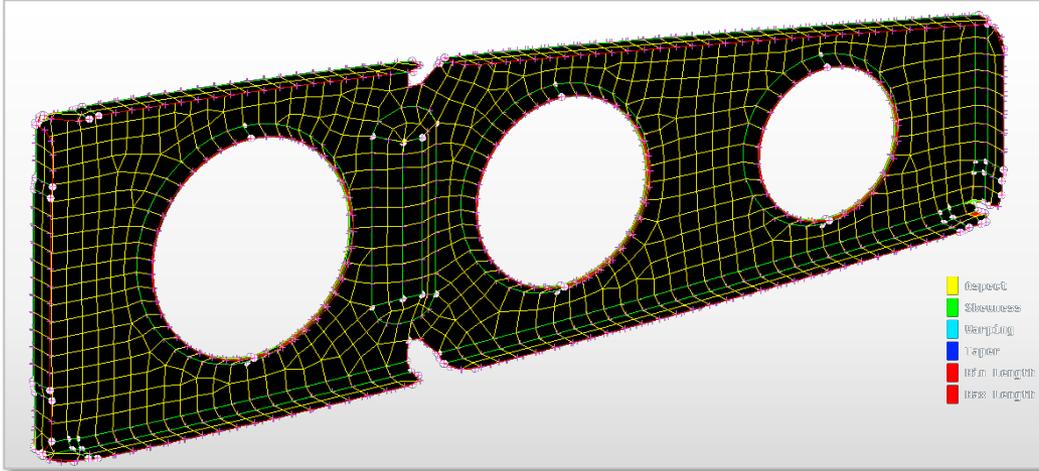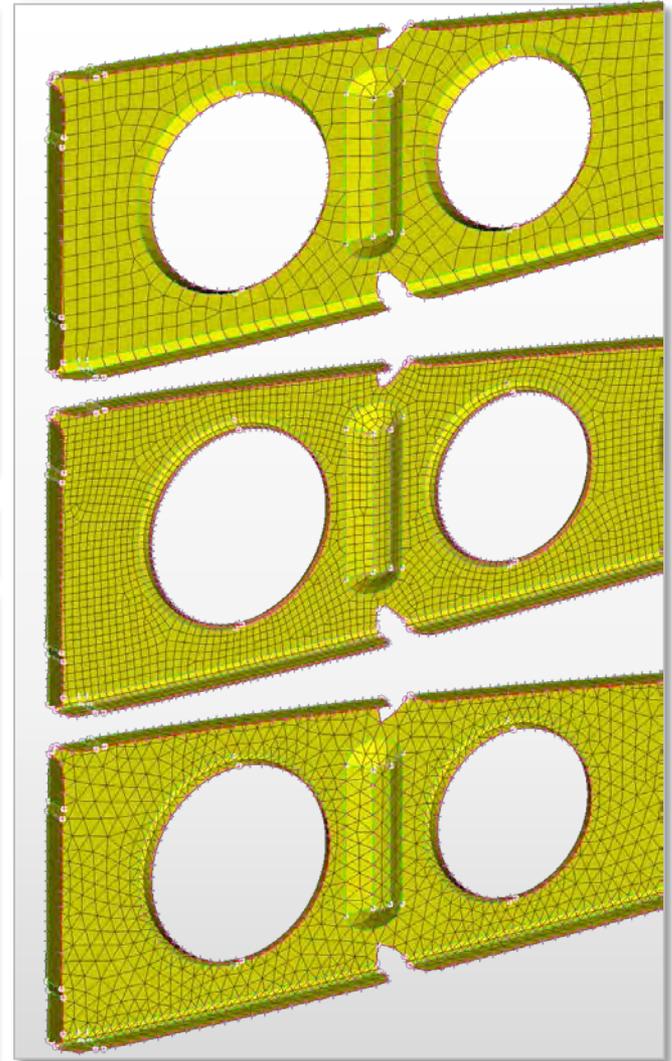
Meshing Features Simplify

Reconstruction
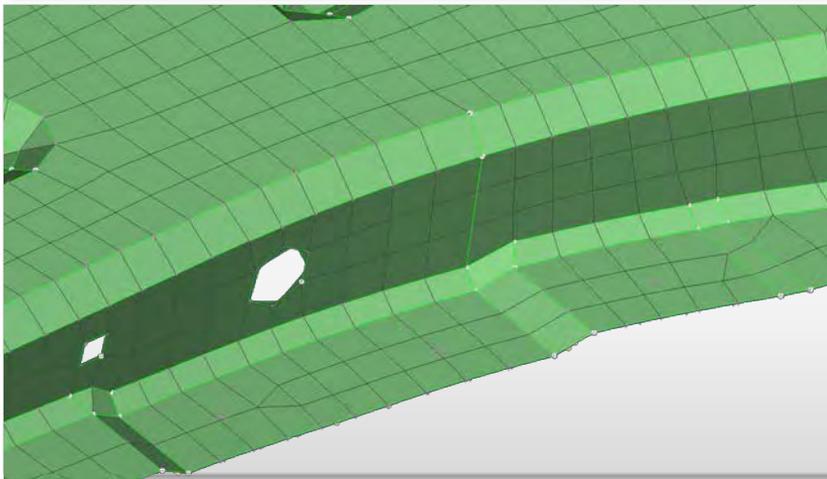
Shell Meshing

Batch Meshing
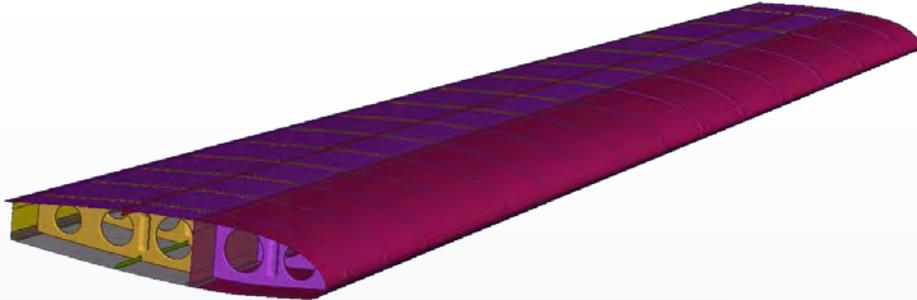
- Definition of meshing parameters and quality criteria

- Features treatment and model simplification

- Automatic meshing and quality improvement

Batch Mesh Manager

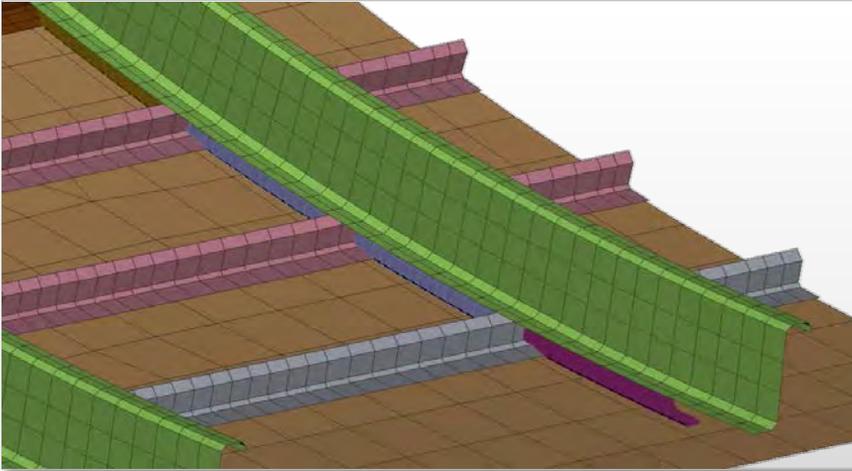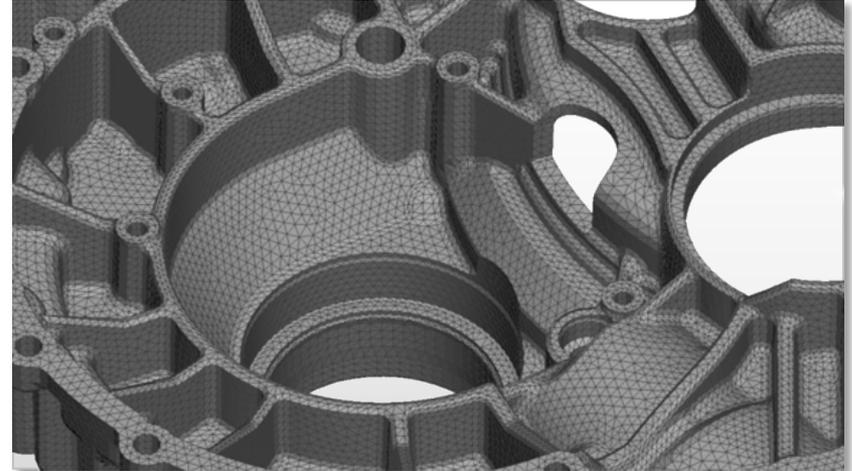| Name	Contents	Color	Mesh Parameters	Quality Criteria	Status
☑ **Meshing_Scenario_1**	**17**				**Completed**
☑ Session_3	4		50mm	Untitled	Completed
☑ Session_2	4		15mm	Untitled	Completed
☑ Default_Session	9		15mm	Untitled	Completed

New Read Scenario Autoload Run ☑ Update status
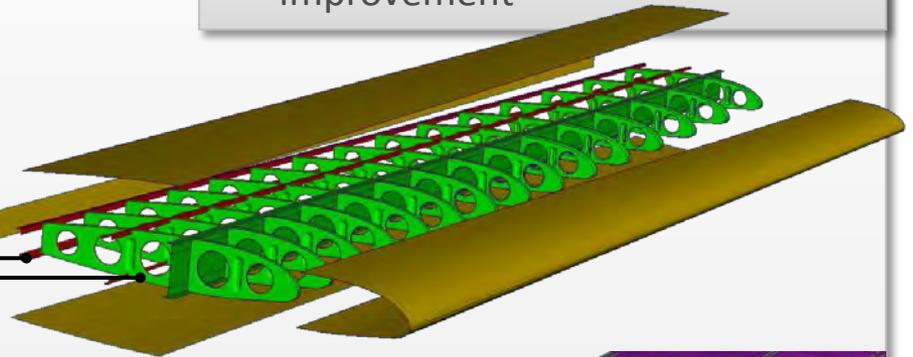
Feature treatment
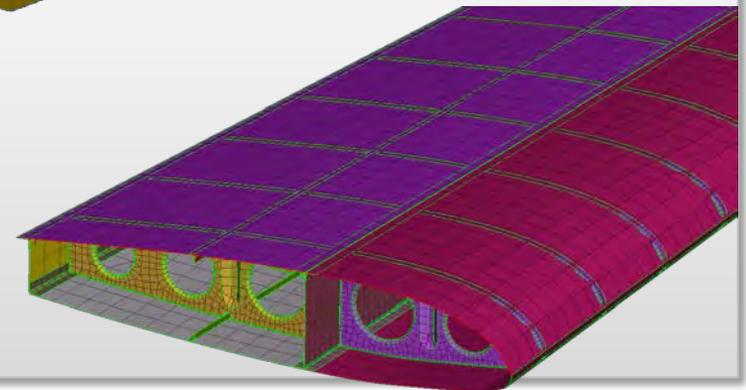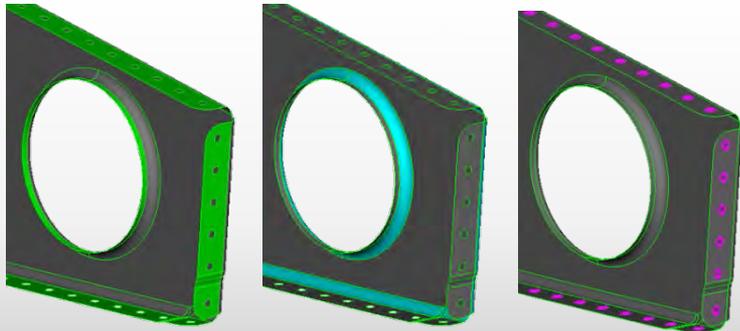
Shell Meshing
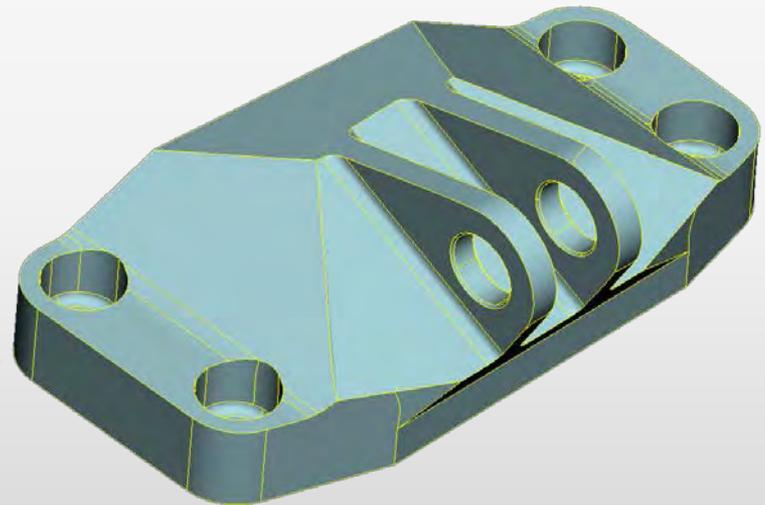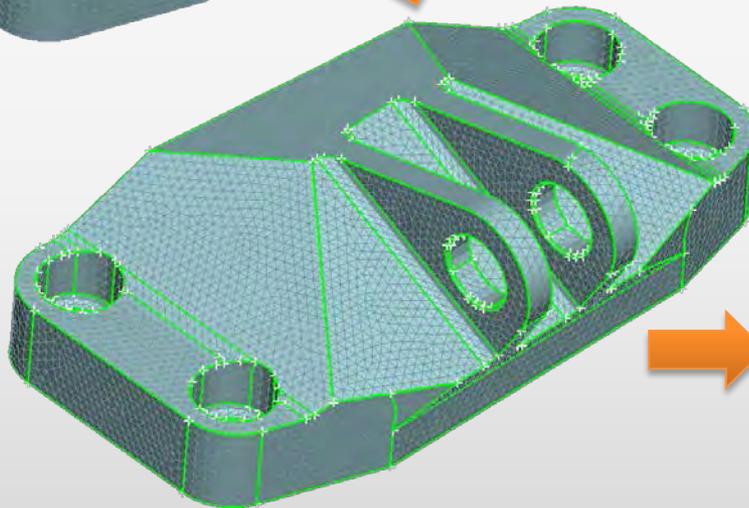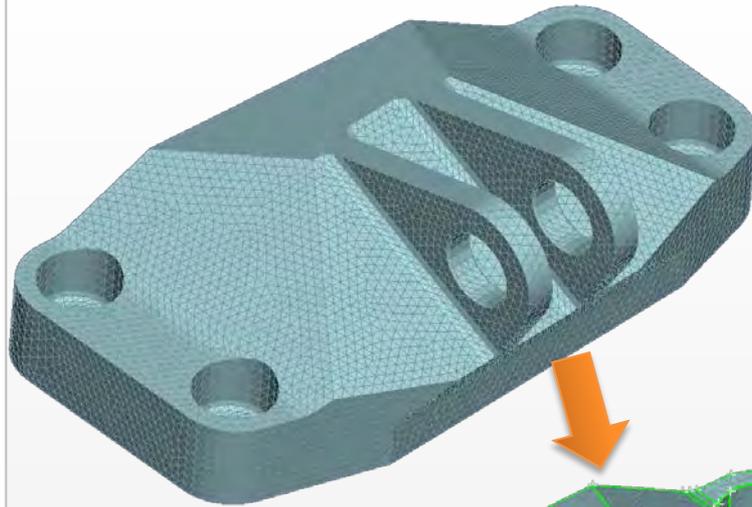
- Automatic definition of geometry from the FE Model
- Faces creation in respect of the model features

VOLUME MESH

Volume Meshing

Unstructured Mesh: Tetra
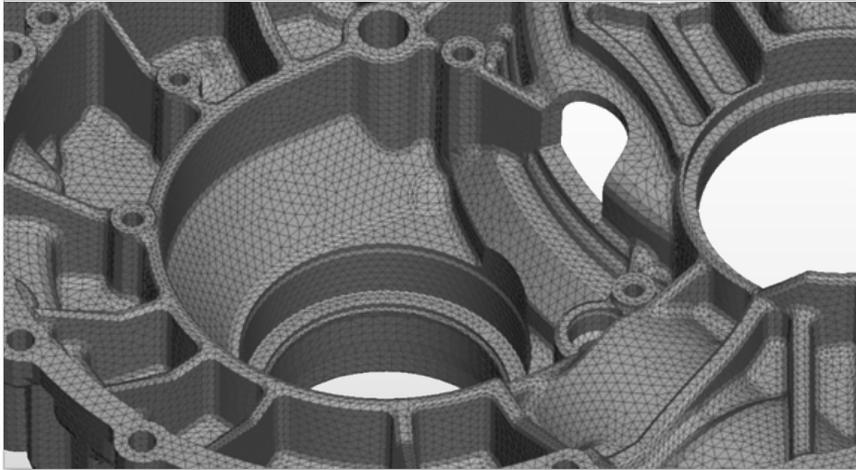
Structured Mesh: Hexa
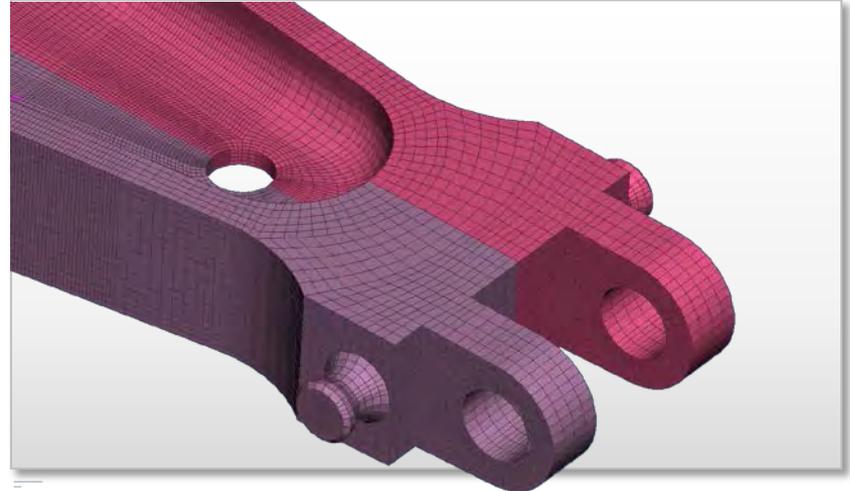
CFD Mesh
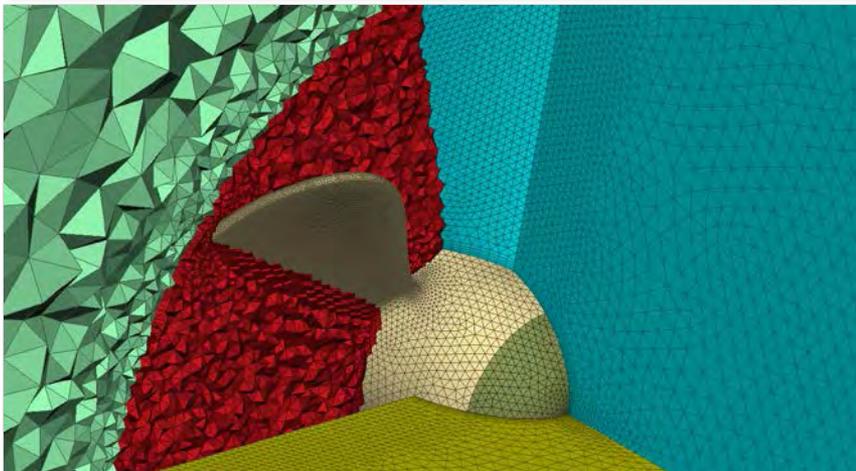
Polyhedral Mesh
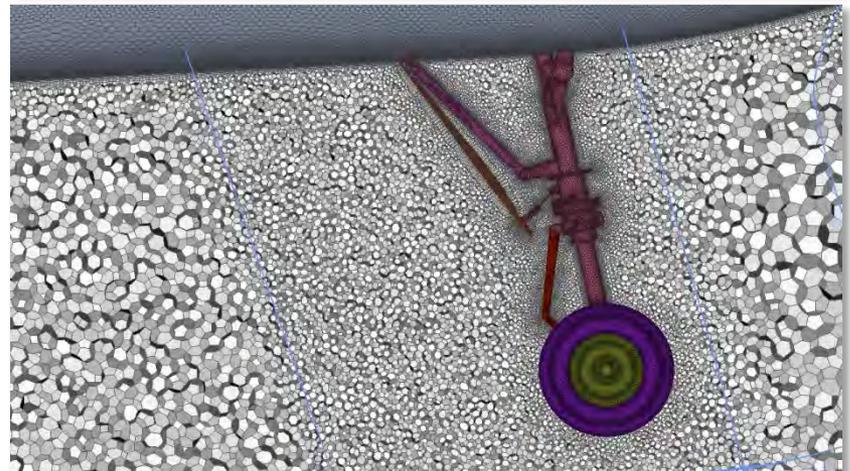
Volume Meshing
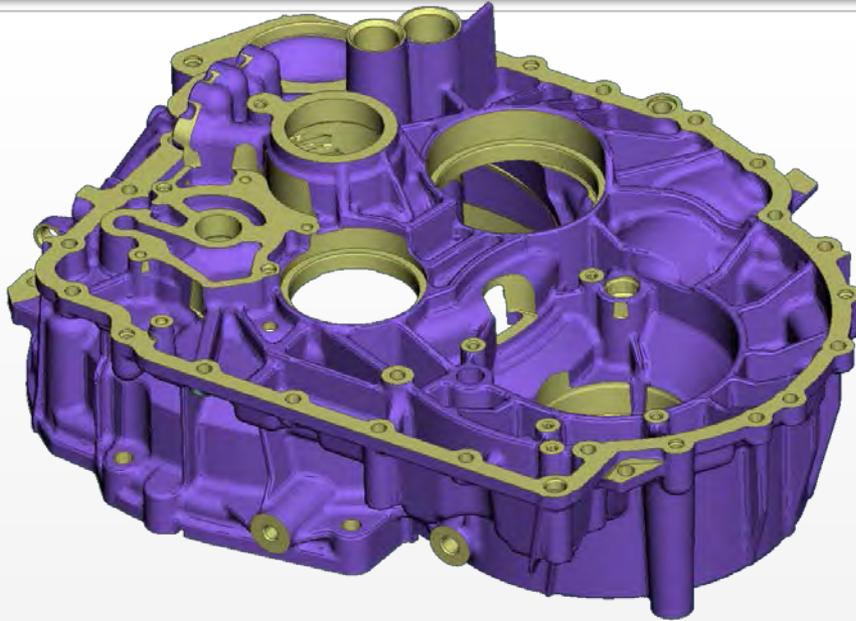
- Automatic defeaturing
- Mesh quality control
- Feature treatment
  - Tubes
  - Fillets
  - Sharp Edges
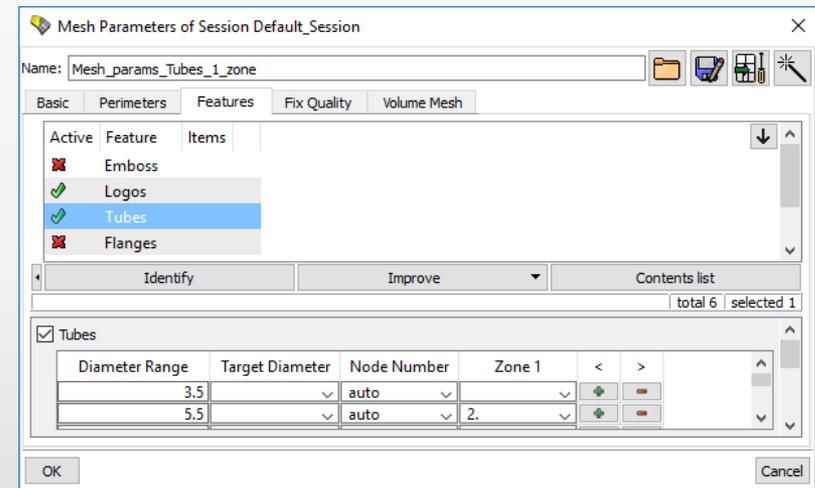
Feature treatment
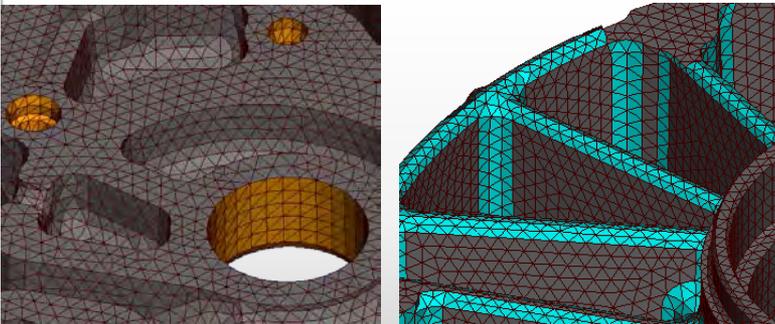
Hexa Block Tool

