Optimizing and Accelerating Product Development efficiency with "One Model, One Solver", OptiStruct

Junji Saiki – SVP Head of OptiStruct Development
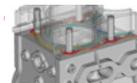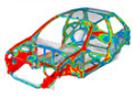
Altair OptiStruct Evolution

1990s

2000s

Present

1990s	2000s		Present
Linear Statics	Complex Eigenvalue	Nonlinear Statics	Nonlinear Transient
Normal Modes	Frequency Response	Large displacement	Plasticity
Inertia Relief	Response Spectrum	Rotor dynamics	Aeroelasticity
Topology Optimization	Transient Response	Composites	Fatigue
Size Optimization	Buckling	Contacts	Explicit Dynamic
Topography Optimization	Heat Transfer	Hyperelasticity	Electrical Analysis
Shape Optimization	Super Elements	Brake squeal	Piezoelectricity
	Random Vibration	Post Buckling	Forming

Optimization

2

OptiStruct v1.0
INDUSTRY WEEK's
Technology of the Year

NVH

Nonlinear

△ ALTAIR

Altair OptiStruct - Complete and Competitive Solutions

Linear/Nonlinear Static

Normal Modes

Linear Buckling

Complex Modes – Brake Squeal

Frequency Response (Modal, Direct)

Linear/Nonlinear Transient Response (Modal, Direct, Fourier)

NVH (Coupled Fluid-Structure FR)

Random Response

Response Spectrum/DDAM

Linear/Nonlinear Steady State Heat Transfer

Linear/Nonlinear Transient Thermal

Rotor Dynamics

Acoustics – Infinite Element/APML

Fatigue

Aeroelasticity

Explicit

Electrical Analysis

Piezoelectricity

One step Forming

Electrostatic

CFD – Cooling (Q4 2025)

Cavity Radiation (Q4 2025)

3

ALTAIR

OptiStruct Vision

THE Solver for linear and non-linear Analysis with powerful Optimization Technology

One Model, One Solver (Multi-Physics)
Pervasive Optimization
High Scalability

BIW : OptiStruct Workflow
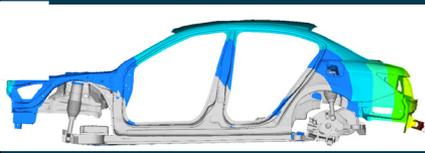
One Model One Solver

Single Input file with Multiple Load cases

No model conversion needed in order to run different loadcases
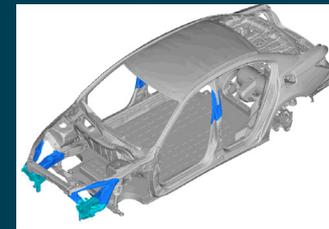

Design Optimization with multiple Design Criteria

MBD Road Simulation to FE-Load

Vibration
OptiStruct

Brake Load, Speed Bump ,Pothole
NL Static
OptiStruct

Modal Transient
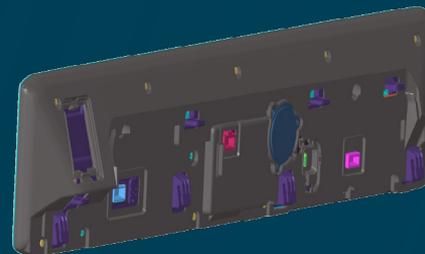OptiStruct

PSD Fatigue
OptiStruct

△ ALTAIR

One Model, One Solver at LGVS

Complex fatigue analysis reduced development time for vehicle infotainment components by more than 20%

TROY, Mich., July 31, 2024 – Altair (Nasdaq: ALTR), a global leader in computational intelligence, and LG Electronics Vehicle component Solutions Company (LG VS Company) have collaborated to develop analysis solutions aimed at extending product lifespans. LG Electronics reduced the development time for their vehicle infotainment components by over 20% with the help of Altair OptiStruct – an optimization-enabled structural analysis software and key product in the Altair® HyperWorks® design and simulation platform.