Structural models
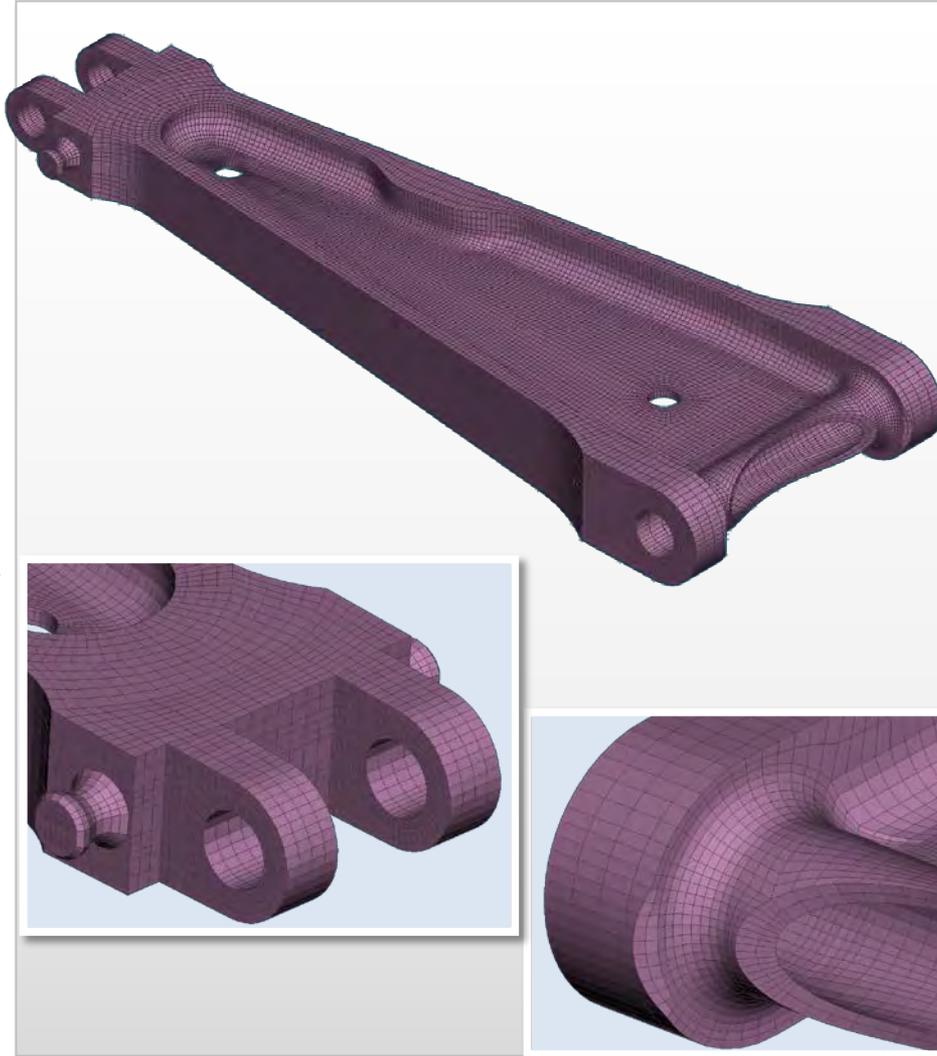
Element zones generation
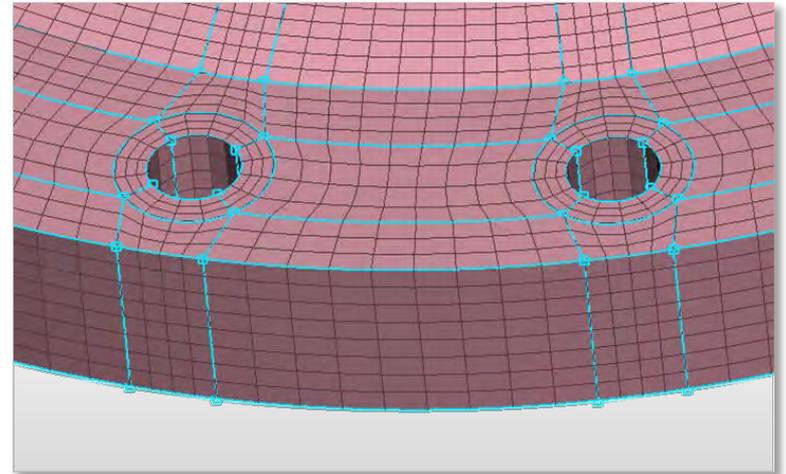
C/L type structure generation
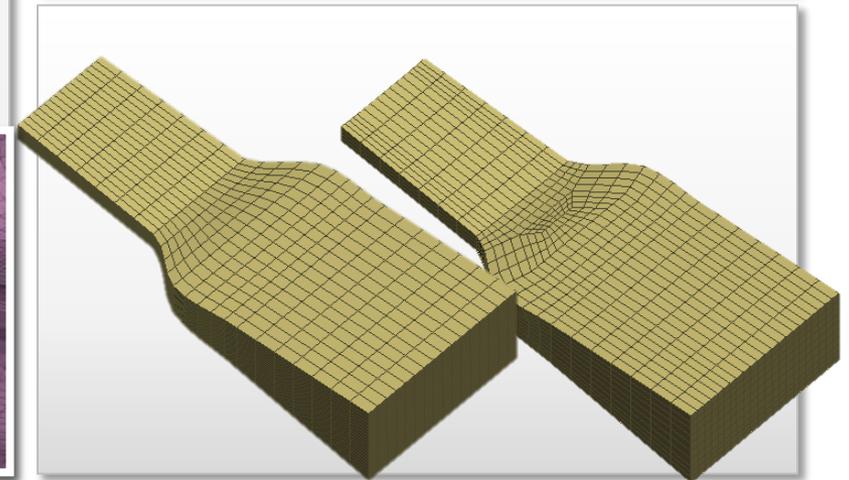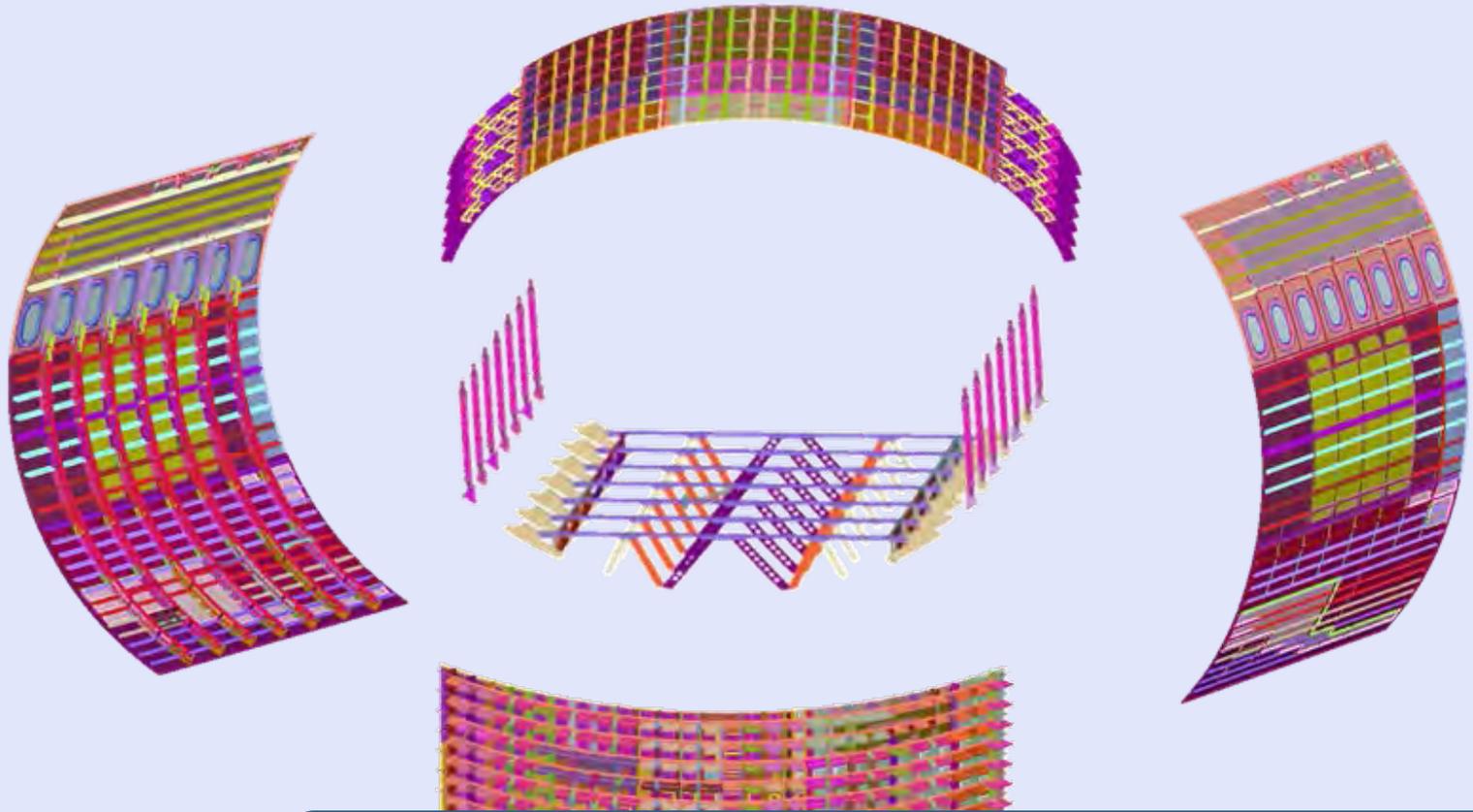
ANALYSIS TOOLS

Analysis Tools

Shell to Beams Stiffeners replacement
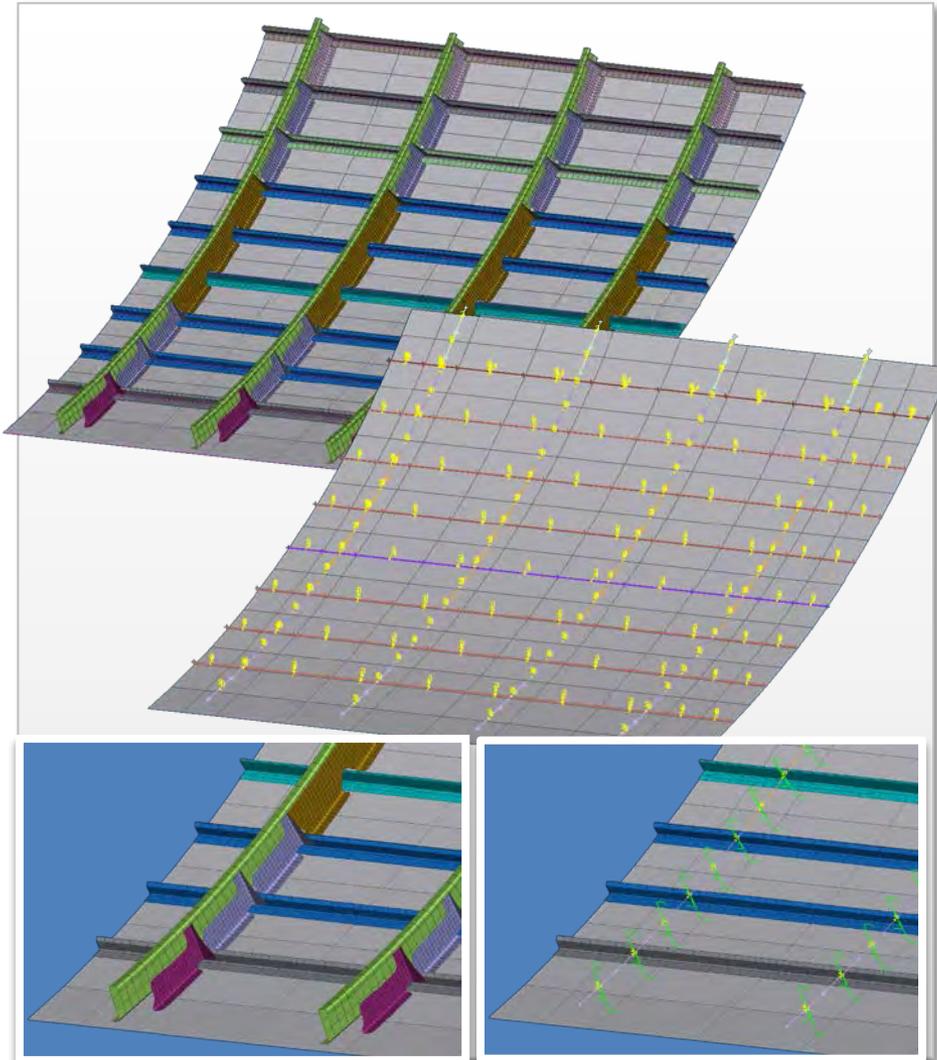
Beam Stiffeners definition

Create Beam Reinforcements

☐ Flip path direction

Orientation vector	Fixed
dx	0.00004
dy	-0.98231
dz	-0.18728
Rotate vector (deg.)	180.

OK   Preview   Cancel
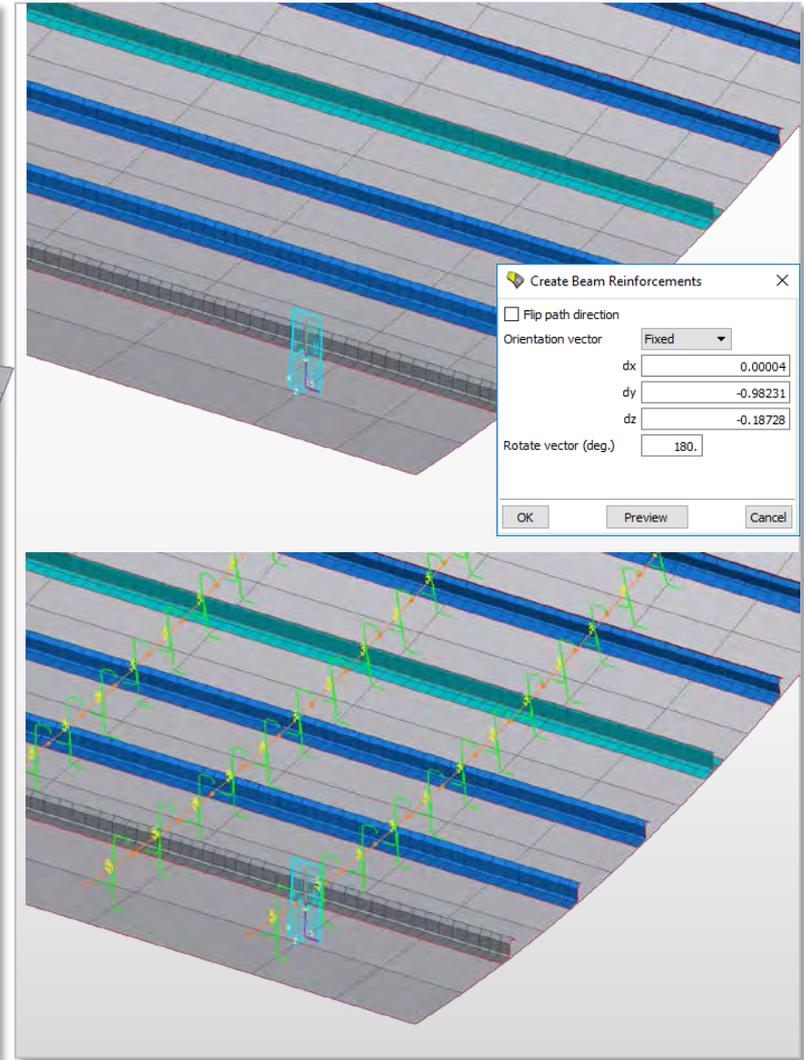
Analysis Tools

Reconstruction of shell – beam panels
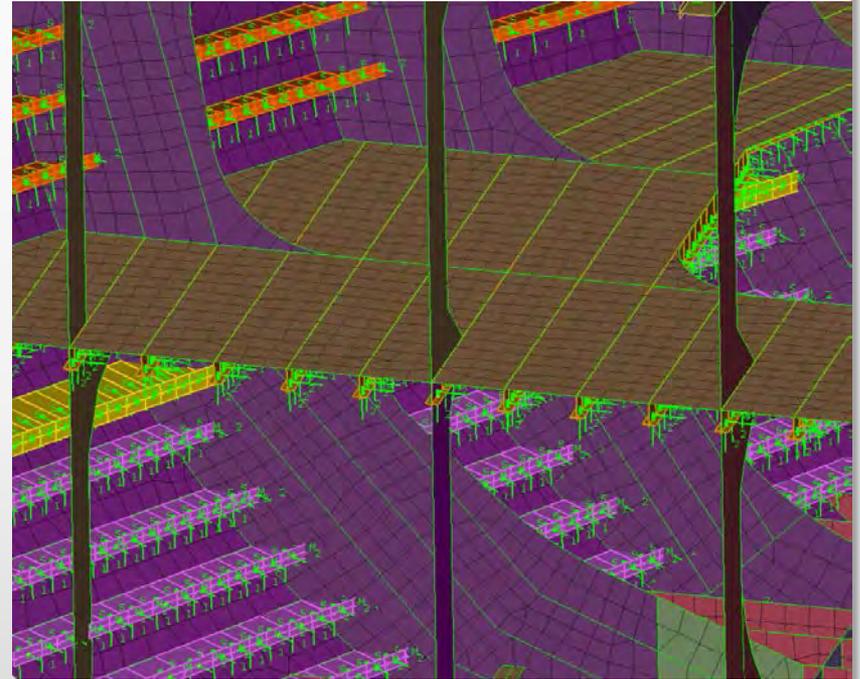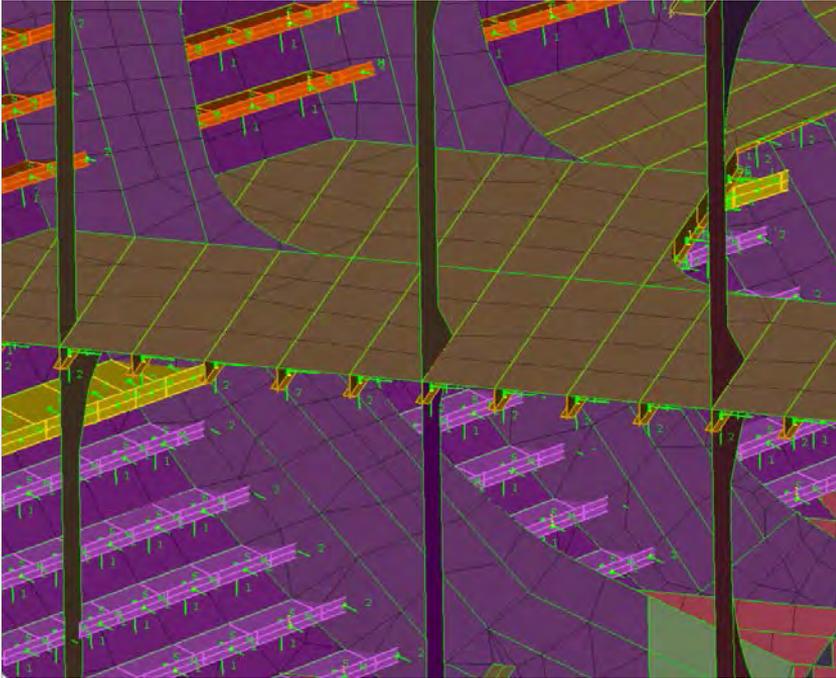
Analysis Tools

Directional re-numbering
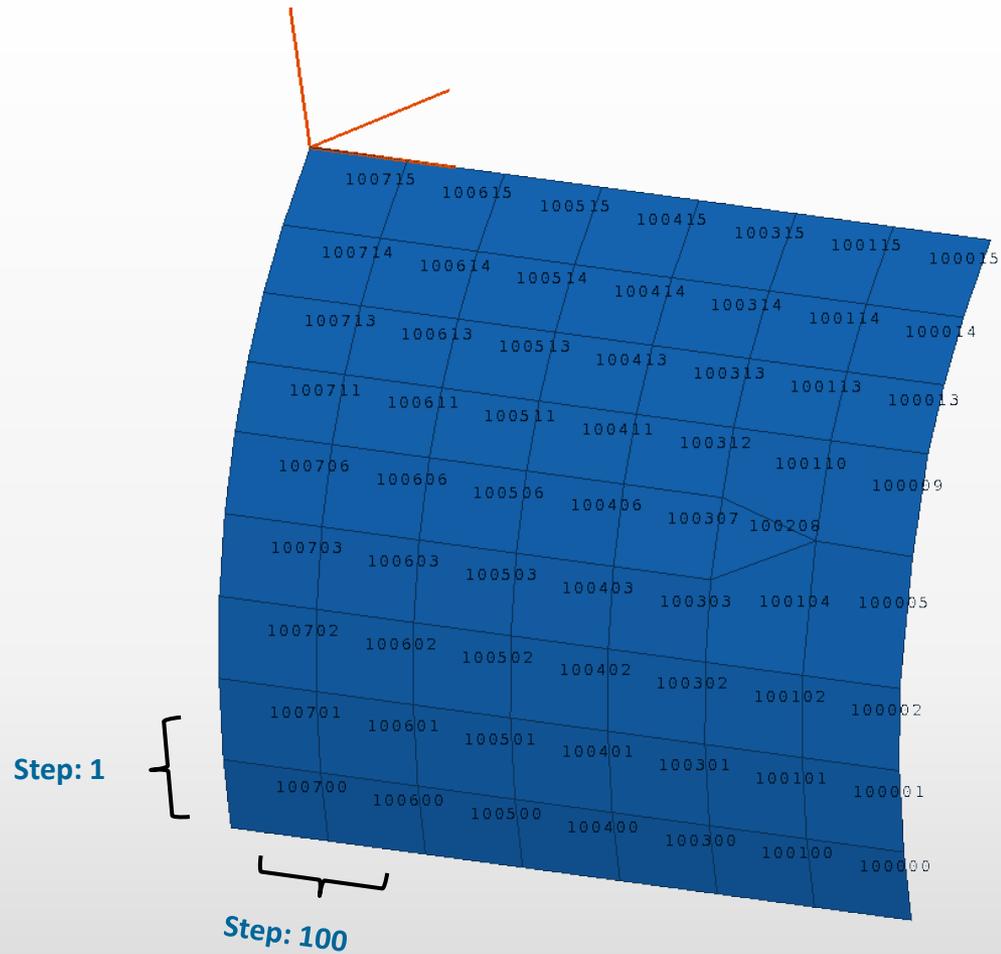
Analysis Tools

Crack Propagation Tool

- Easy set up through wizard
- EPILISYS / NASTRAN solver selection
- Read in cyclic loads (spectrum file)
- Works on multiple cracks
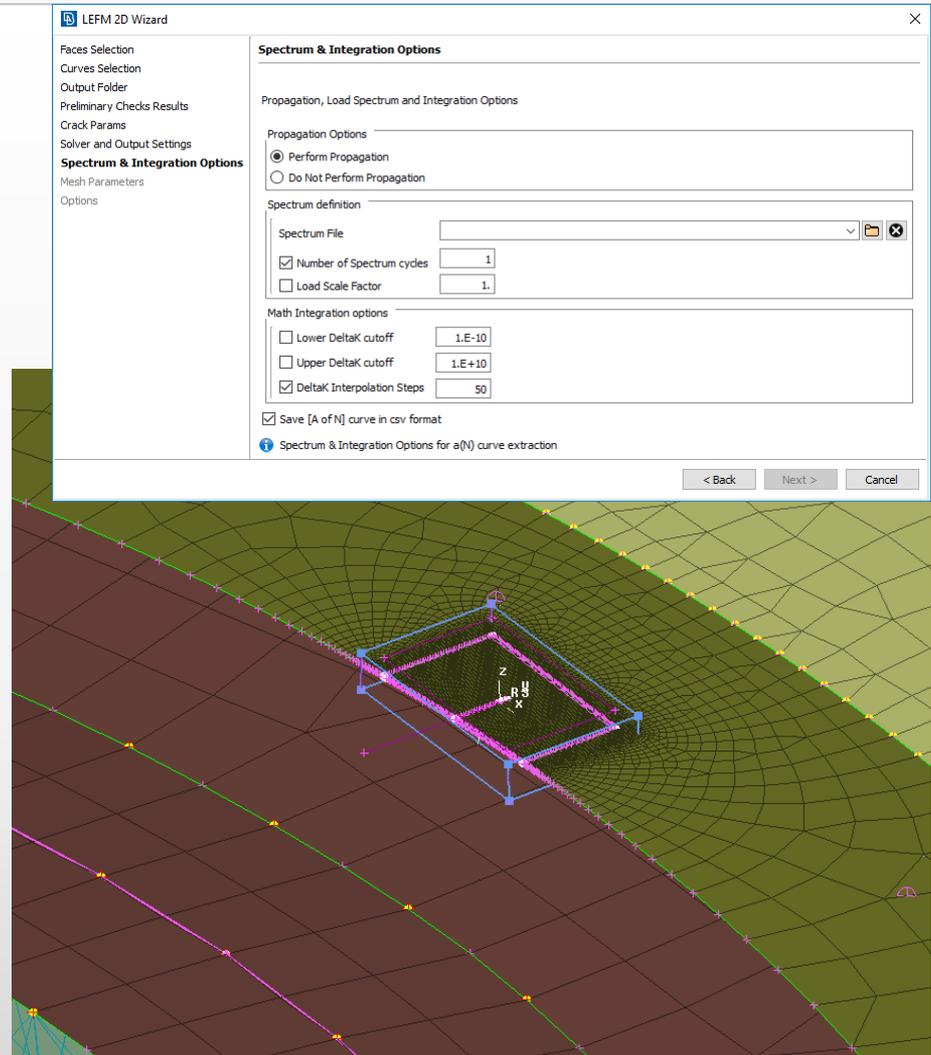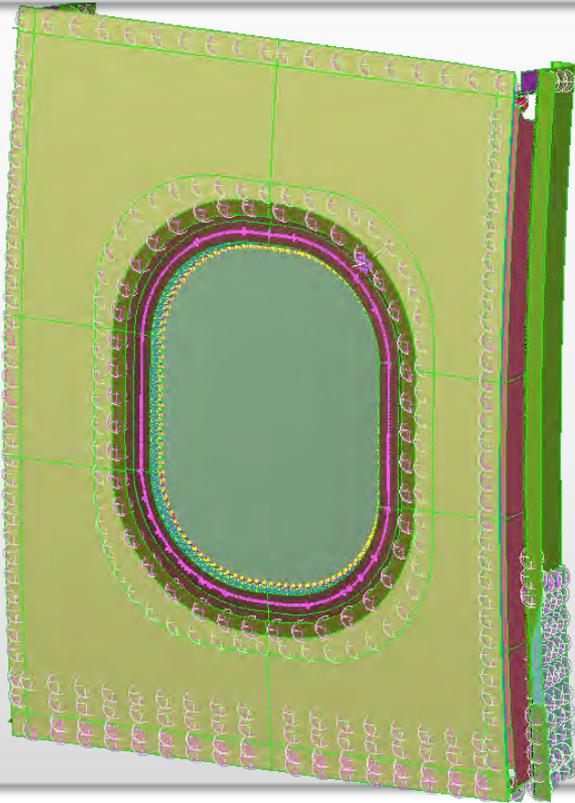
Analysis Tools

Crack Propagation Tool
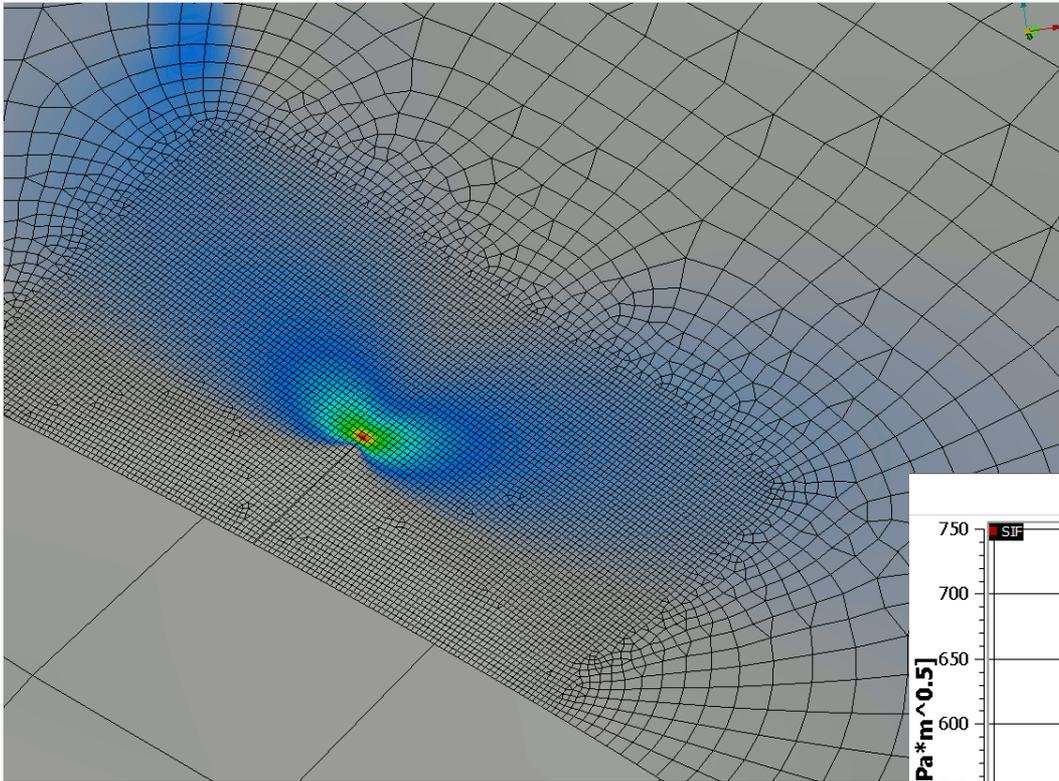
- Automatic re-meshing around crack tip area
- Determines crack growth direction
- Paris Law integration
- Stress Intensity Factor Plot

Termination conditions

- Max crack length reached
- Unstable crack
- Inactive crack status
- Spectrum completely applied
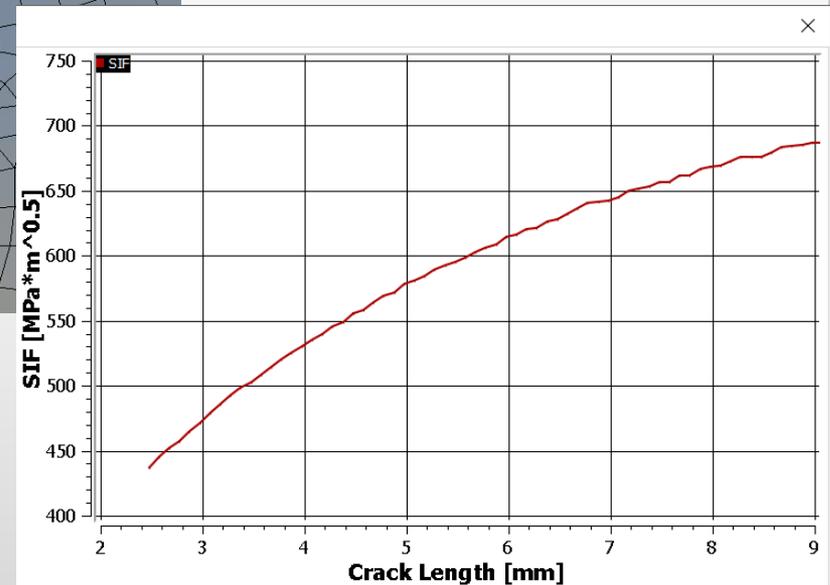
Analysis Tools

Tank Tool
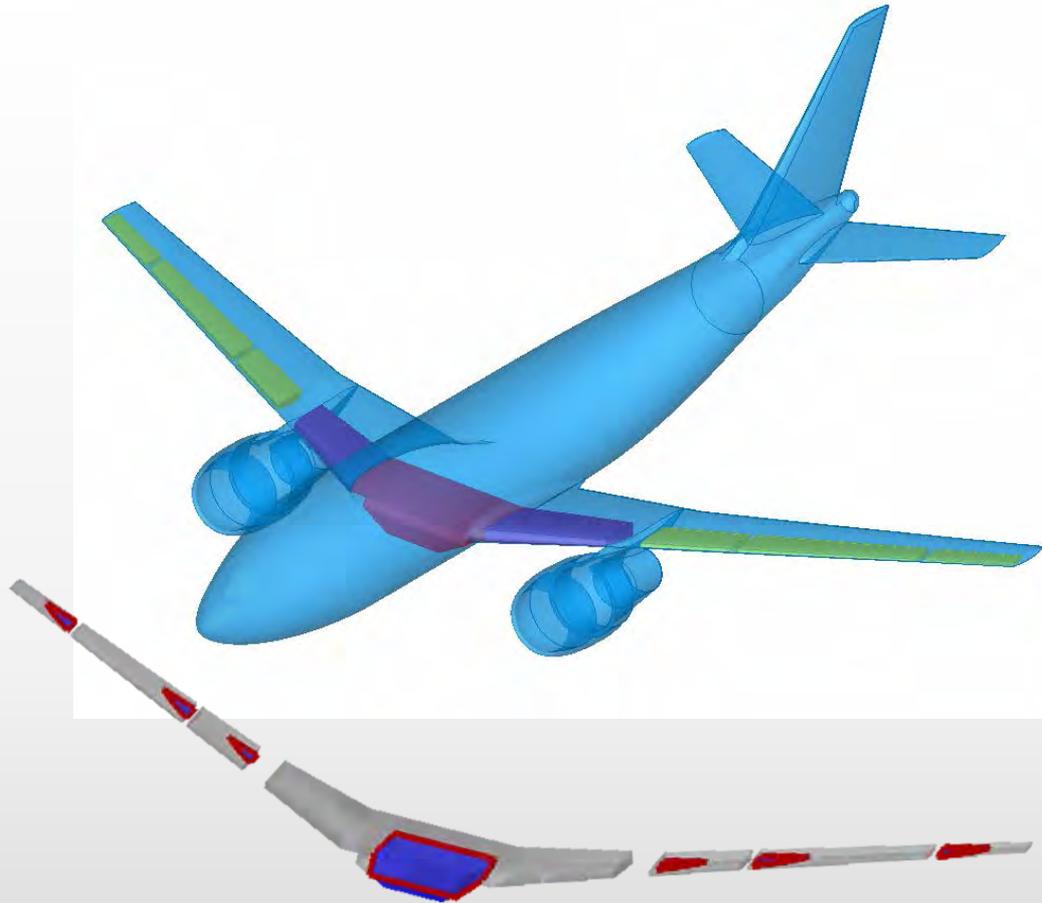
Unused liquid traps
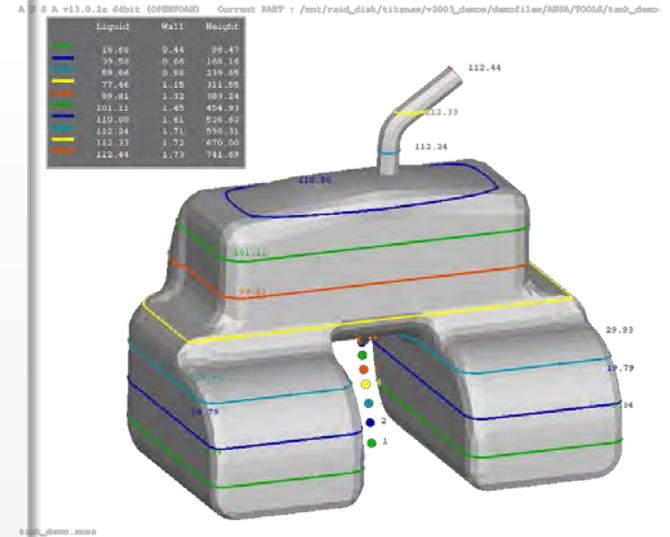
Calculation of:

- liquid levels

- liquid volume

- unused trapped liquid center of gravity (COG) for various tank configurations and positions

Analysis Tools

Compare Tool

- Explore differences
- Capture and re-use
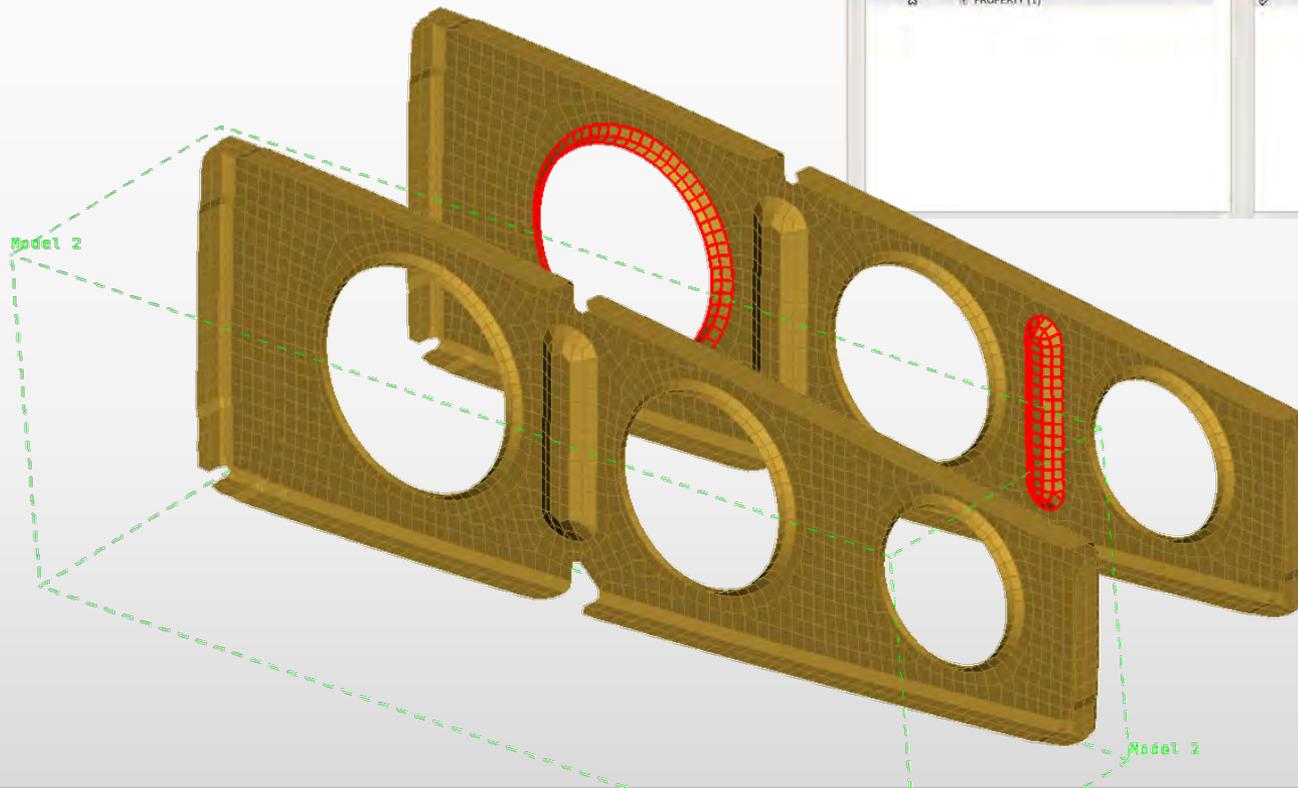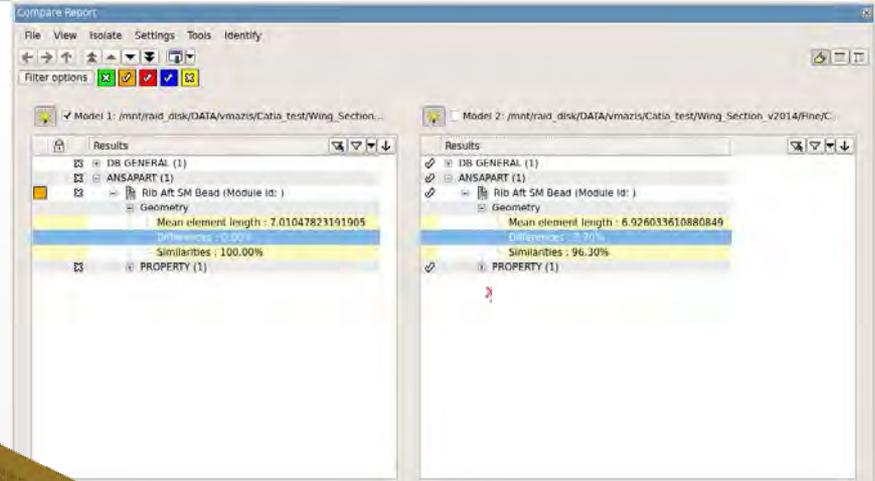
Analysis Tools

Results Mapping
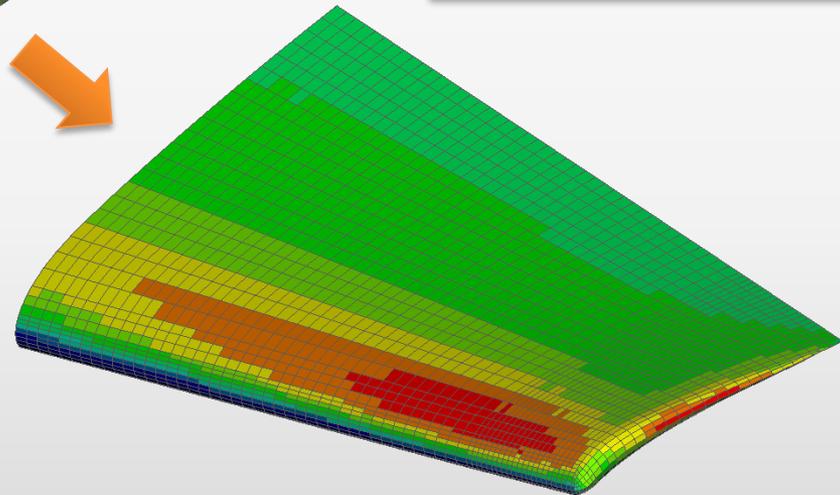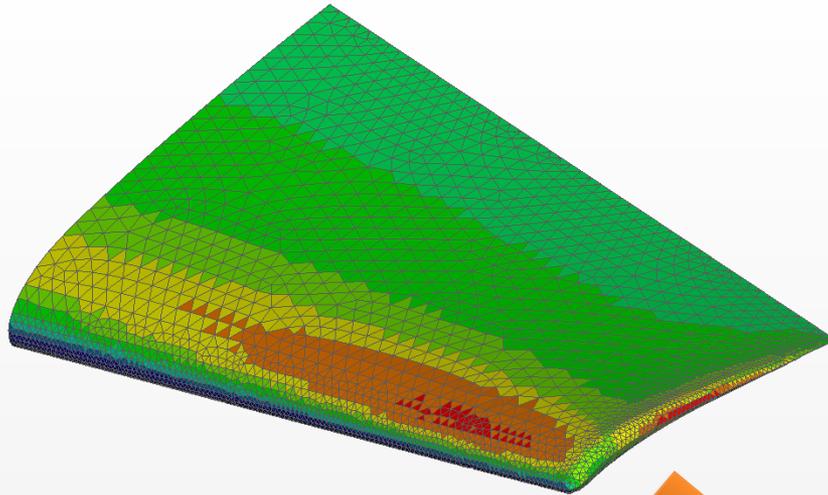
- Nodal thickness
- Pressure
- Initial Stress
- Initial temperature
- Equivalent Plastic Strain
- Strain
- Material Orientation

Analysis Tools
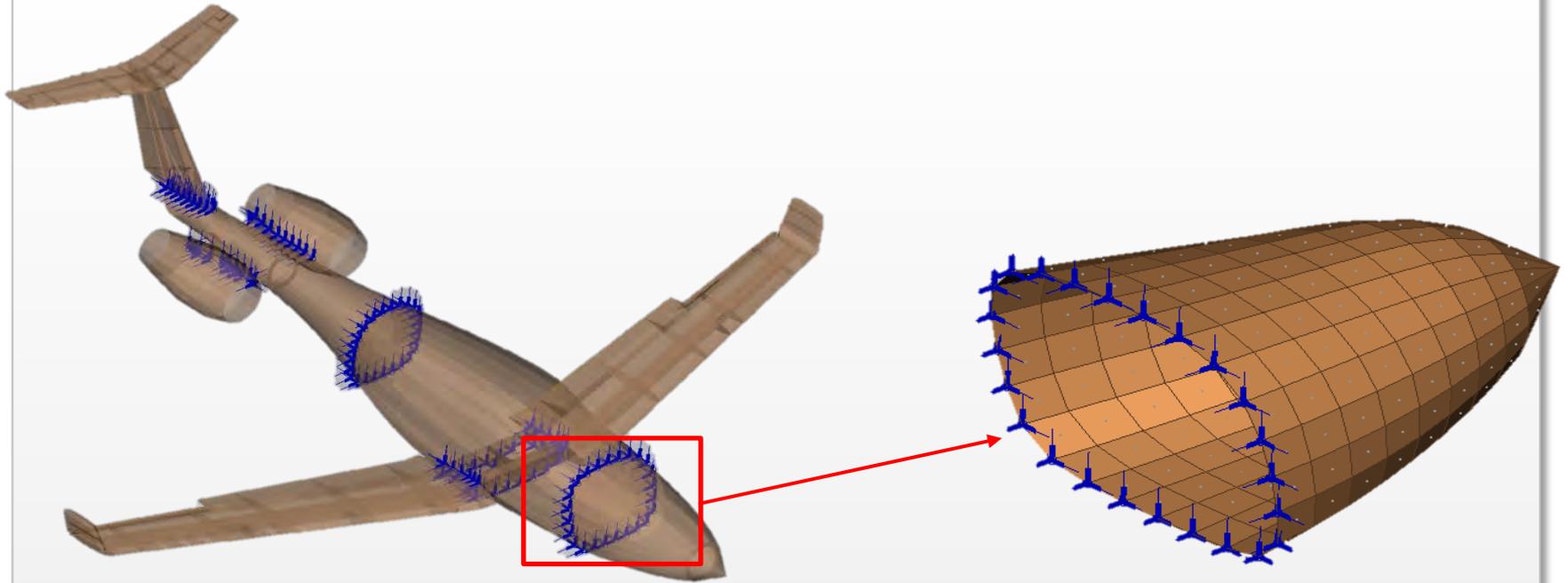
Easy definition of partitioned superelements (EXTRN or SEBULK) through boundary points (SECONCT)
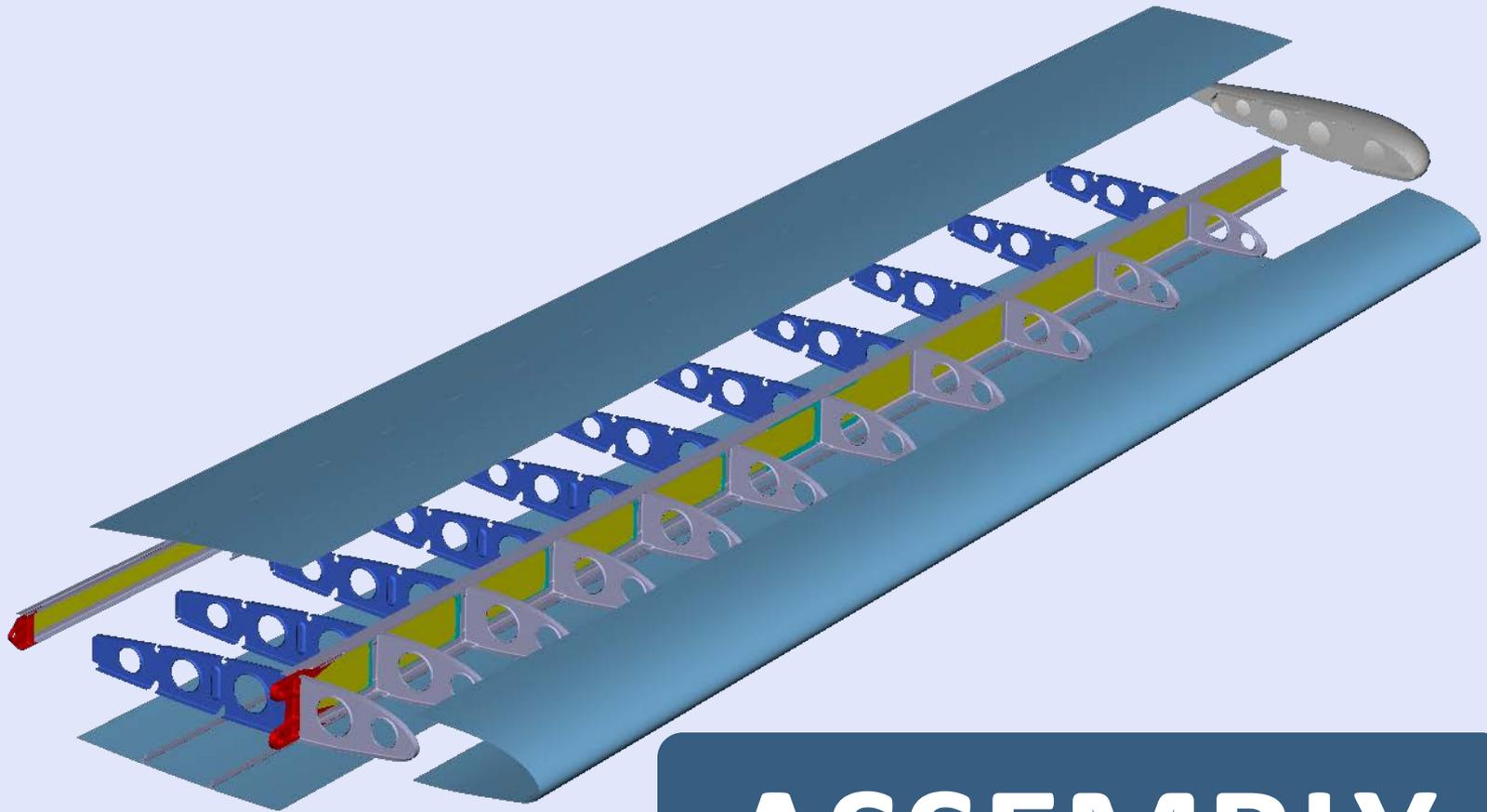
ASSEMBLY

Managed data types

Meshing Settings	Connection Templates	Connector library	Materials	Header templates	Process templates
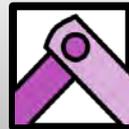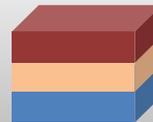
DM

Model & Simulation Data
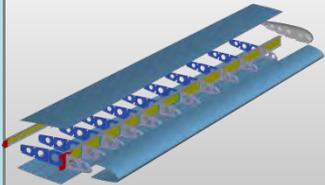
Parts & Connections	Sub-systems	Simulation Models	Simulation Runs	Key-results & reports
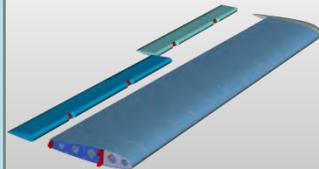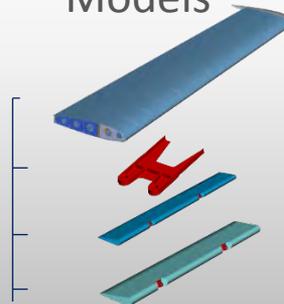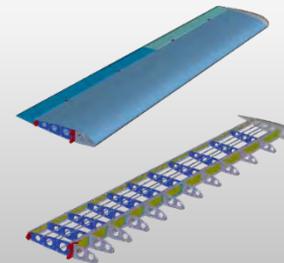
PPTX XLSX PDF
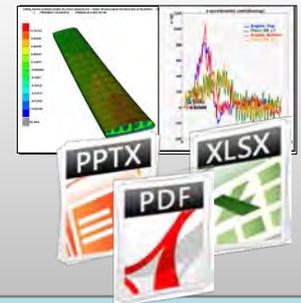
Assembly

Lists and Tools
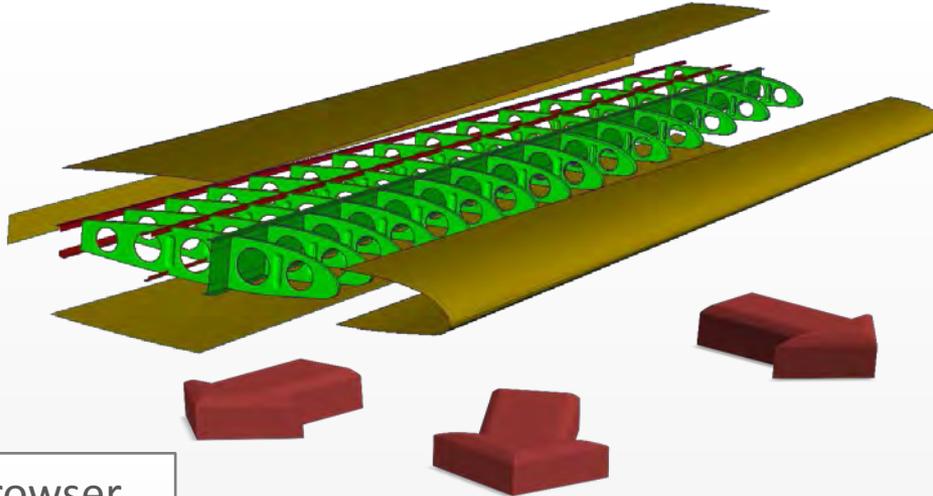
- Multi-Instantiated Parts generation
- Mesh Representations
- Version Control

Model Browser
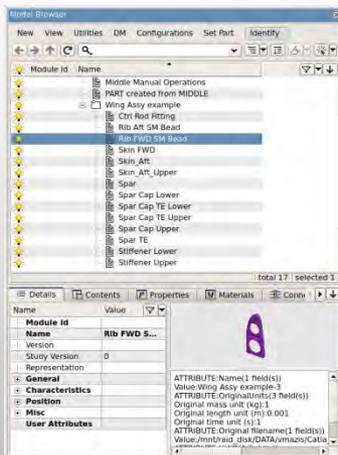
Material, Property, SETs Lists

Database Browser

Assembly

Part Management

Assembly

Includes Manager

Includes Manager

Id	Name		FULL STRUCTURE	WING FRAME		Id	Name
1	SKIN_UPPER		☑	☑		1	FULL STRUCTURE
2	SKIN_LOWER		☑	☑		2	WING FRAME
3	RIBS_AFT_S/M		☑	☑			
4	HINCHES		☑	☑			
5	AILERON_LH		☑	☐			
6	FLAP_LH		☑	☐			
7	SPAR_MAIN_ASSY		☑	☑			
8	SPAR_TRAIING_EDGE_ASSY		☑	☑			
9	TIP_FAIRING		☑	☑			
10	RIBS_FWD_MACHINED		☑	☑			
11	SPAR_REINFORCEMENT		☑	☑			
12	FITTING_TE		☑	☐			

OK   Load Files ▾   Apply   Clear ▾   New Configuration   Log File   Cancel
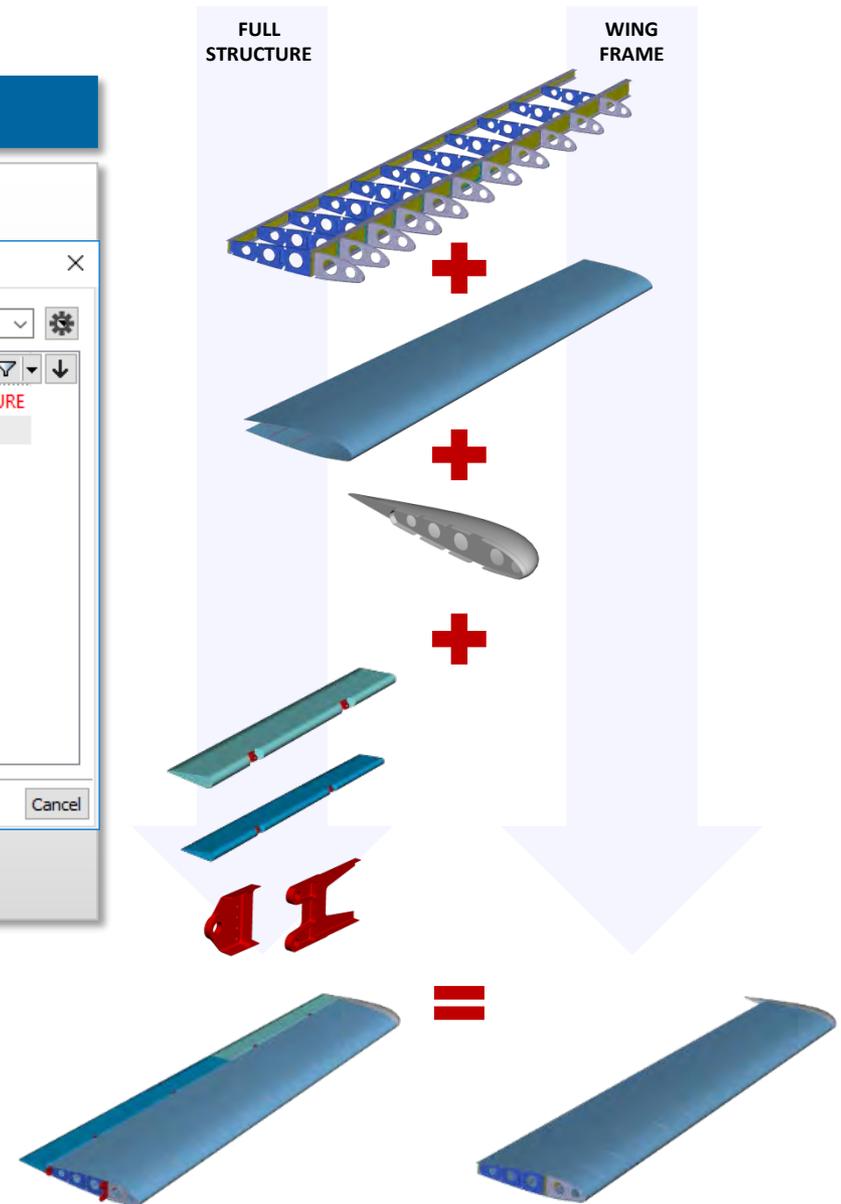
Assembly

Connection Manager

- Point, Line, Surface Connections
- Numerus FE Representations

FE Representation Type

Connectivity

Connection Entities

Connection Manager

Spotwelds - Mesh dependent

Spotwelds - Mesh independent

Seamlines - Elements arc-weld

Adhesives – Hexas

www.beta-cae.com

Connection Manager

...by diameter

...by number of parts
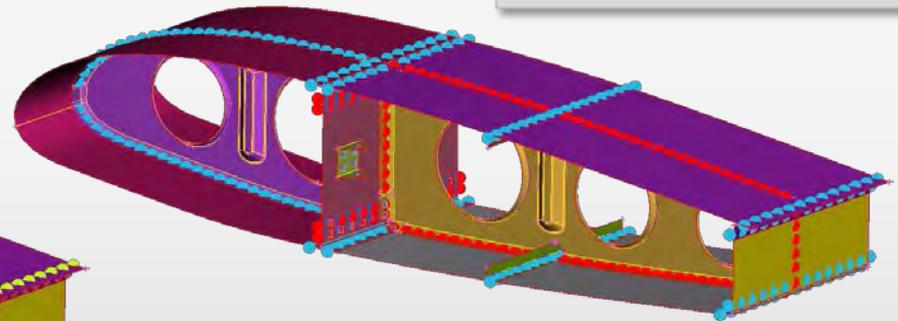
...by status

Color Coding by:

- Number of parts
- Connectivity
- Type
- Status
- FE-Representation
- Diameter
- Template

Connection Manager: Bolts

From bolt geometry…

From tubes…
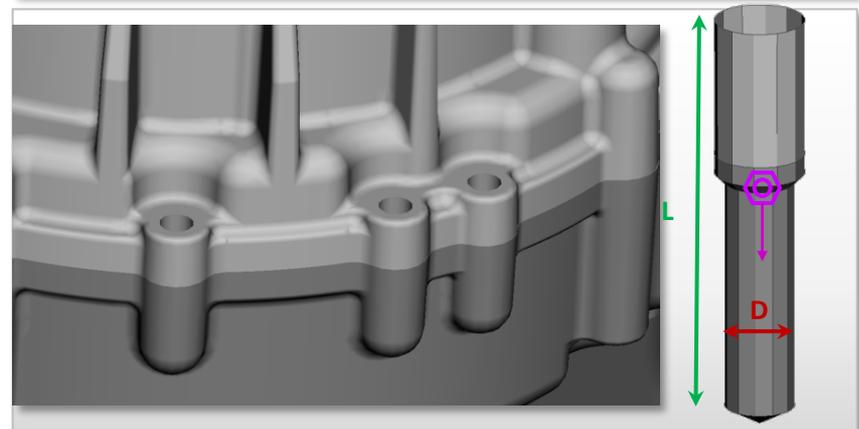
…to numerous realization patterns
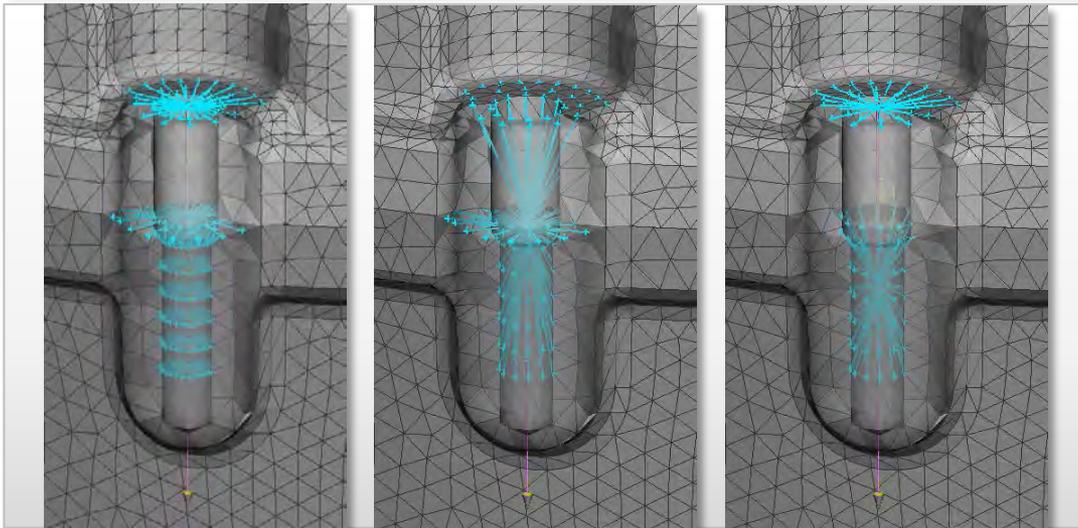
Solid bolt representation

Connector Entities

Revolute Joint

| NASTRAN CBAR | LS-DYNA joint | PAM-CRASH KJOIN | ABAQUS CONN3D2 |

Bushing

| NASTRAN CBUSH | PAM-CRASH SPRING | LS-DYNA discrete | ABAQUS CONN3D2 |

www.beta-cae.com
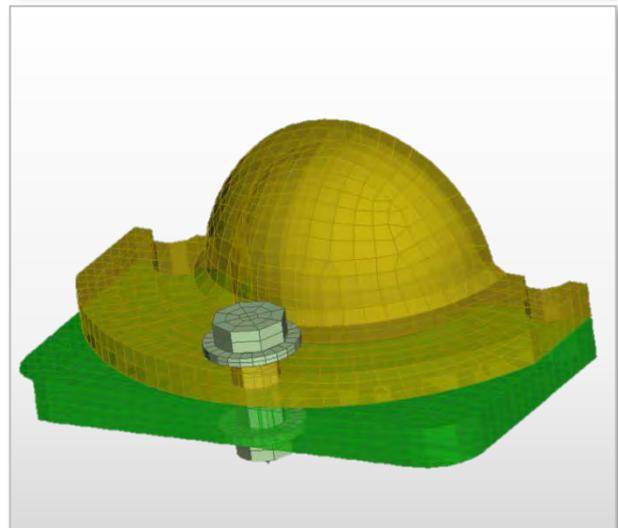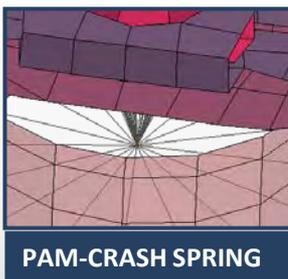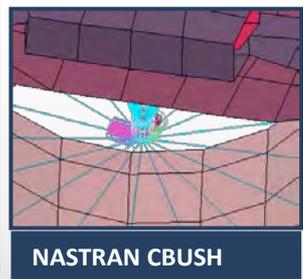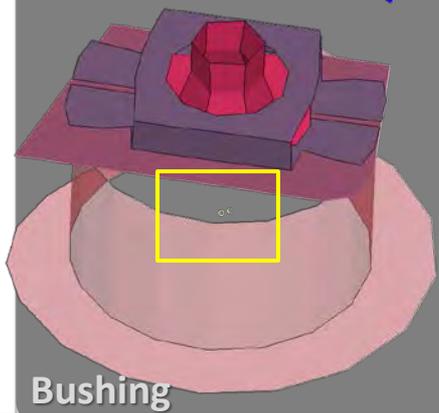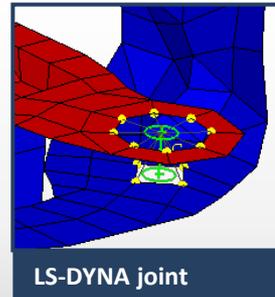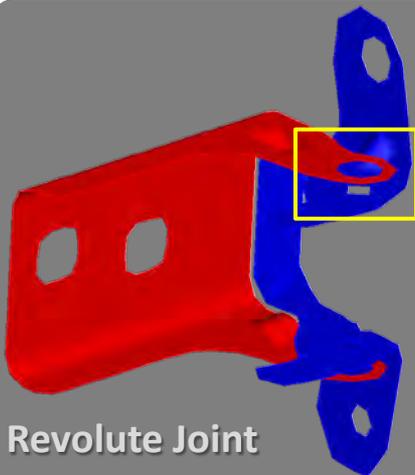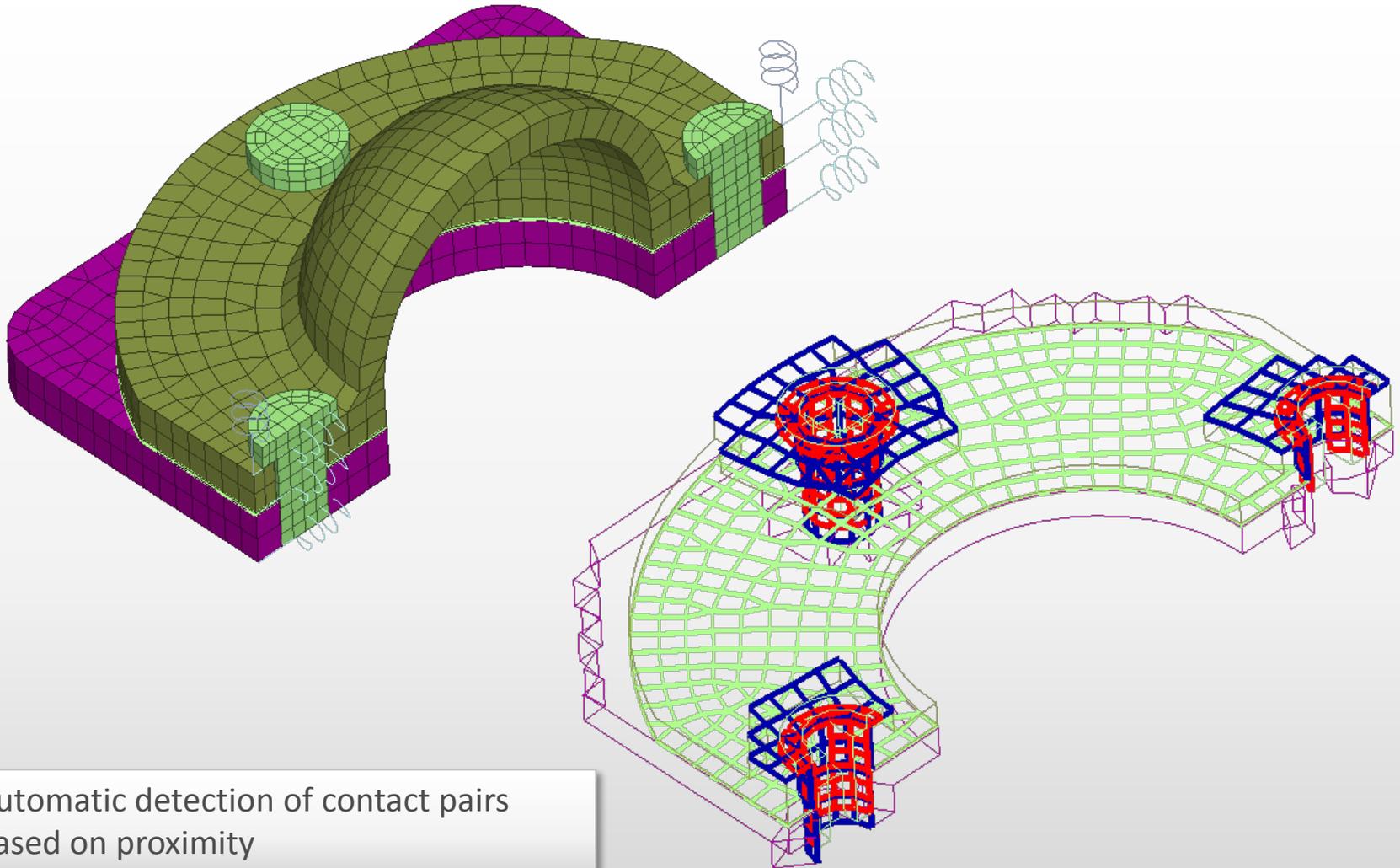
Contacts

Automatic detection of contact pairs
based on proximity
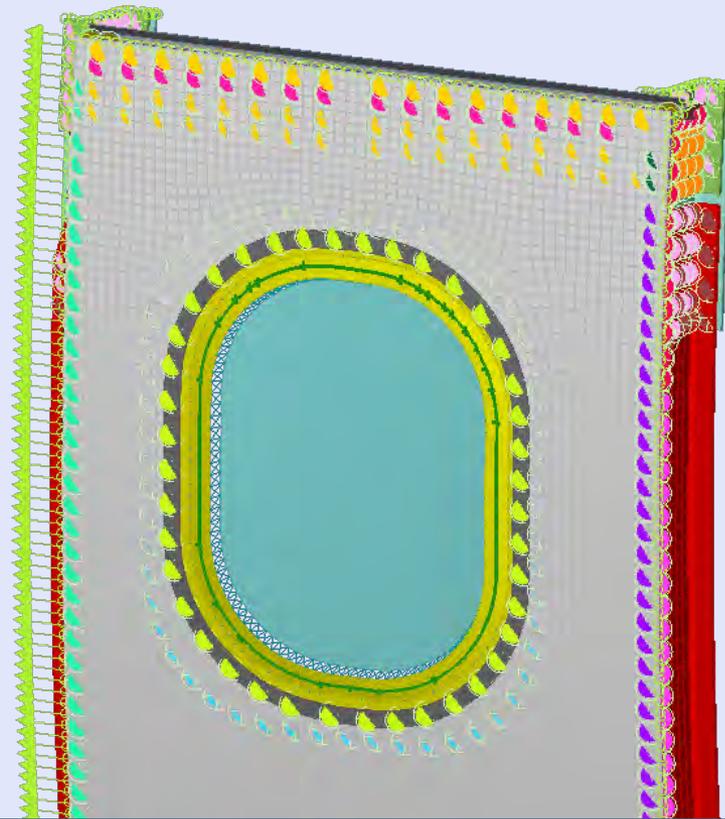
ANALYSIS SET-UP

Analysis Set-up

inside BOX

on SETs

on tubes
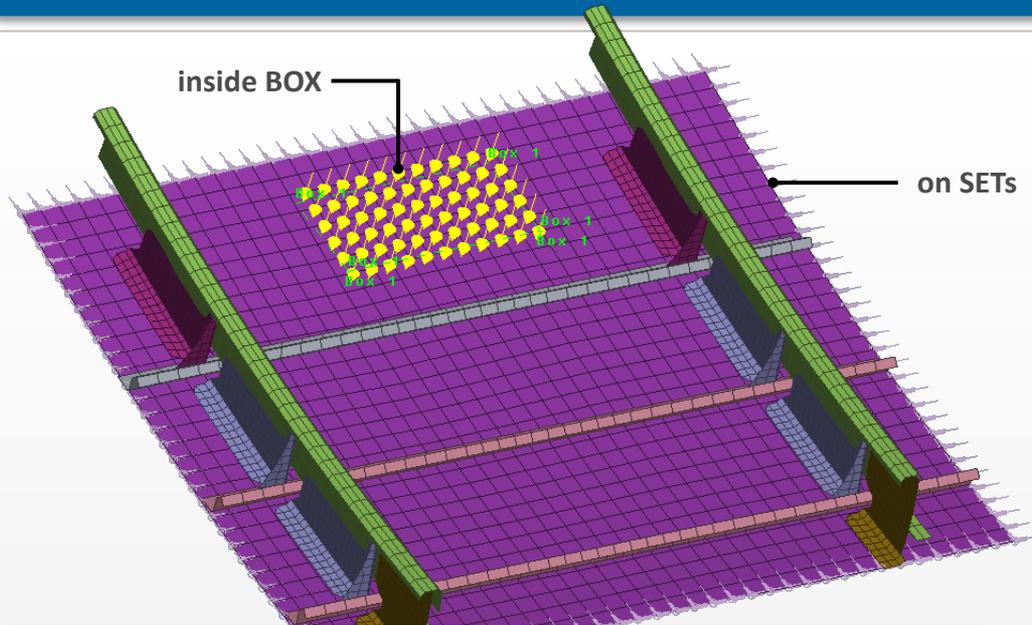
on openings

...applied on

- SETs
- tubes
- around openings
- entities inside BOX
- entities by Name
- entities by ID range
- overlapping areas
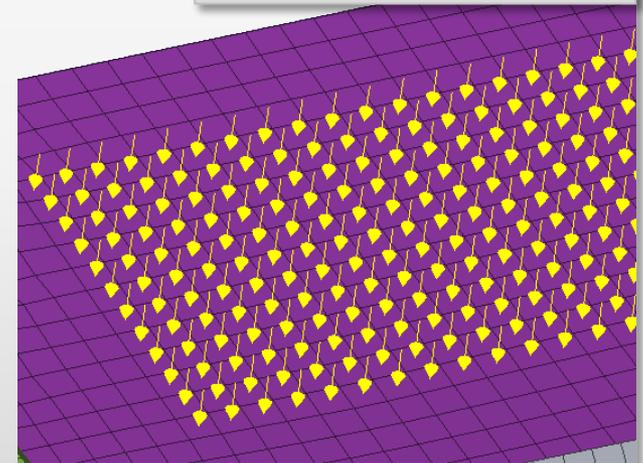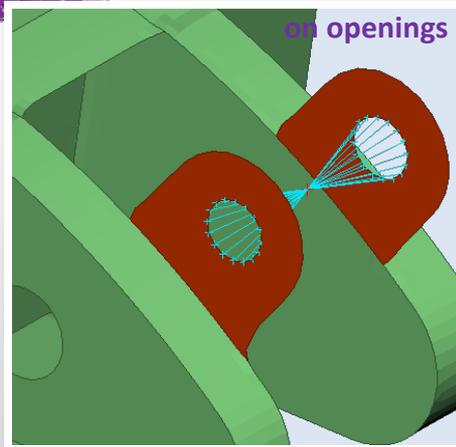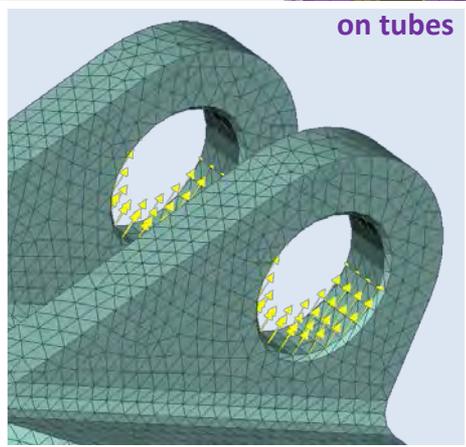
mesh independent application !!

Analysis set-up

Material Database

- Loaded automatically during start-up
- Can load one MatDB per deck
- Materials update from MatDB:
  - By material name
  - By material id

Material Mapping

Automatic transfer of curves and tables between materials !!

Analysis set-up

Model validation through build in Checks

Hundreds of model checks

General and solver checks

Automatic fix functions

Custom checks through script

Check templates

Color coding of results

Type	Entity	ID	Description
Duplicate			
PLINKS			
Mass Scale Ratio			
Initial Velocity			
Incomplete			
Funct:End Time			
Curves:Axes			
Dependency Pamcrash			
Check Contact 409999			
Undefined Properties			
Undefined Materials			
Range			
Multiple Boundary Conditions			
Massless			
Free:Whole DB			
Warning	NODE	313	Node is Free and doesn't belong to any elen
Warning	NODE	312	Node is Free and doesn't belong to any elen

Show only   Show   Hide   All

total 1167   selected 0

Errors

Warnings

OK

Analysis Set-up
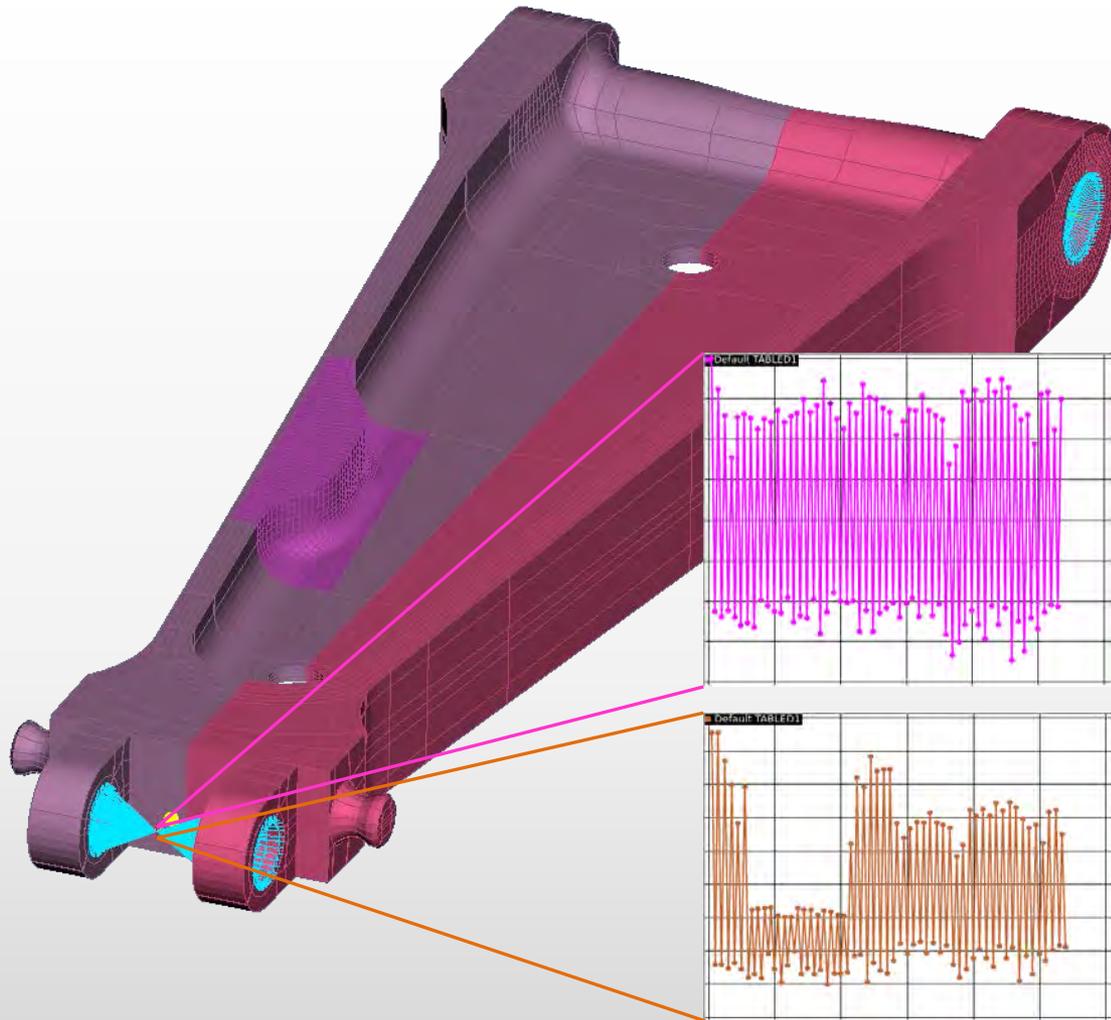
Support of all fatigue analysis types:

- S-N Analysis
- E-N Analysis
- Multiple Loading
- Modal Transient Analysis
- Design Optimization

NEF supported keywords:

- FATIGUE
- DTI, UNITS
- FTGDEF
- FTGPARM
- FTGEVNT
- MATFTG
- PFTG
- TABLFTG
- UDNAME
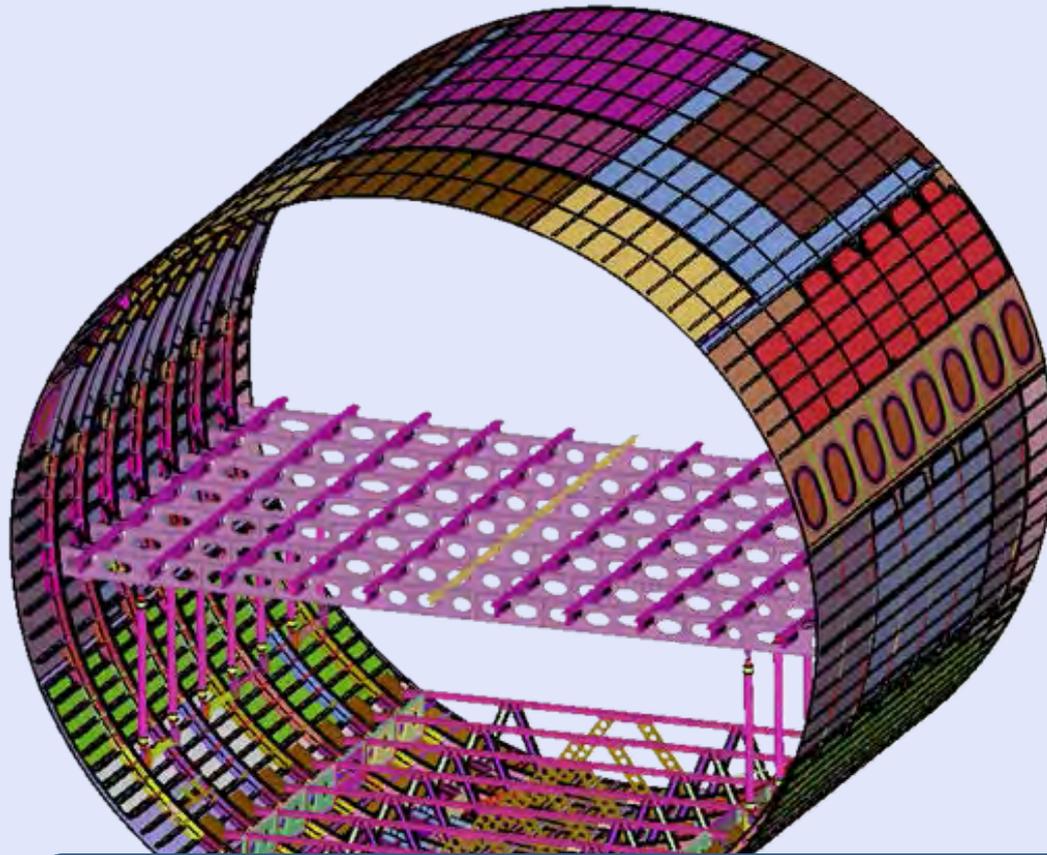
PROCESS AUTOMATION

Process Automation

Python Scripting Language

Python Scripting Capabilities

Entities Handling

Create   Delete

Modify

Acquire Info

Custom GUI

Line edits   Buttons

List boxes   Check buttons

Radio groups   Tables

Task Manager

ASCII files I/O

Read lists   Write XML files

Create lists   Read XML files

ANSA core functionality in batch

CAD files translation

Geometry checks

Batch Mesh

Middle skin extraction
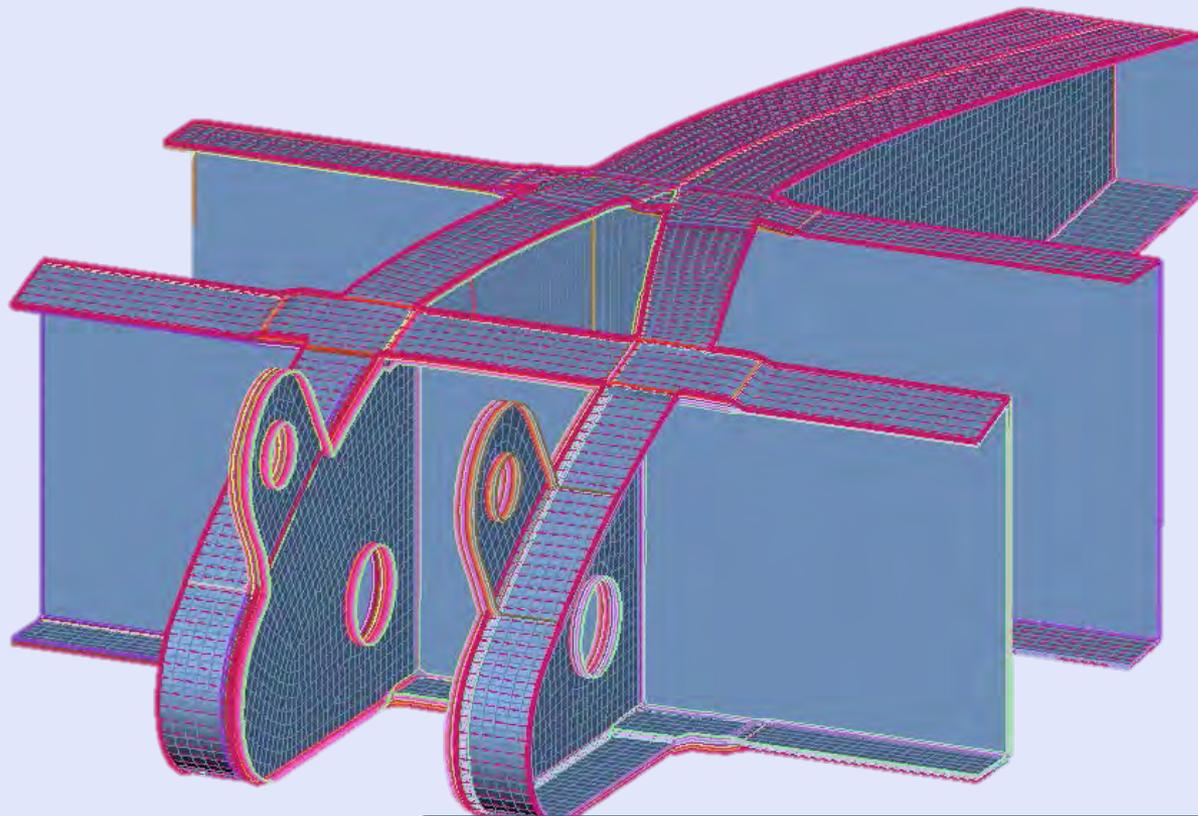
COMPOSITES

Composites

Composites modeling
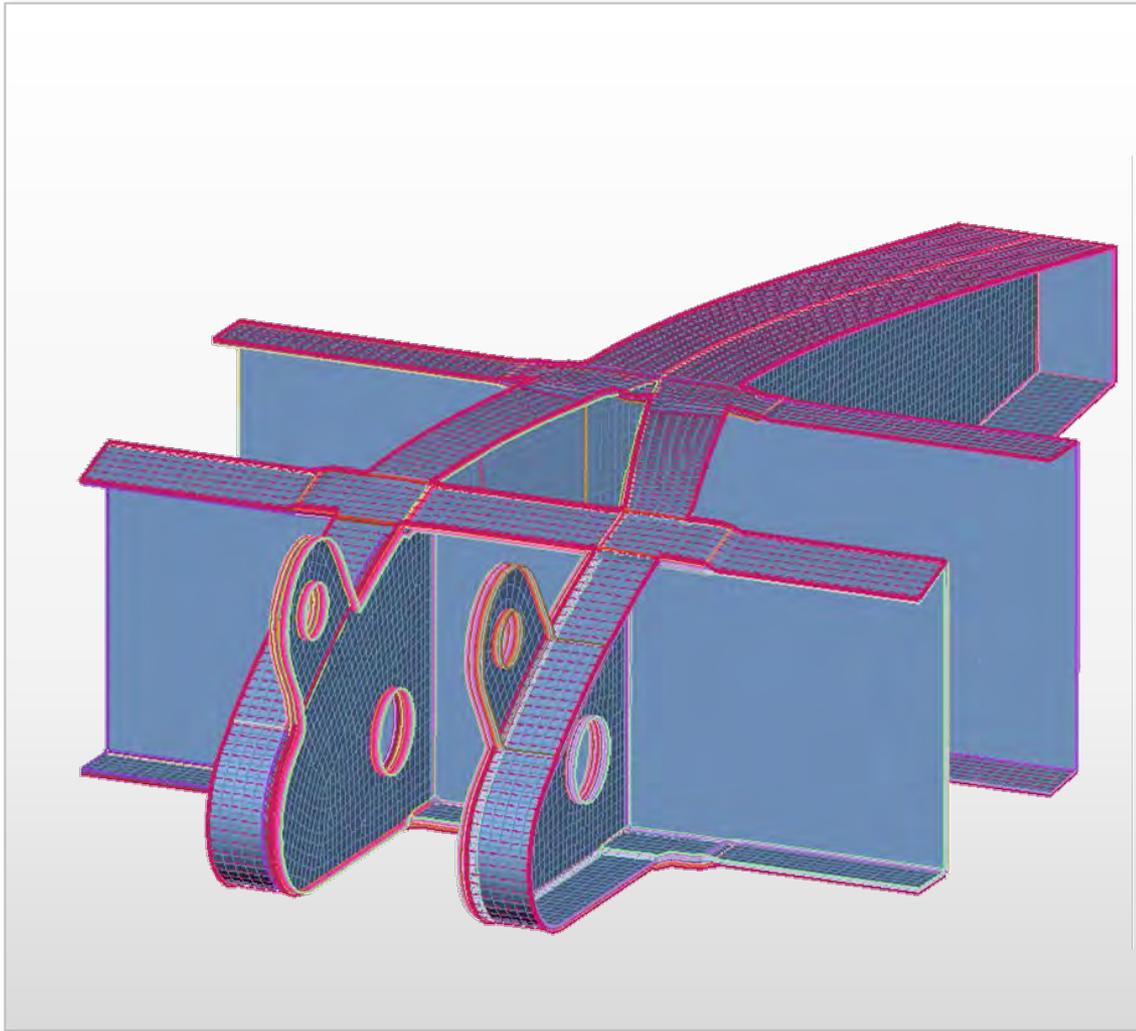
Effective Engineering Properties:
E11: 133701, E22: 56938.6, N12: 0.208924, N21: 0.0889734, G: 10757.5

ABD matrix:
237046.75037 21090.862969   -56.2394123 | 215599.34446 13245.172318 -26.9949173
21090.862969 100949.76094   -56.2394123 | 13245.172318 90427.936983 -26.9949173
 -56.2394123 -56.2394123 18718.040818 | -26.9949173 -26.9949173 11285.839368

215599.34446 13245.172318 -26.9949173 | 236910.26718 11738.555779 -13.43746965
13245.172318 90427.936983 -26.9949173 | 11738.555779 118470.81542 -13.43746965
 -26.9949173 -26.9949173 11285.839368 | -13.43746965 -13.43746965 9056.8427551

Laminate PART.
Total thickness: 1.74
Reference plane: Bottom surface
Symmetry: None

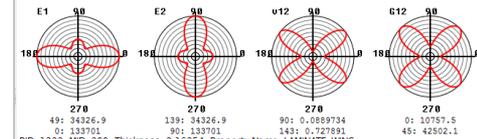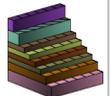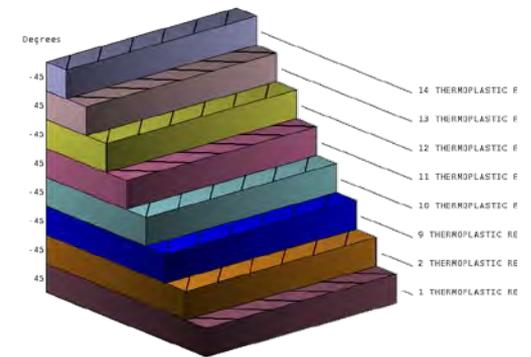Layer 1: thick: .31999999285, angle: 0., material: 309 Default MAT8
Layer 2: thick: .31999999285, angle: 45., material: 309 Default MAT8
Layer 3: thick: 0.1400000006, angle: 0., material: 318 Default MAT8
Layer 4: thick: 0.1400000006, angle: 0., material: 318 Default MAT8
Layer 5: thick: 0.1400000006, angle: 0., material: 318 Default MAT8
Layer 6: thick: 0.1400000006, angle: 0., material: 318 Default MAT8
Layer 7: thick: .21999999881, angle: 0., material: 320 Default MAT8
Layer 8: thick: .31999999285, angle: 0., material: 320 Default MAT8
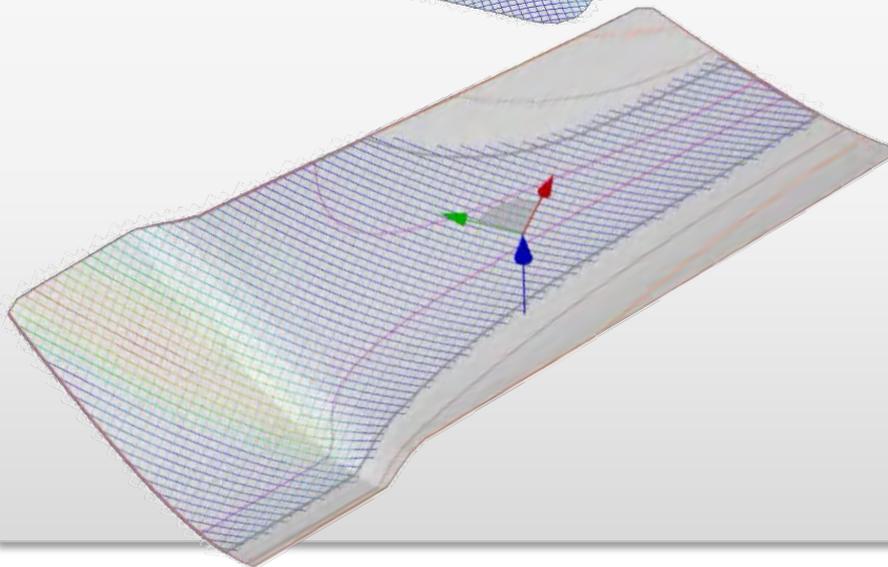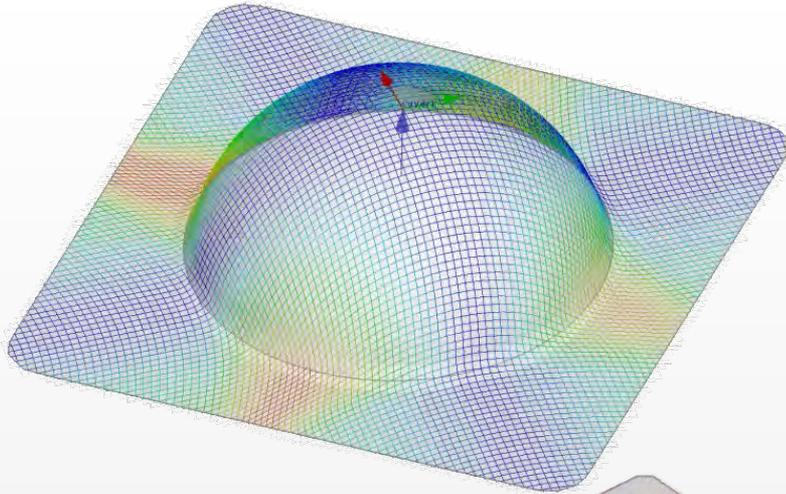
E1   E2   v12   G12
49: 34326.9   139: 34326.9   90: 0.0889734   0: 10757.5
0: 133701   90: 133701   143: 0.727891   45: 42502.1
PID: 1233, MID: 309, Thickness: 2.16354, Property Name: LAMINATE_WING
MODULE ID: , PART NAME: Front_wing_v3

Degrees

14 THERMOPLASTIC R
13 THERMOPLASTIC R
12 THERMOPLASTIC R
11 THERMOPLASTIC R
10 THERMOPLASTIC R
9 THERMOPLASTIC RE
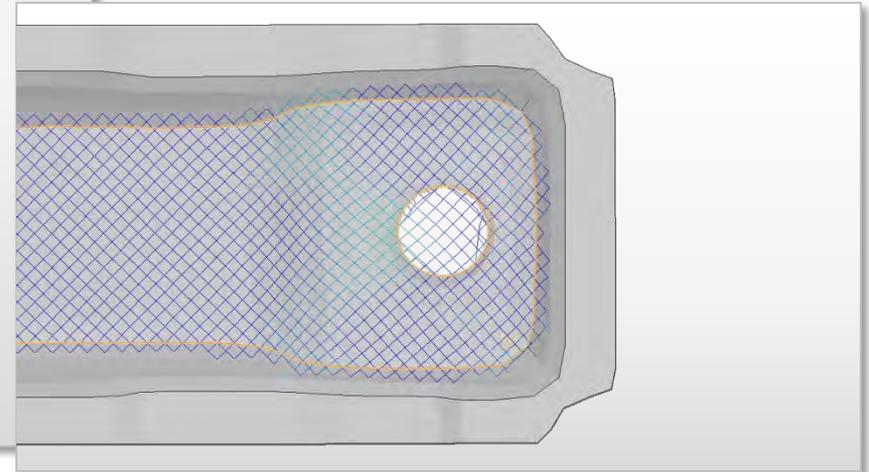2 THERMOPLASTIC RE
1 THERMOPLASTIC RE
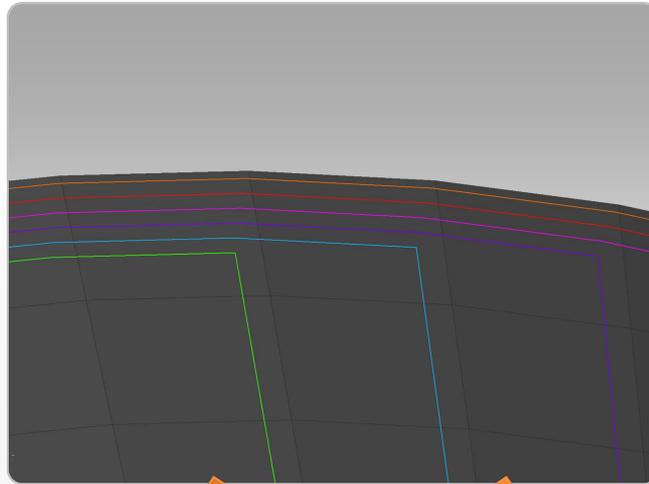
Composites

Draping Tool

- Inherit Fishnet algorithm
- Based on Rosettes with start and stack directions
- Calculate thickness and orientation of warp and weft woven
- Define initial material orientation
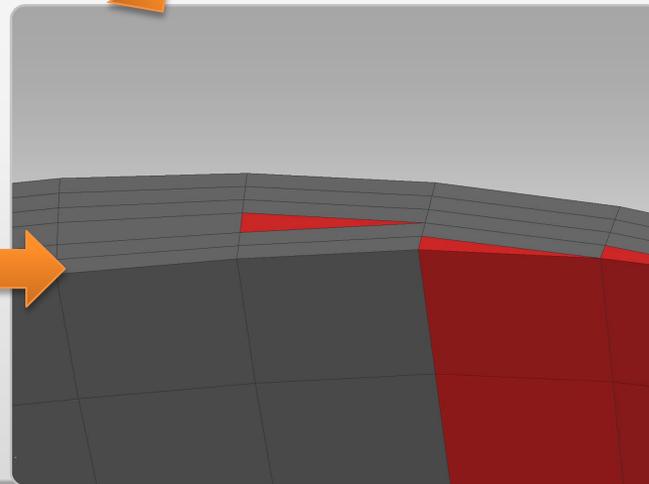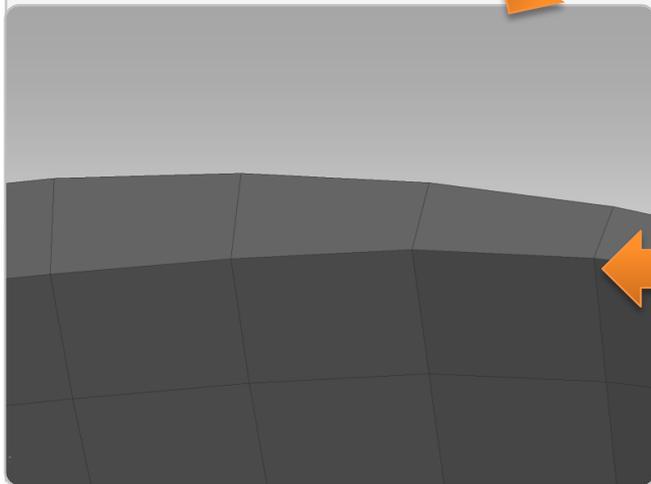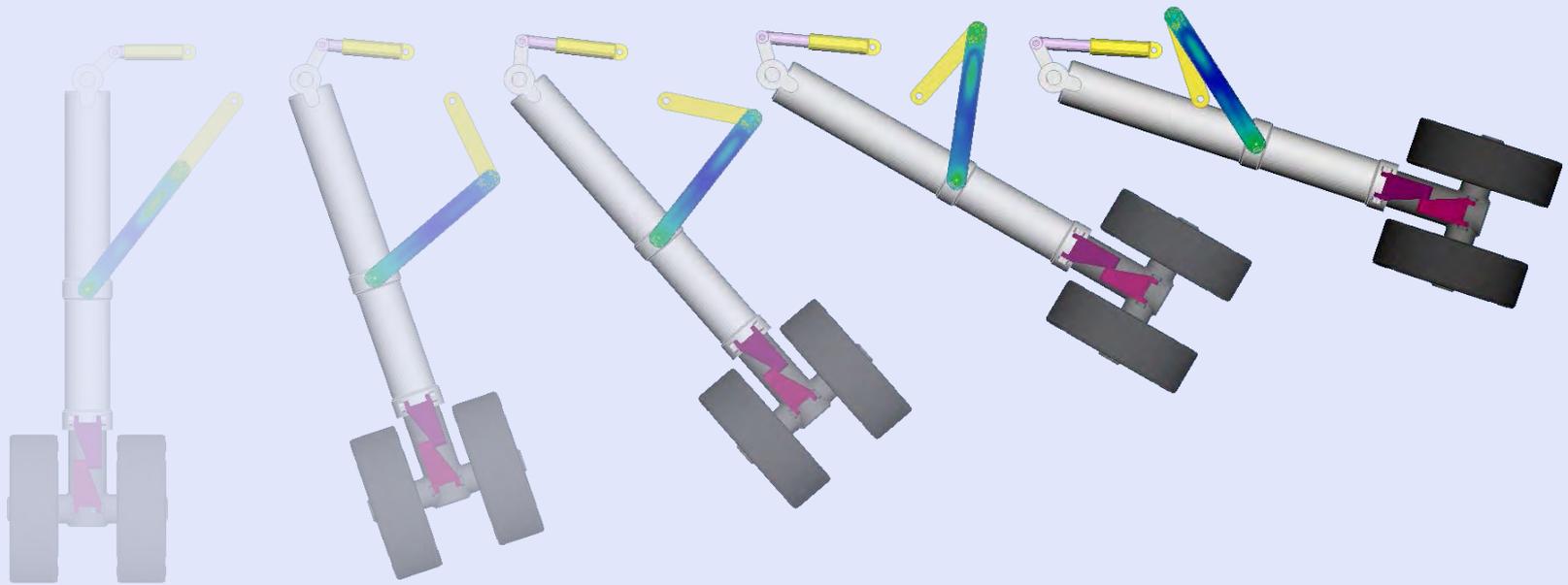
Disregard holes / beams option

Composites

- **Volumize** Composite shell elements
- **Single** element modeling (modify layer stackup)
- **Per-ply** element modeling (fill ply drop-offs)
- **Bidirectional** single to per-ply conversion

KINETICS

Kinetics

- KINETICS is an integrated MultiBody Dynamics software within ANSA that incorporates an in-house solver

- MBD is used to study the kinematic or dynamic behavior of mechanical systems that undergo large displacements
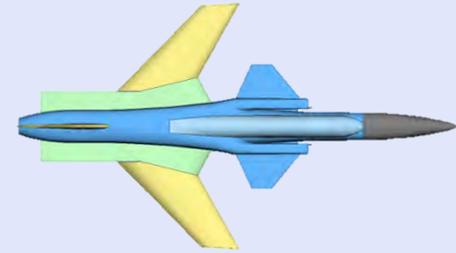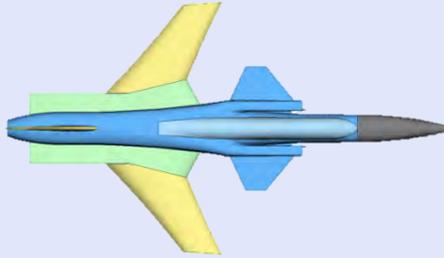
- MBD applications can be found in many areas of engineering like automotive, machining, industrial, robotics, biomechanics and more

- Dedicated menu for KINETICS
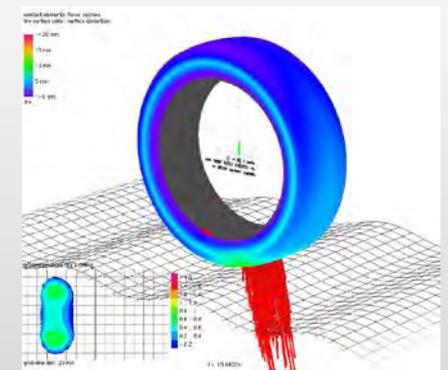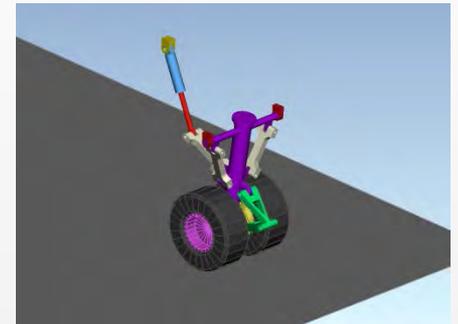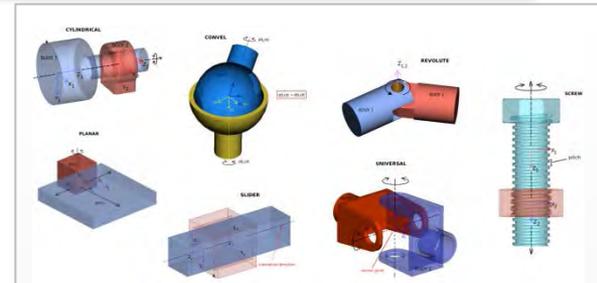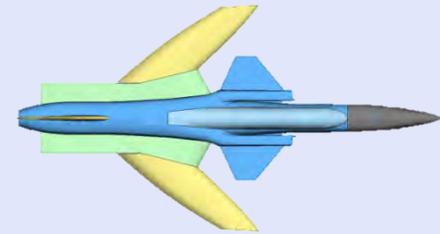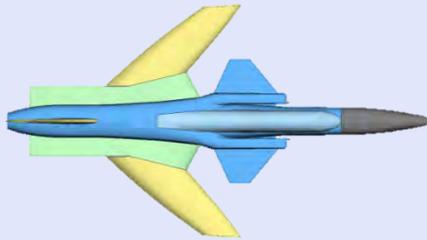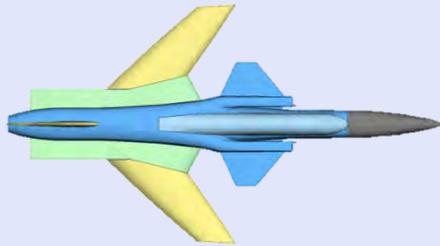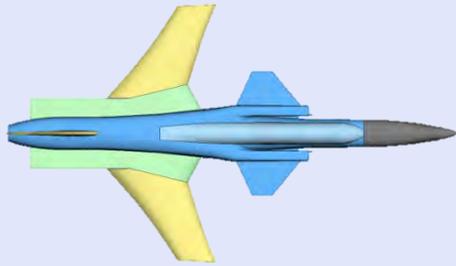
MORPHING - OPTIMIZATION

Morphing

Morphing

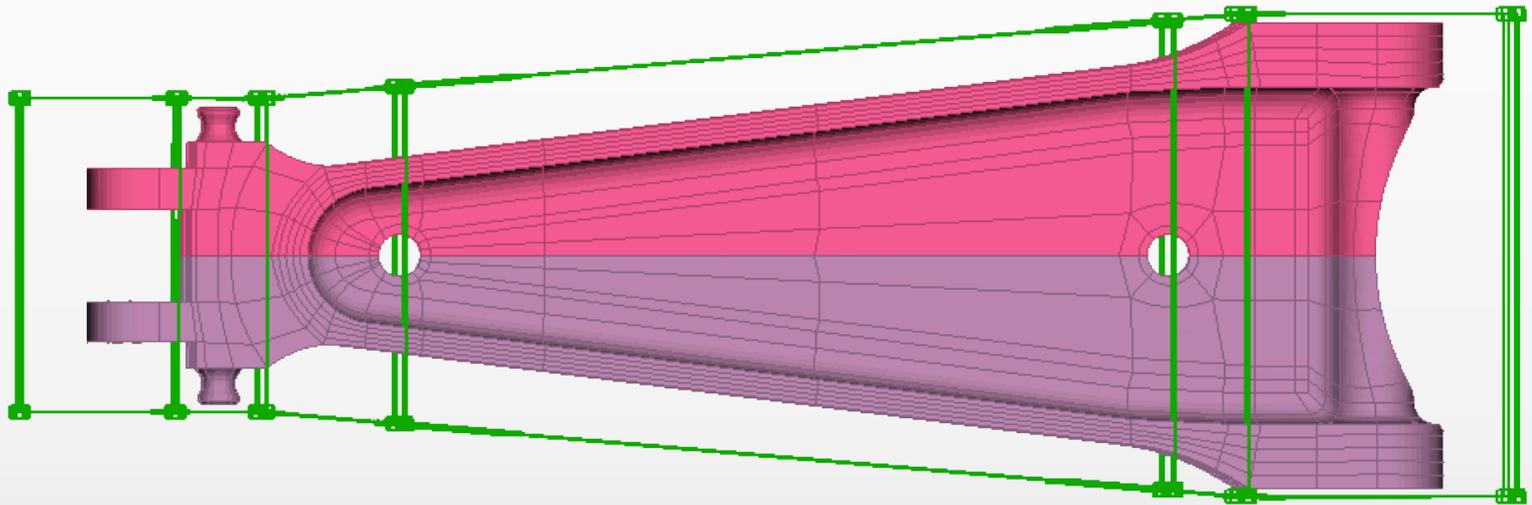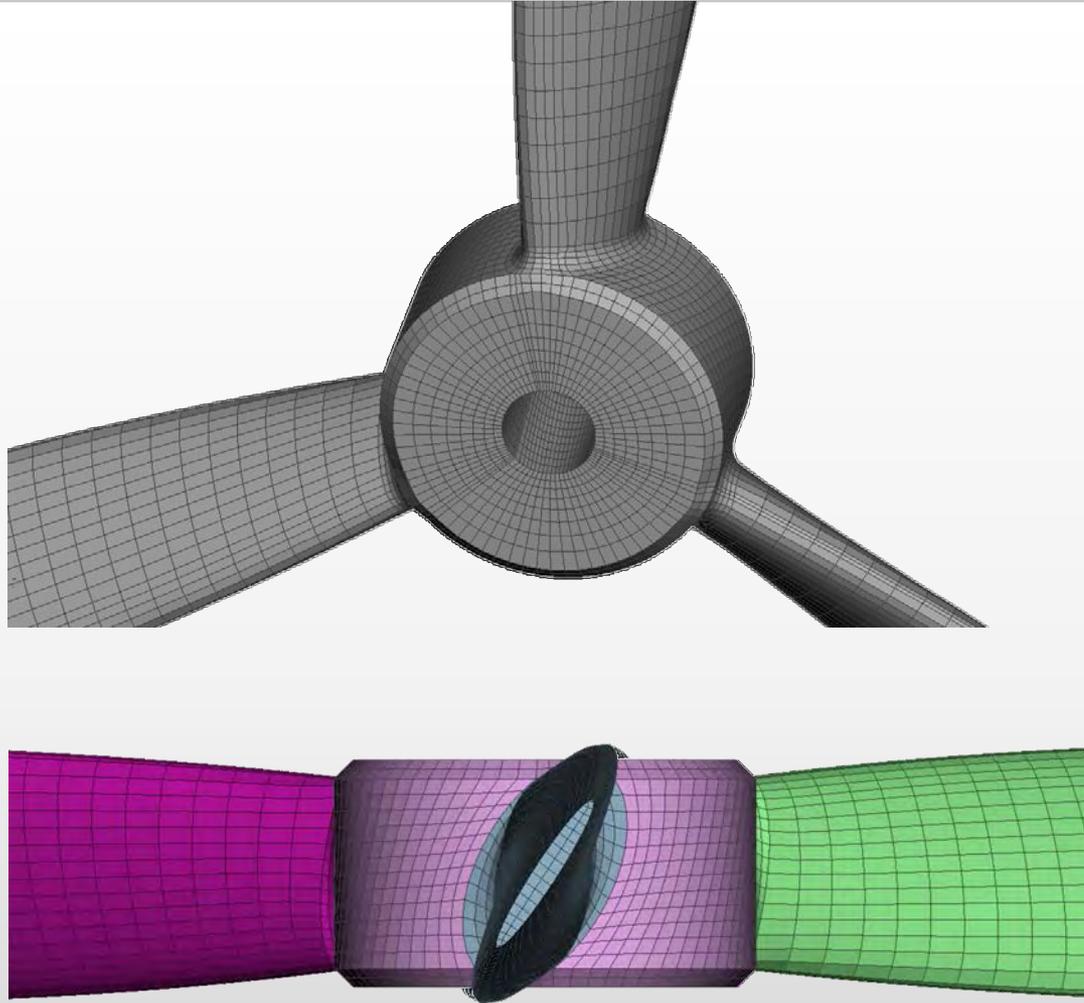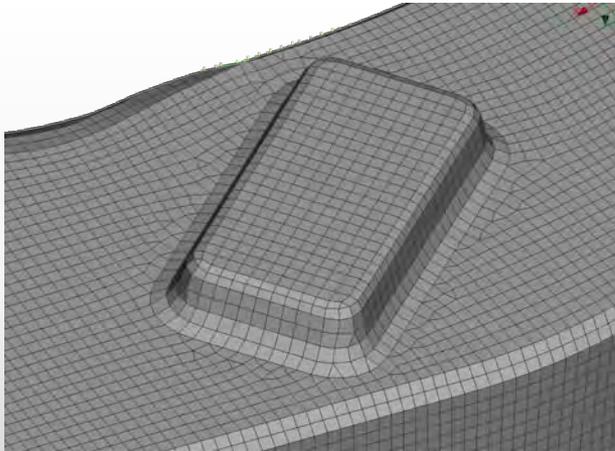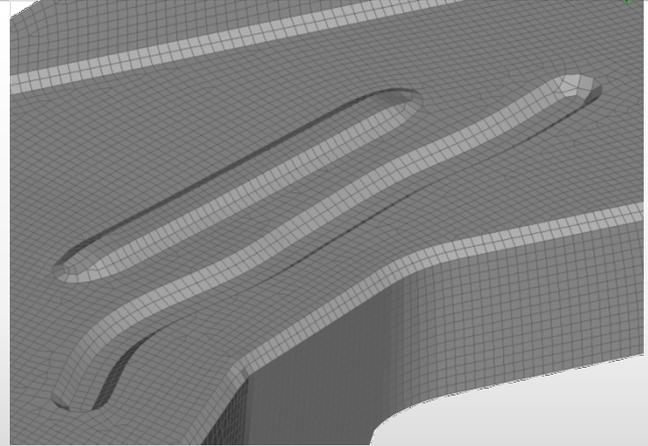# Features Creation

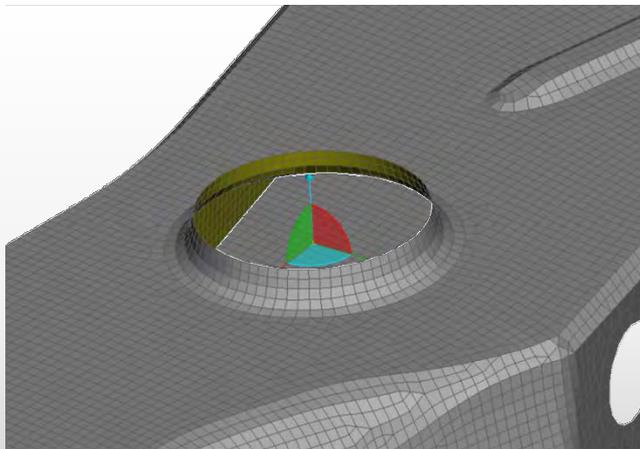## Rectangular Rounded Stamp

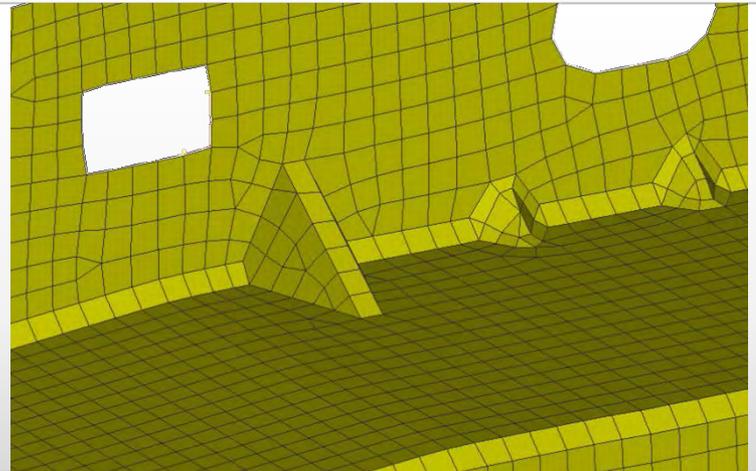## Curved & Rounded Flat Bead

Circular flange opening

Gussets

Features Creation

Shell Rib

Solid Rib

Optimization

Optimization

Mass Reduction 60%

Optimization

- Integrated workflow in Task Manager
- Wizard for step by step workflow definition
- Multiple design areas support
- First and second order elements

Optimization

- Auto detect results file (.des)

- Several View Modes

- Creates smoothed surface from the optimized area

- Exports the surface in neutral format
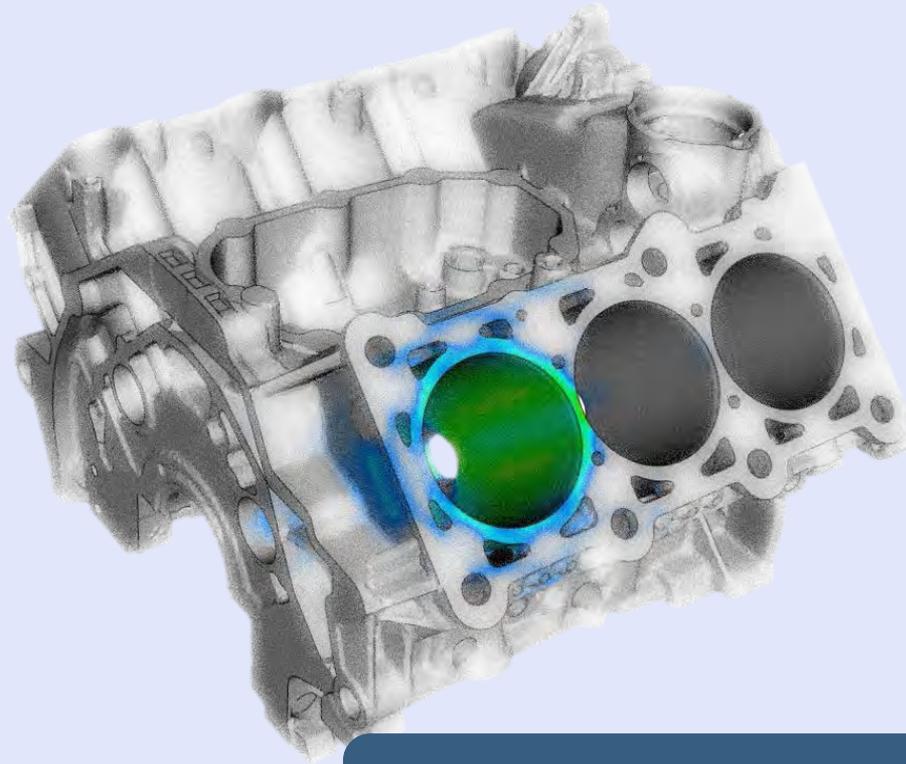
EPILYSIS

EPILYSIS

Επίλυσις

[epi-li-sis]
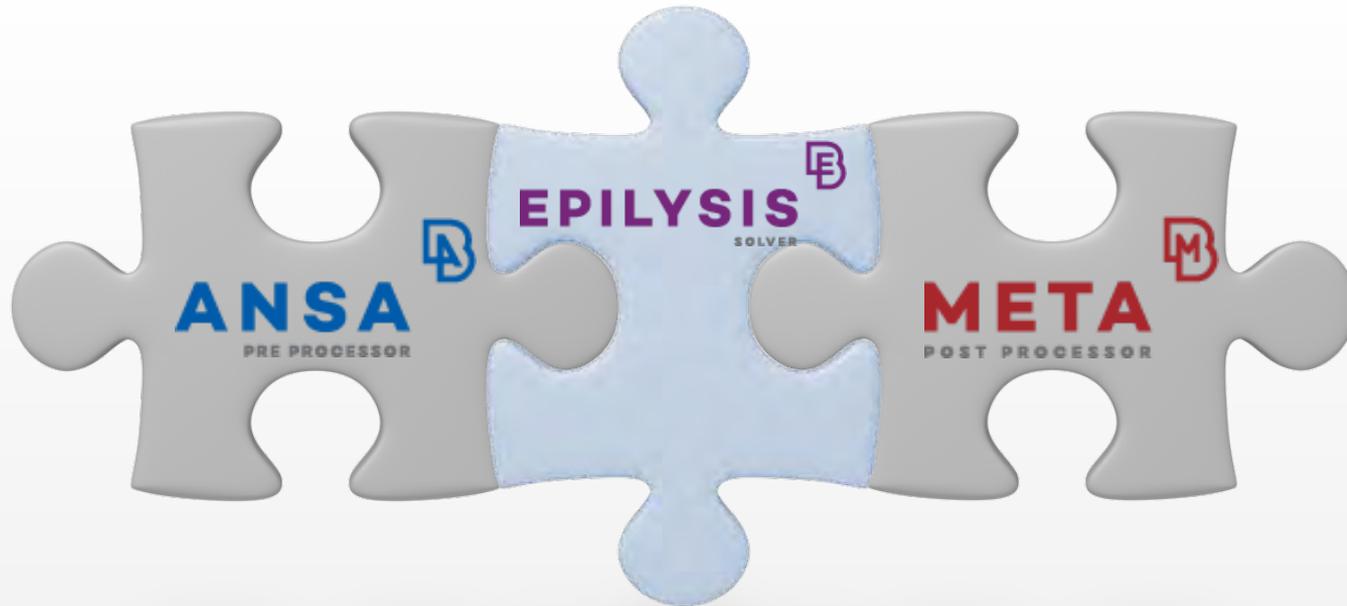
noun 1. solution

- General-purpose FE Analysis Software
- One Solver for many engineering problems
- Standalone & integrated in ANSA

EPILYSIS

Programming Language

- C++
- Double Precision

Quality

- Benchmarks accurate (NAFEMS, SFM and other – More than 3500 tests)
- Robustness
- Repeatability

Performance

- Shared Memory Parallel Processing (SMP)
- Automatic utilization of system resources without time consuming tuning
- Multiple high-performance direct sparse linear solvers

Easy to Use

EPILYSIS
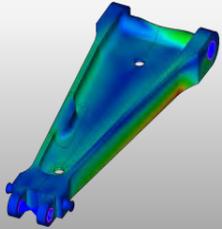
Static	Real Eigenvalue	Direct Transient Response	Direct Frequency Response	Modal Transient Response	Modal Frequency Response
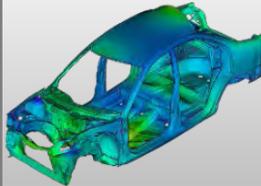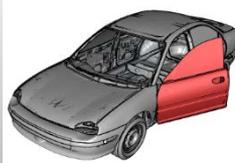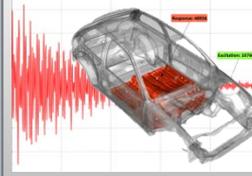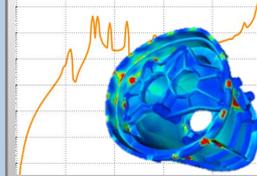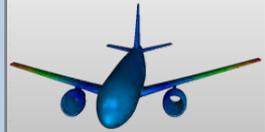
Non - linear analyses

Static: linear elements / materials -non linear contacts

Optimization

Topology optimization

META TOOLS

META Tools

Connections management & spotweld analysis

FASTENER

RBE3-HEXA-RBE3

SPIDER
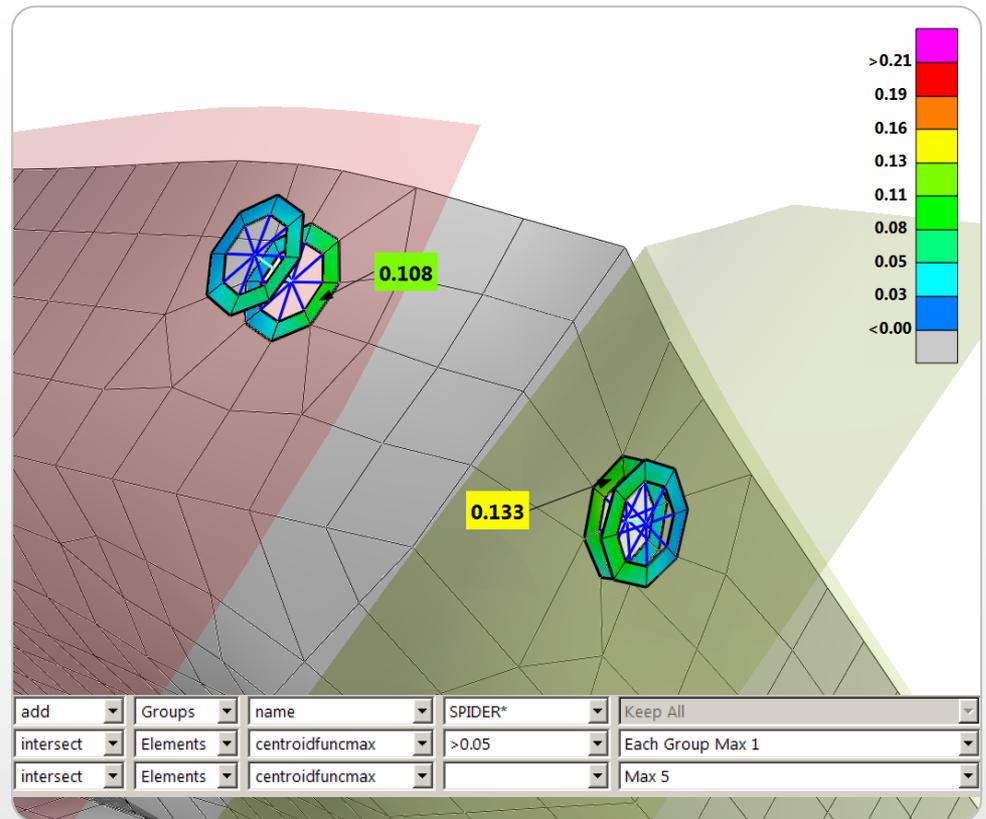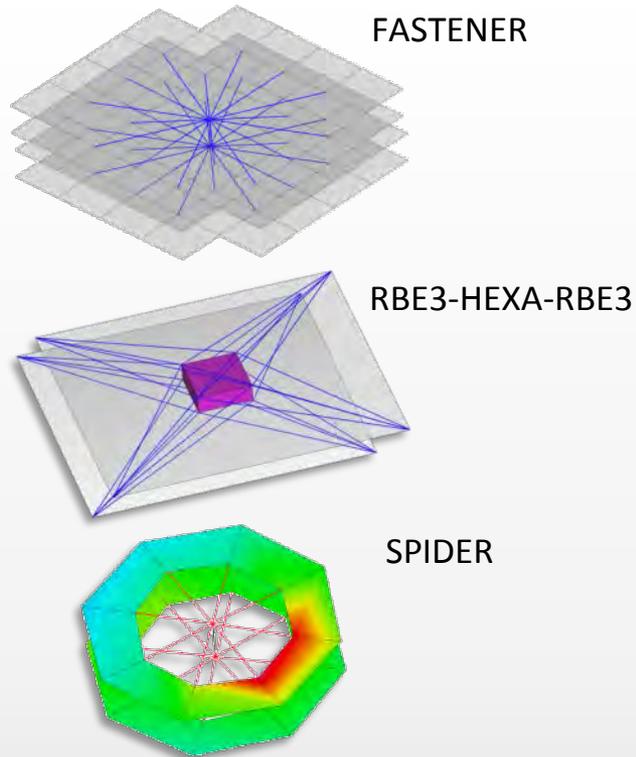
- Connection information read from ANSA comments
- Connections grouped by type
- Identification of the critical element per connection with Advanced Filter

META Tools

Hot Spots identification

Identified Hot Spots

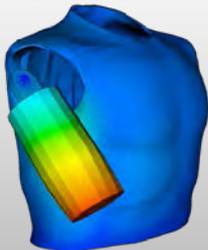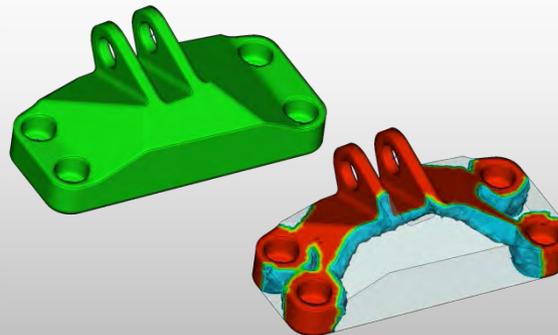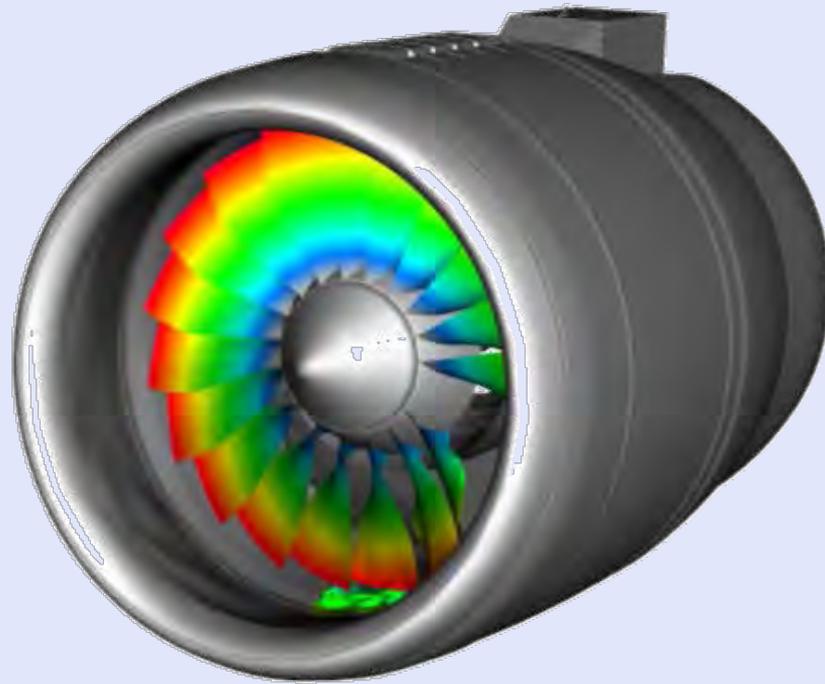| Id :: C0	Max :: C1	Mid :: C9	Type :: C10
238692	15.3112	1218	NODE
240526	14.8633	1218	NODE
237836	14.535	1218	NODE
240621	13.0989	1218	NODE
240529	10.2032	1218	NODE
240588	9.8943	1218	NODE
240640	7.93867	1218	NODE
238651	7.47679	1218	NODE
238643	7.43315	1218	NODE
237472	6.03507	1218	NODE
236696	5.75861	1218	NODE
238763	5.17451	1218	NODE
Sum (...	117.722		
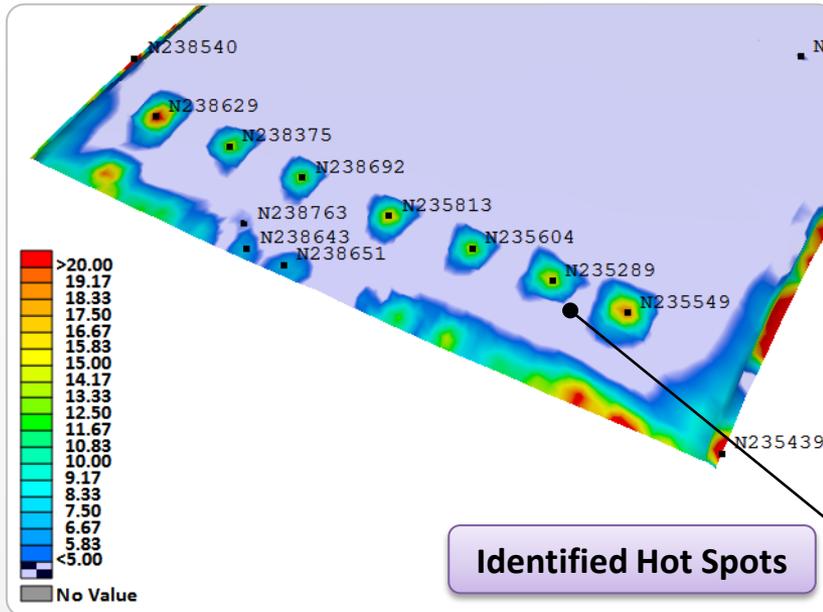
Current State: Stresses, Von Mises, Max of Top Bottom : SUBCASE 1   :: TORSION: SUBCASE :

All | Invert | Visible | Pick | Filtering:

Model 0 | Function | All | All Entities

Hot Spots in Statistics Table
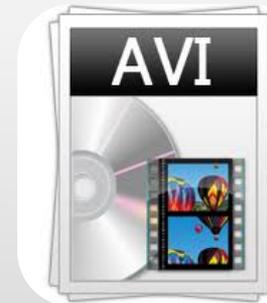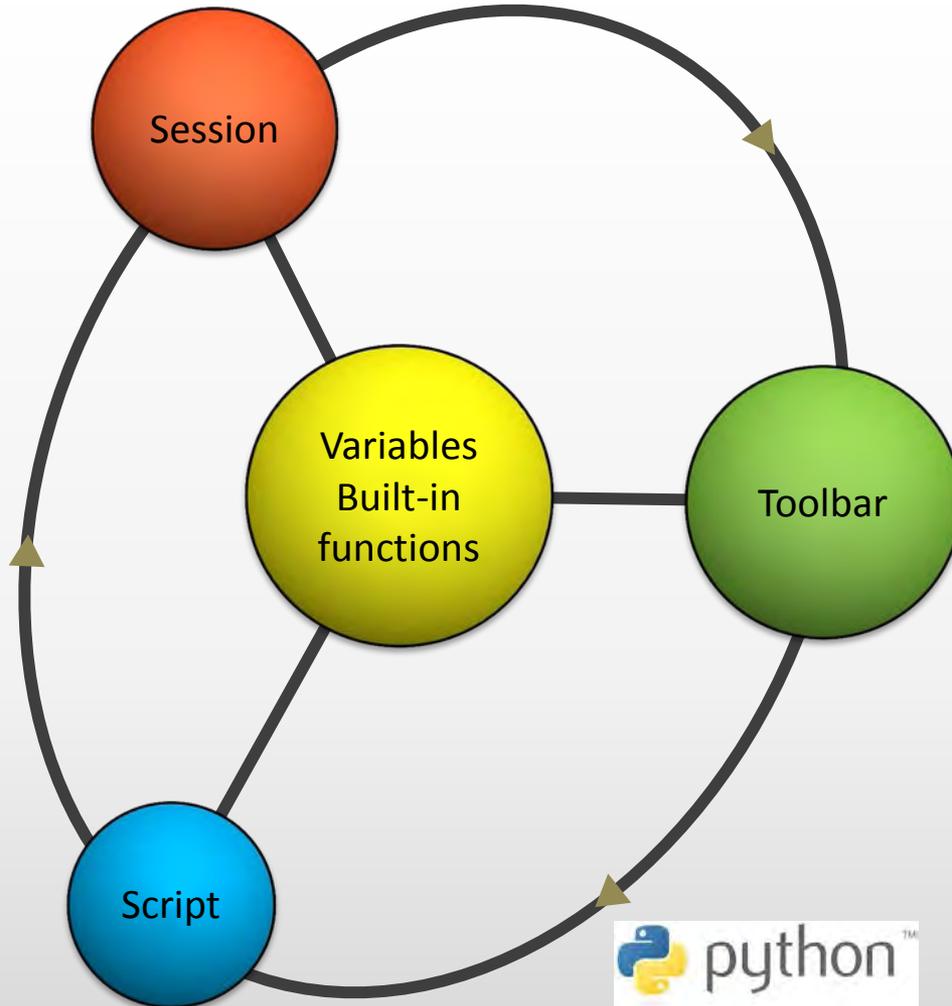
META Tools

META Tools

Composite Post toolbar
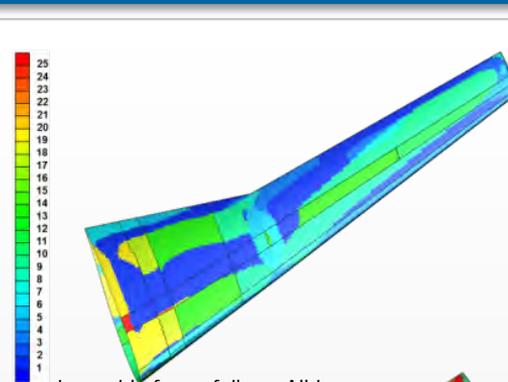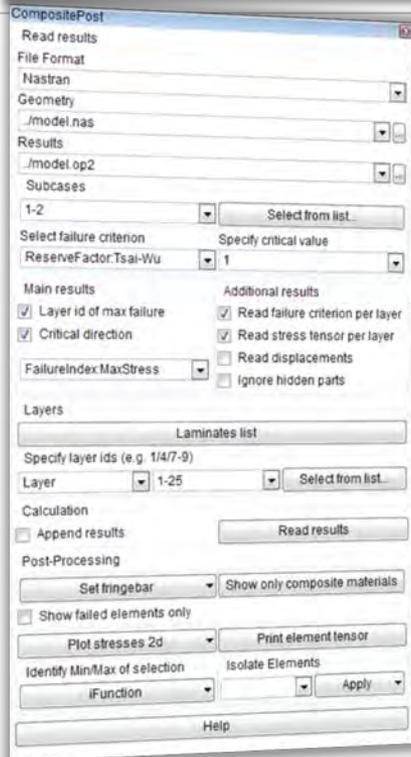
Layer id of max failure, All Layers

CompositeStresses,ReserveFactor:Tsai-Wu,MinofAllLayers

Critical direction,FailureIndex:MaxStress,Layer:1
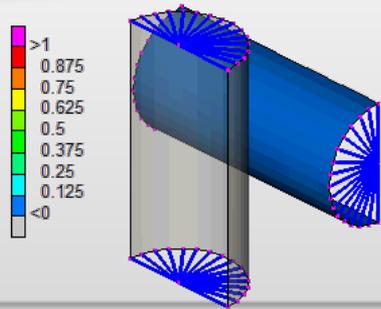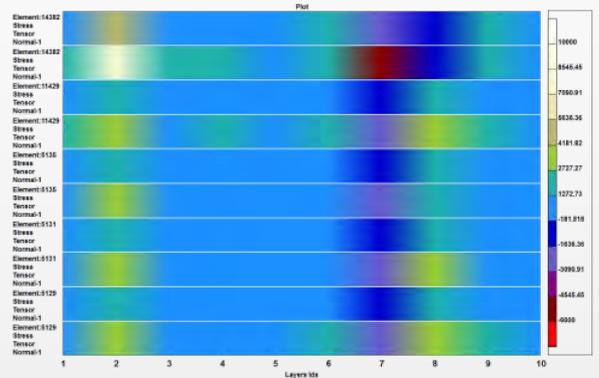
- Calculation of Failure criteria - Reserve Factor - Effort (Tsai-Wu, Puck, …)
- Identification of Layer id with max failure
- Identification of Critical direction
- Show failed elements only
- Curves plot of stress tensor results through thickness
- Re-evaluation of failure criteria by modifying materials' properties

META Tools

Random Response

Stresses,Von Mises,Max of Top Bottom,PSDF,Centroid @ 340 Hz
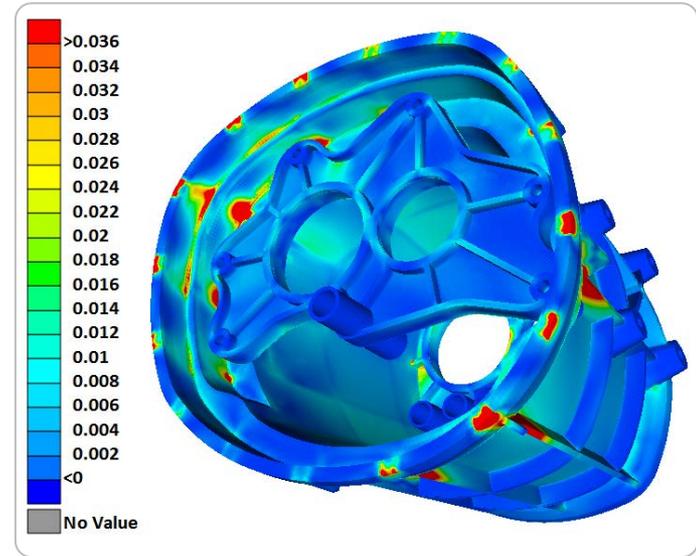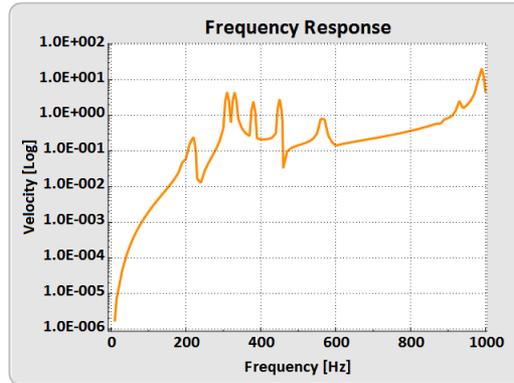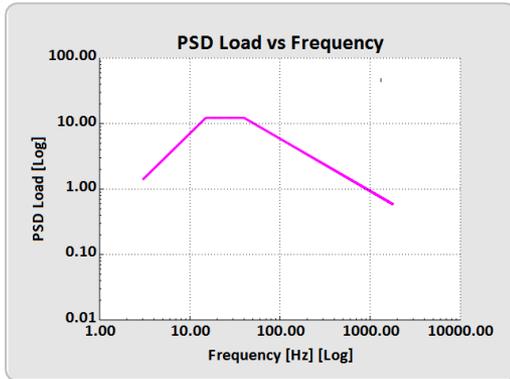
Random Response loadcase
(including Coupled Excitations)

$+$

Frequency Response analysis

$\Rightarrow$

Correlation Matrix of Subcases

$$\begin{bmatrix} 1 & \cdots & 0{,}003 \\ \vdots & \ddots & \vdots \\ 0{,}003 & \cdots & 1 \end{bmatrix}$$
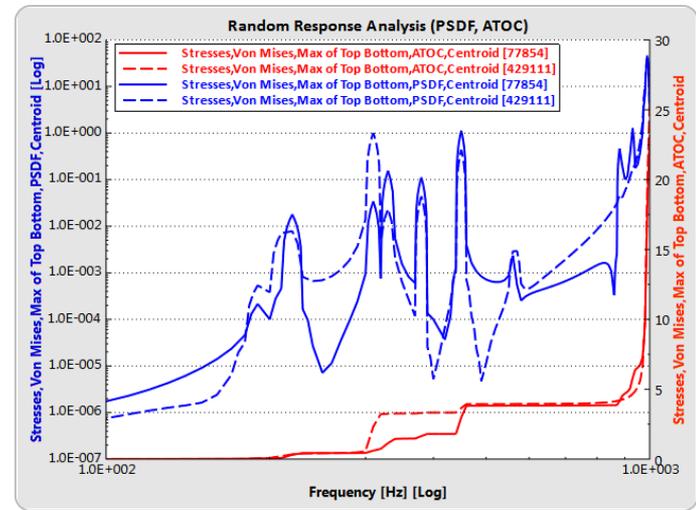
Random Response results

Calculations for Nastran:

- Von Mises (PSDF, ATOC, NO, RMS) and other…

META Tools

Strain Gauges

Gauge : STRAIN_GAUGE_1
Ex : 1.572E-004
Ey : -2.424E-004
Exy : 6.796E-005
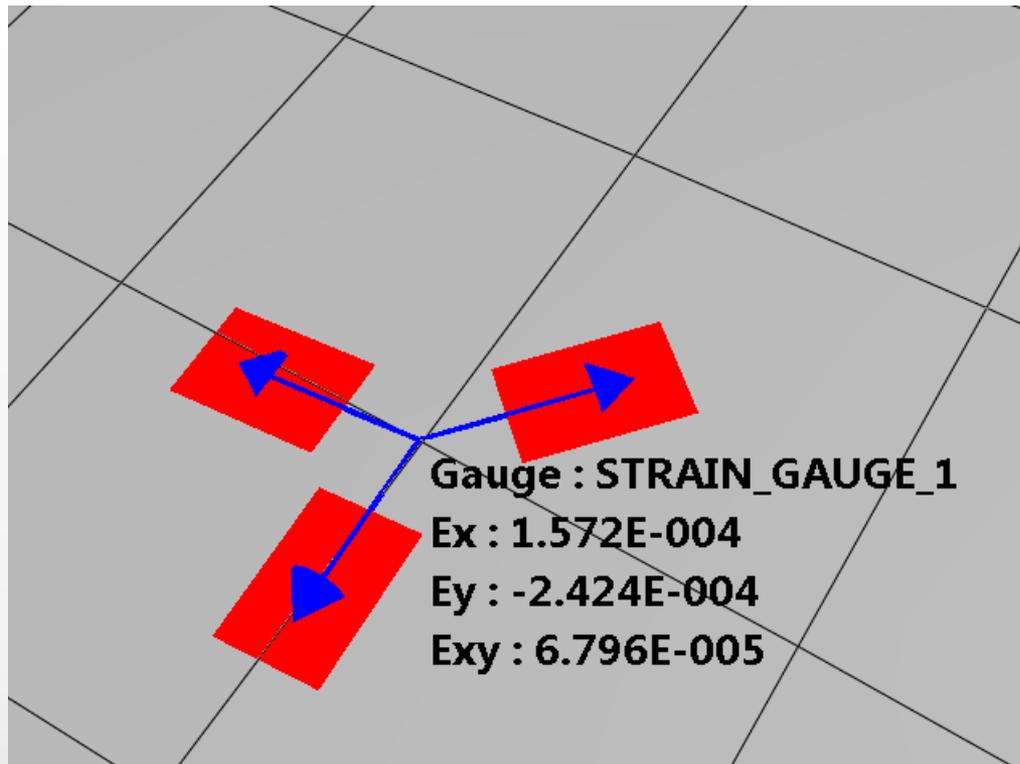
- Tool to Create/Edit/View strain gauges
- Calculate Strain results
- Correlate physical tests with FE calculations
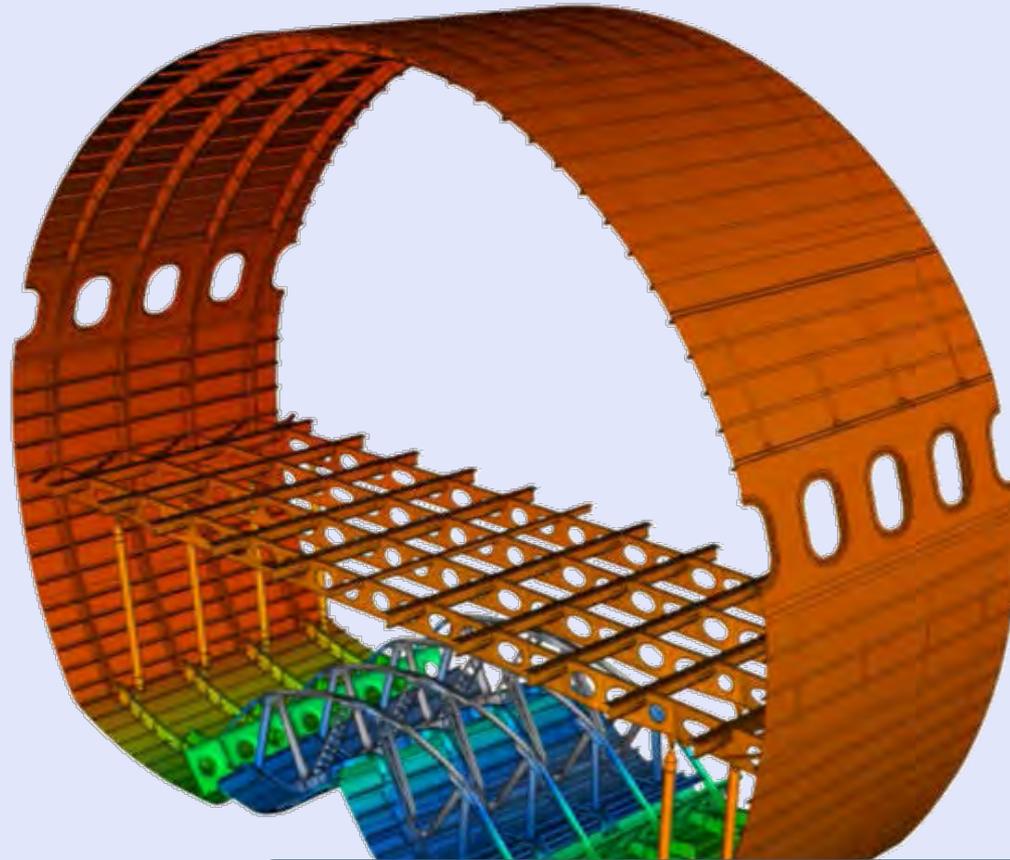
CASE STUDIES

Case Study - Fan Blade Out and Rotor Unbalance Simulation
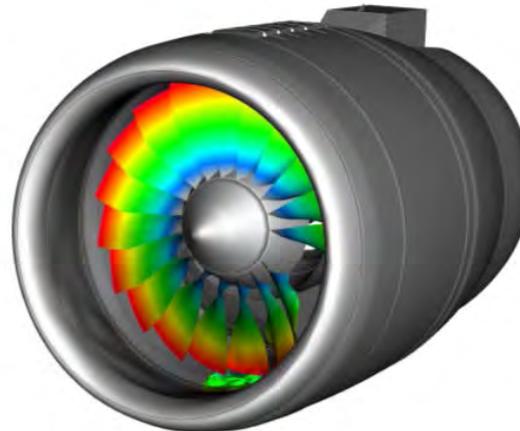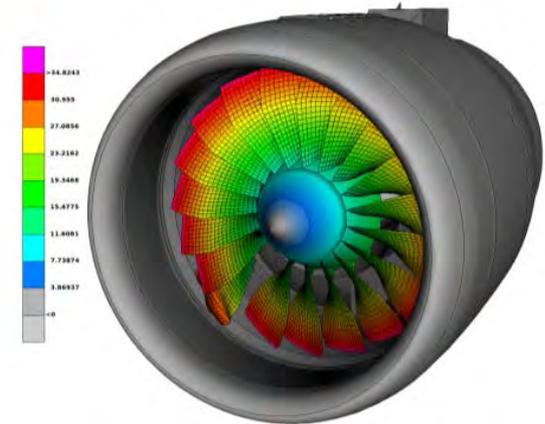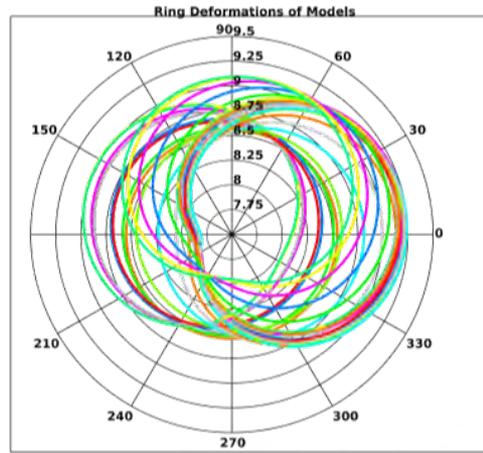
Fan Blade Out (FBO):
MD NASTRAN 2010 Transient Explicit Dynamic Analysis - 64000 Elements
Blade & Rotor (Titanium): Elastic-Plastic Material
Case: Elastic-Plastic material

Case Study - Fan Blade Out and Rotor Unbalance Simulation

Case Study - Fuselage central section vertical drop test
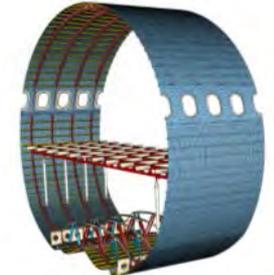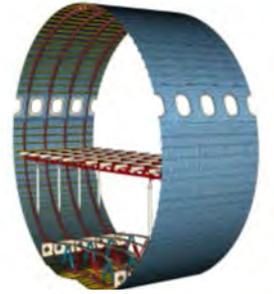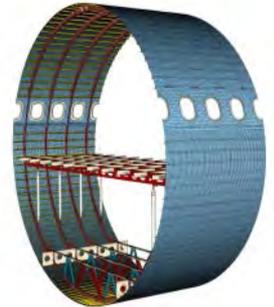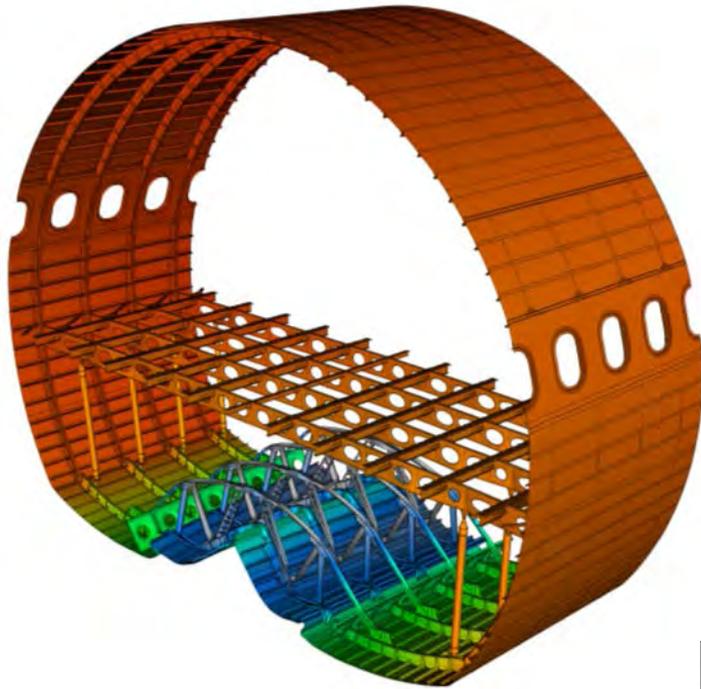
Case Study - Fuselage central section vertical drop test
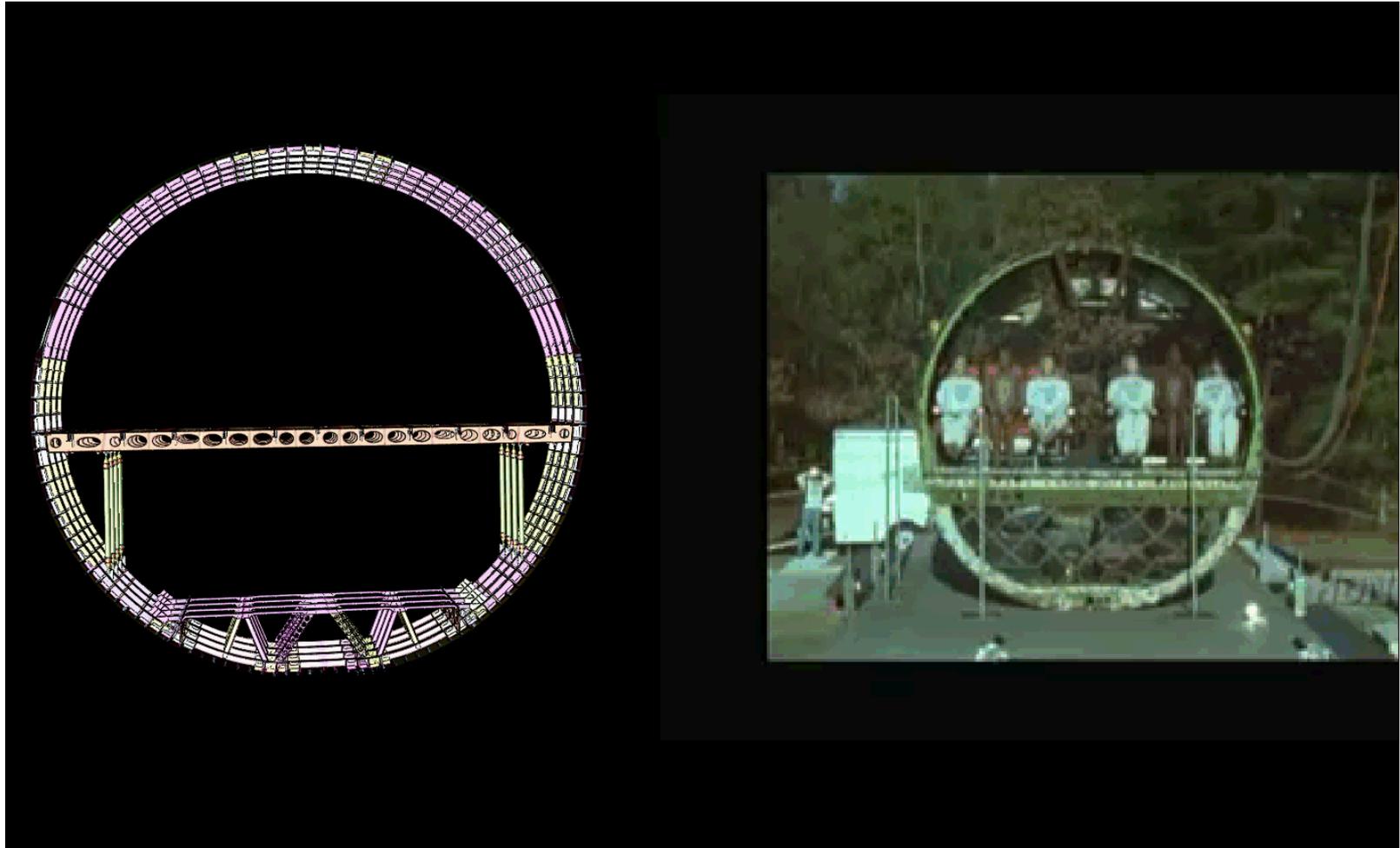
Case Studies - Buckling

Post Buckling performance of a stiffened panel
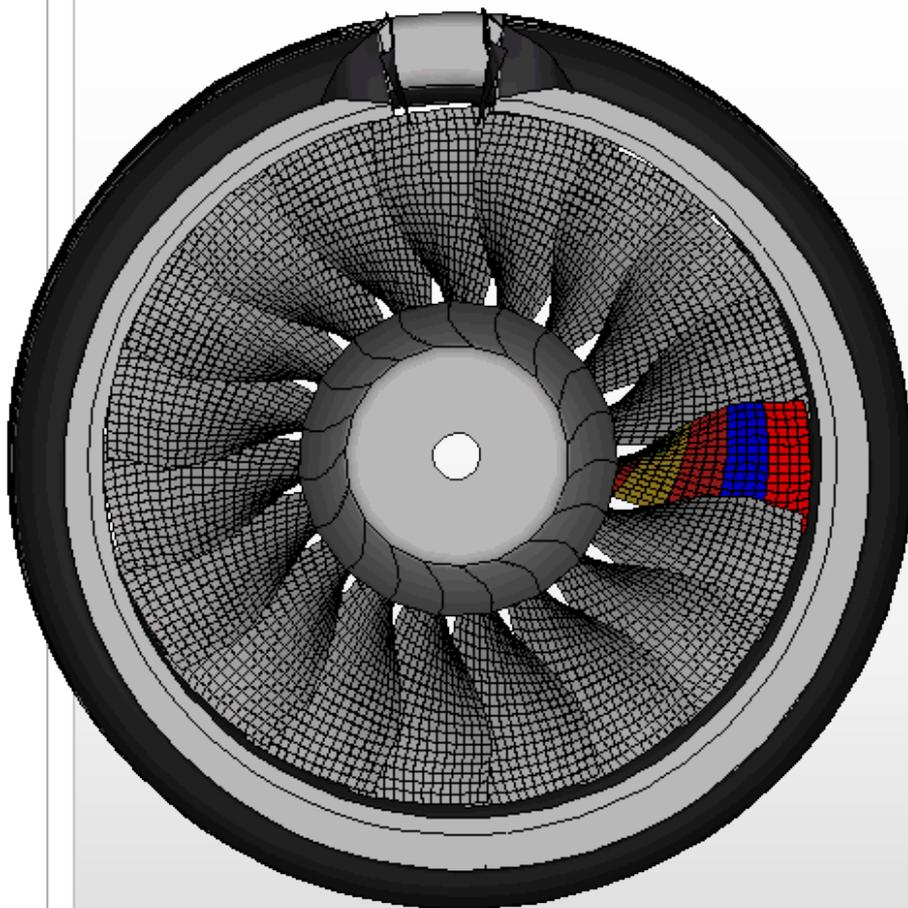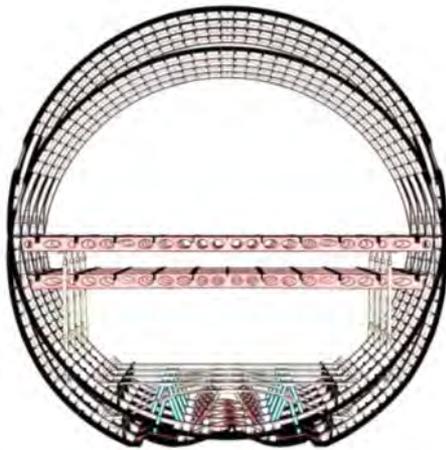
- Design for Post Buckling performance
- Tested to Destruction with initial imperfection sensitivity

Neutral Axis

69 kN
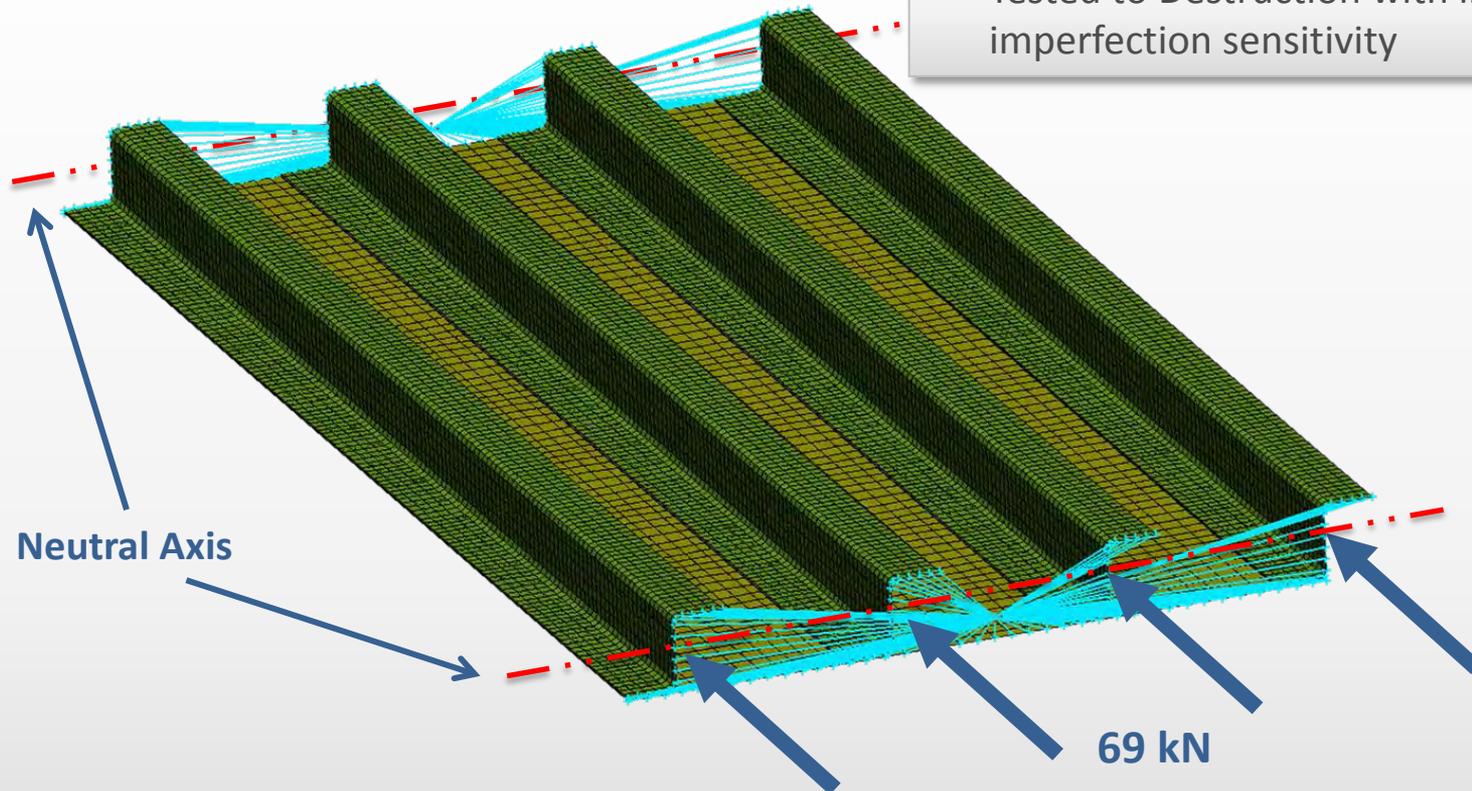
Source: Lillico, M. et al, 2000, "Optimum Design and testing of a postbuckled stiffened panel". 41st AIAA conference .

Case Studies - Buckling

Linear static results in META

0:buckl_Force_tied_RBE2_improved_2_4@COG-6.nas : Scalar: Stresses,Signed Von Mises,Max of Top Bottom : : Scale Factor 1.000E+01 : SUBCASE 1
CASE SUBCASE 1

Legend:
- >-120
- -121
- -122
- -123
- -124
- -125
- -126
- -127
- -128
- -129
- <-130
- No Value
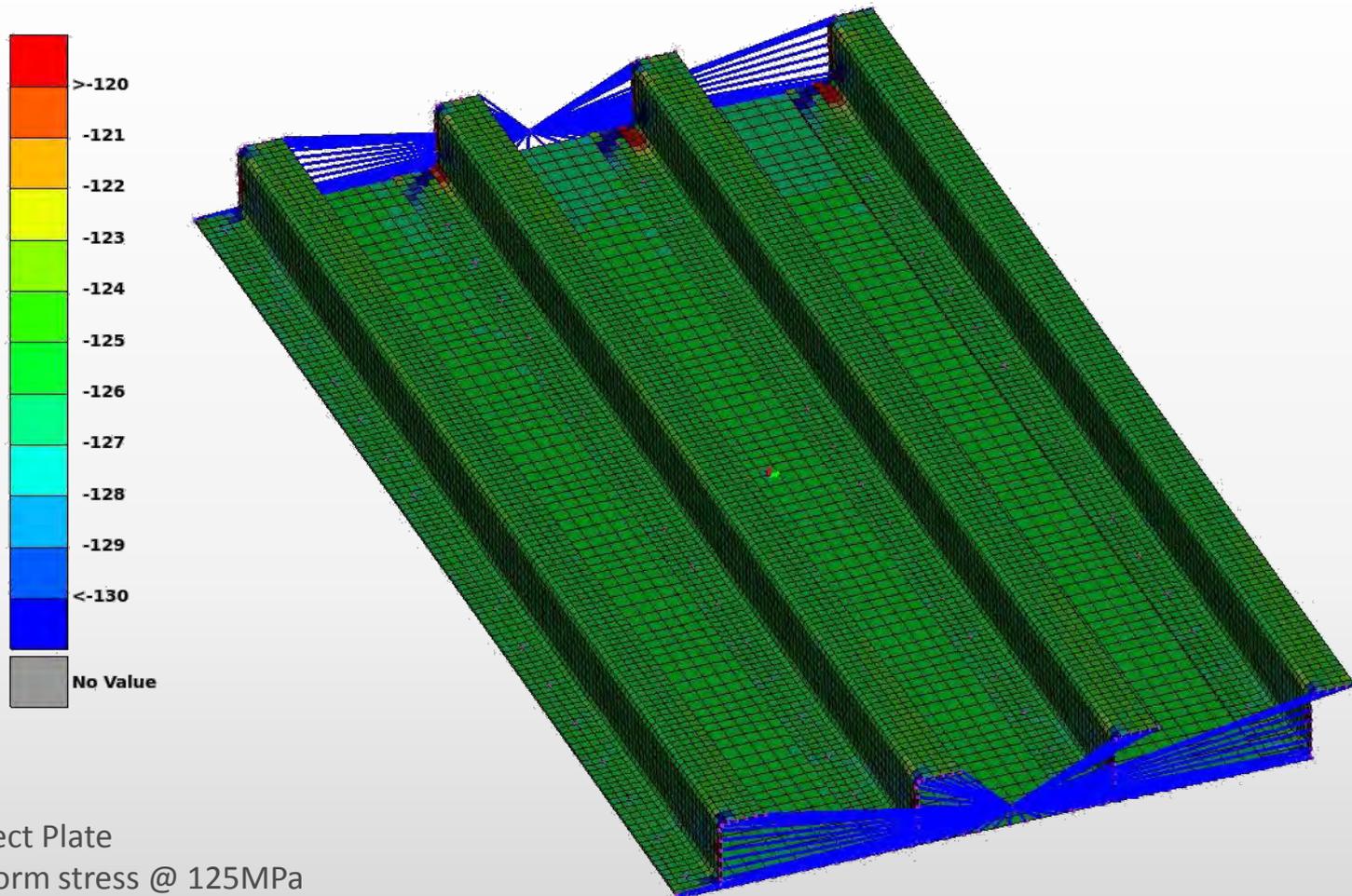
- Perfect Plate
- Uniform stress @ 125MPa

Case Studies - Buckling

Buckling results in META

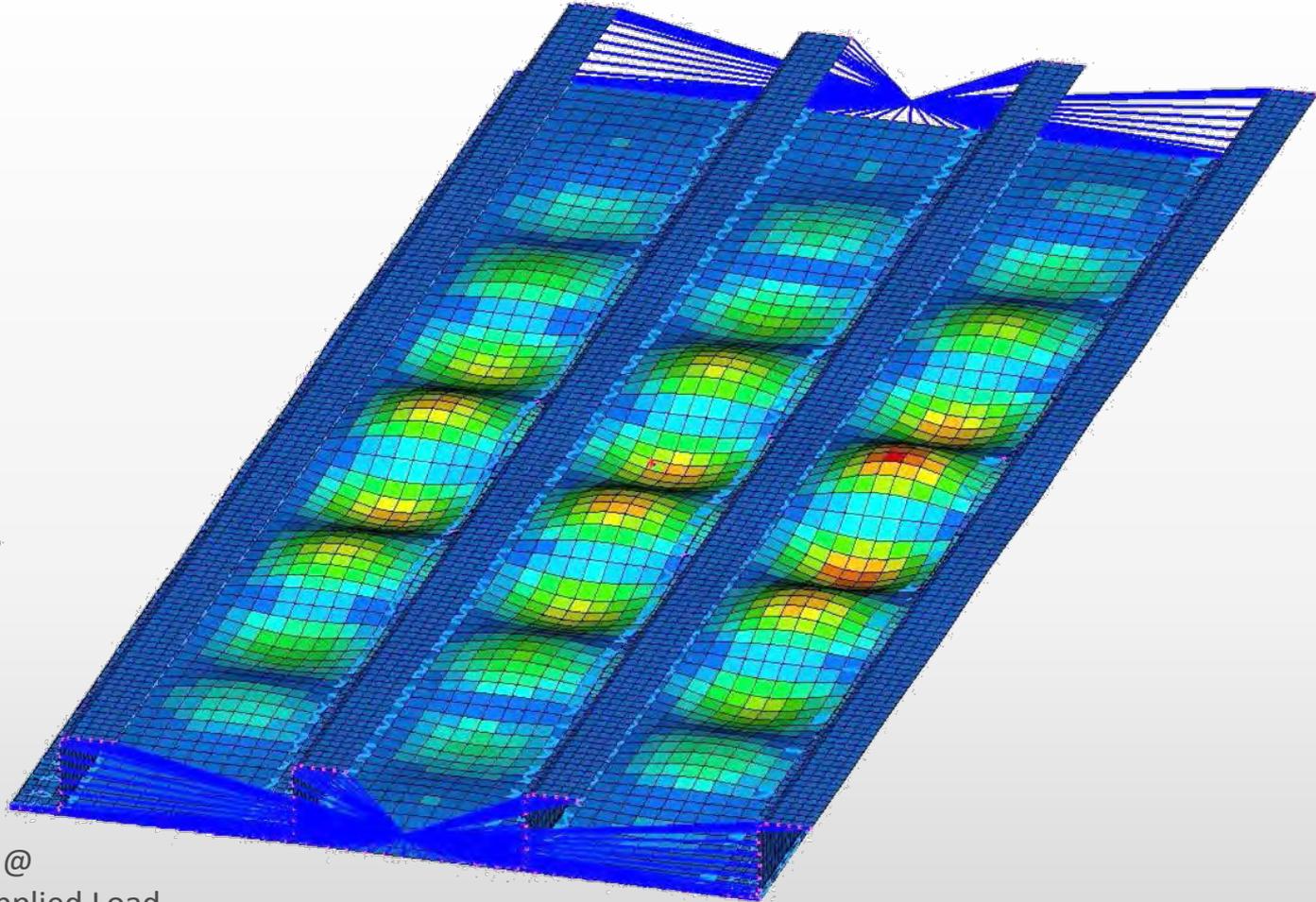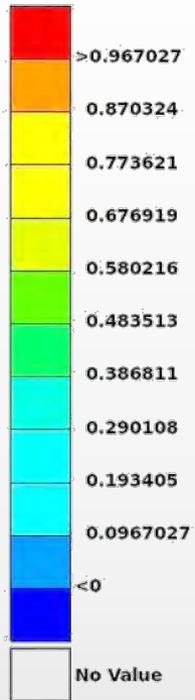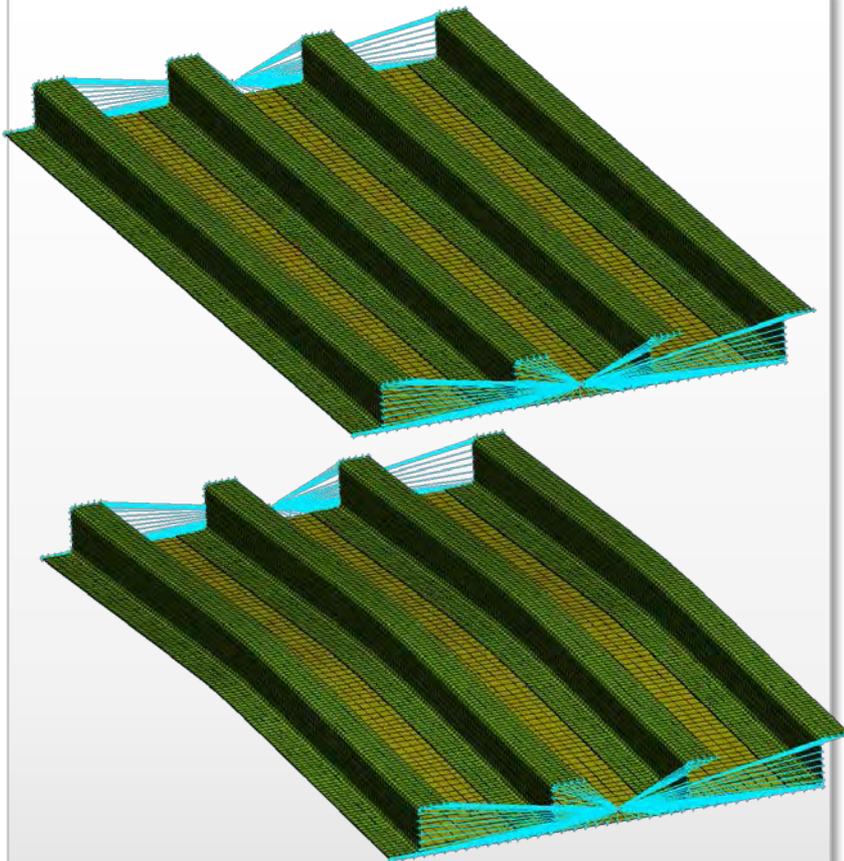0:buckl_Force_tied_RBE2_improved_2_5@COG-6.nas : Scalar: Eigenvectors,Translational,Magnitude#1 : : Scale Factor 1.000E+01 : SUBCASE 2   ::MODE 1
,FREQUENCY 1.396500E-01   ,EIGENVALUE 7.699131E-01   ::BUCKLING CASE SUBCASE 2

>0.967027
0.870324
0.773621
0.676919
0.580216
0.483513
0.386811
0.290108
0.193405
0.0967027
<0

No Value
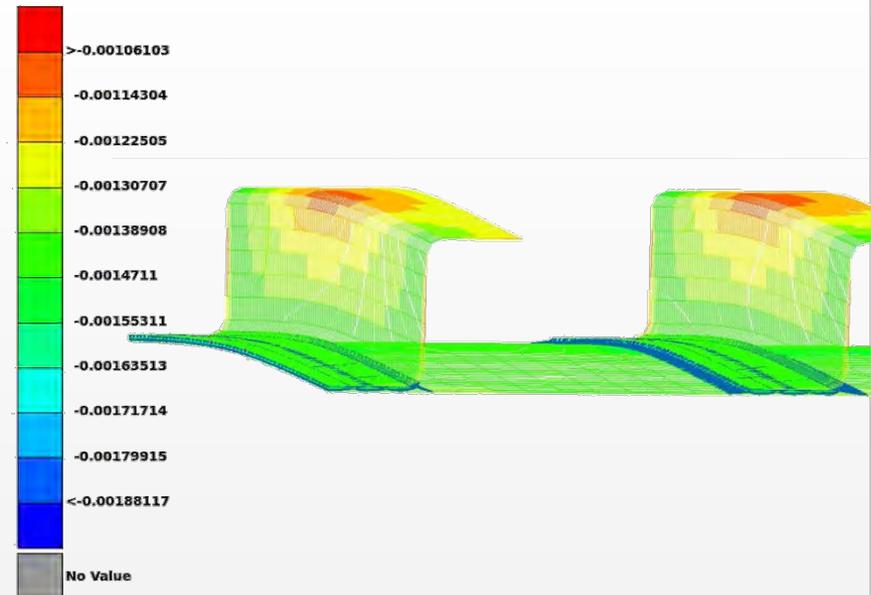
- 1st Mode @
- 77% of Applied Load

Case Studies - Buckling

Defining eccentricity using Morph

0.2% Eccentricity created using the Morphing Tool which is required for initial imperfection

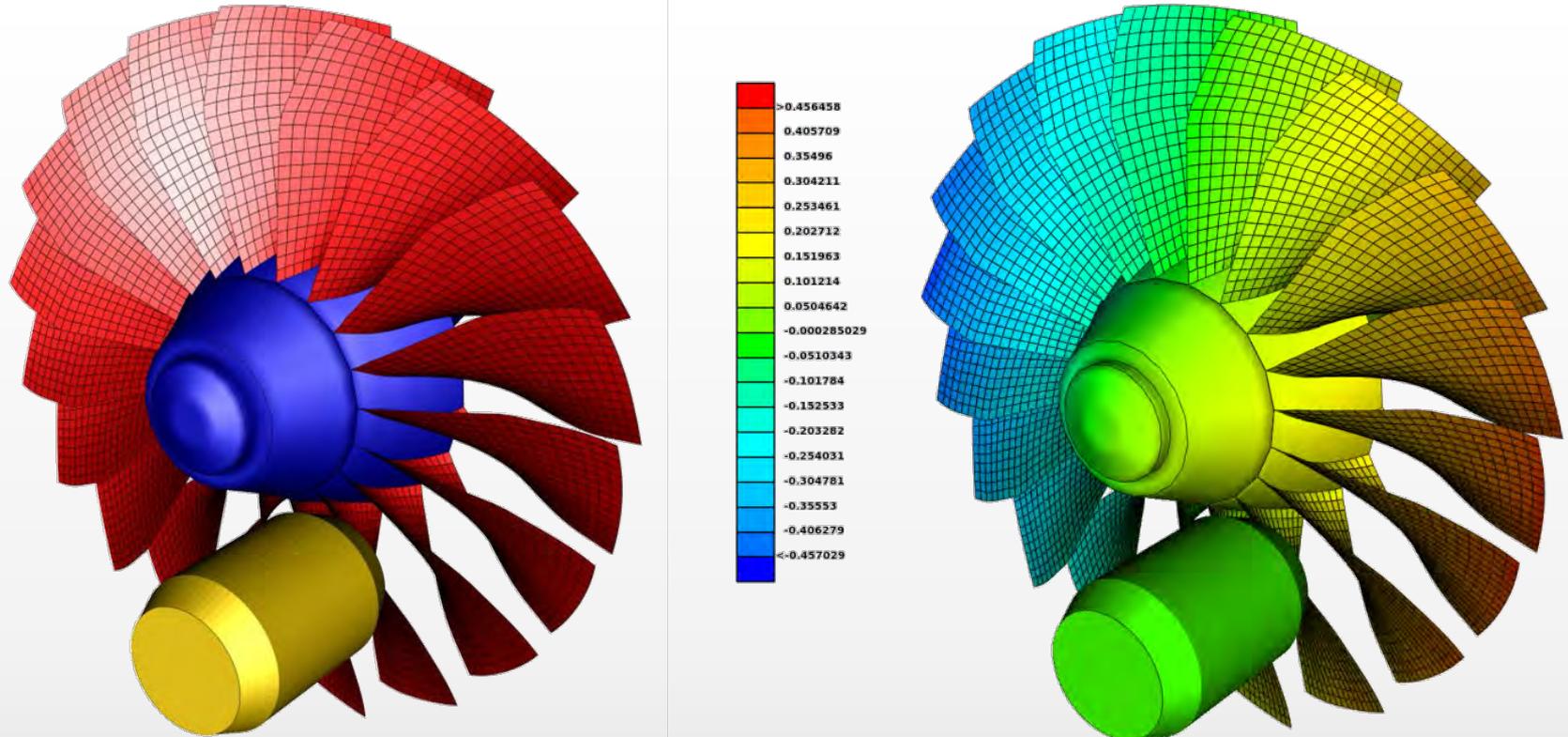## Eccentricity - Results

Experiments:
- Experiment 1 : - length/500 = -1.078mm (sagging)   EigVal: + 5.6 %
- Experiment 2 : Perfect Panel
- **Experiment 3 : + length/500 = 1.078mm (hogging)   EigVal: - 5.9 %**

Case Studies - Bird Impact Simulation

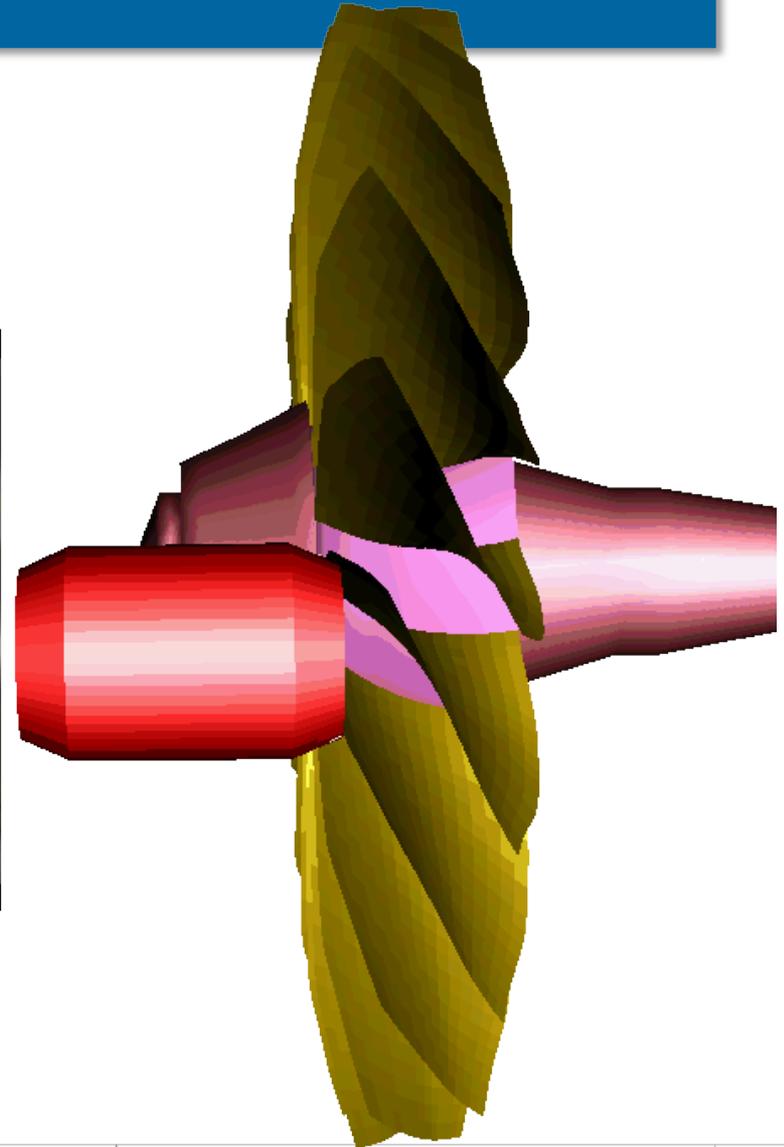## FE model and results in META

Bird Strike:

MD NASTRAN 2010 Transient Explicit Dynamic Analysis - 19000 Elements

Blades: Piecewise linear plastic material (MATD024)

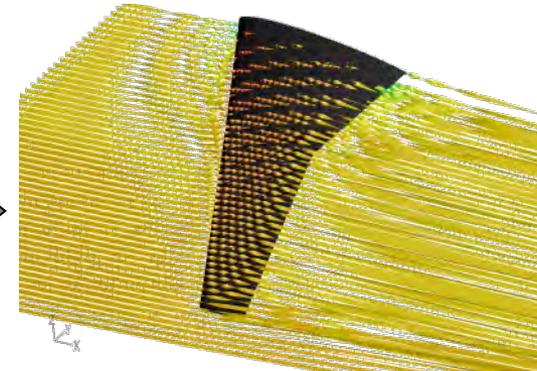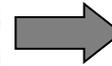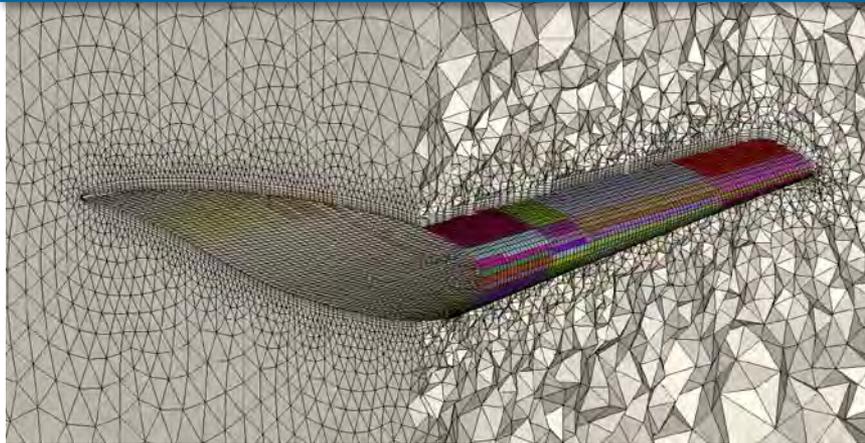Bird: Elastic-Plastic hydrodynamic Material (MATD010) – 10752 Solid Elements

Case Studies - Bird Impact Simulation

Case Study – Results mapping

External Aerodynamics
analysis in Fluent
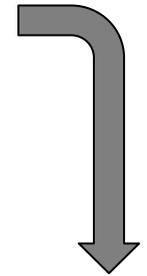
External Aerodynamics
Pre-Processing in **ANSA**

NASTRAN
SOL 101

Mapping of Pressure Field to
Wing Composite Model in
ANSA

Wing Deformation in **META**

> 2453.31
2155.82
1858.32
1560.82
1263.32
965.822
668.324
370.825
73.3271
< -224.171

Thank you

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