LG | ALTAIR

One Model, One Solver | Altair OptiStruct

All-in-One Analysis

Non-Linear Static · Noise & Vibration · Rotor Dynamic · Composite · Thermal · Durability · Impact & Drop · Optimization · Linear Static

Test	Solver
Shock test	LS-Dyna
Thermal test	Abaqus
Sine sweep test	OptiStruct
Vibration test	OptiStruct
Fatigue	nCode

→ OptiStruct

△ ALTAIR
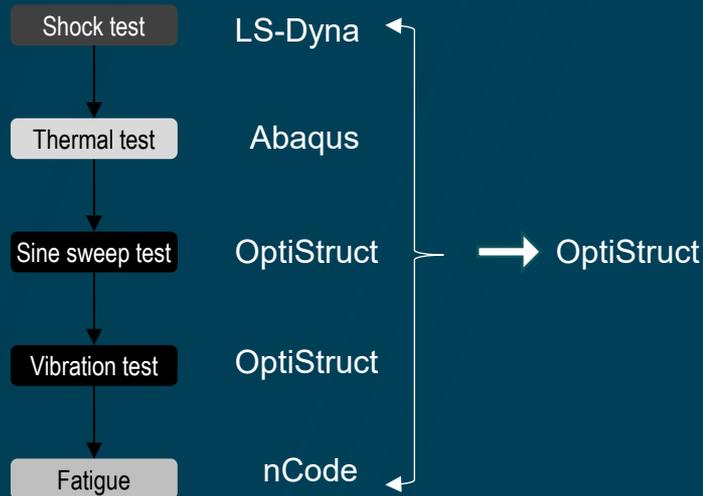
Multi-Physics – OptiStruct

Static Mechanical

Stiffness analysis
Bolt slippage and bolt stresses
Cooling plate overpressure
Lifting analysis (sagging-bulging)

Dynamic Mechanical

Modal Analysis
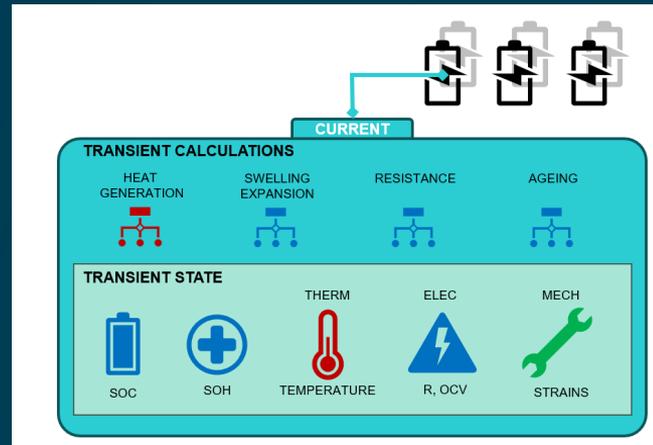Vibration Fatigue
Pack weld fatigue
Module mechanical Shock

Thermo Electric Mechanical

OCV v SOC
Rate Capability Charge & Discharge
Hybrid Pulse Power Characterization
Cycle Life Ageing
Storage
Rapid Charging / Discharging Charging
Swelling - Mechanical
Thermo Electric Mechanical Fatigue

Optimization

Weight Optimization
Multi Attribute Performance
Optimization
Cell / Module / Pack Layout
Optimization

CURRENT

TRANSIENT CALCULATIONS

| HEAT GENERATION | SWELLING EXPANSION | RESISTANCE | AGEING |

TRANSIENT STATE

SOC   SOH   THERM   ELEC   MECH

SOC   SOH   TEMPERATURE   R, OCV   STRAINS

Altair® OptiStruct®

THERMO ELECTRIC MECHANICAL

Explicit Dynamic Analysis

Target Use case for OptiStruct

- **Impact Analysis**
  - Roof Crash, Side pole impact, Seat Belt Anchorage etc…
  - Drop tests (consumer goods, containers, …)

- **Fluid Structure Interaction**
  - Sloshing & Slamming problems especially in shipbuilding industry
  - Wave impacts on offshore structures
  - Ditching of aero planes
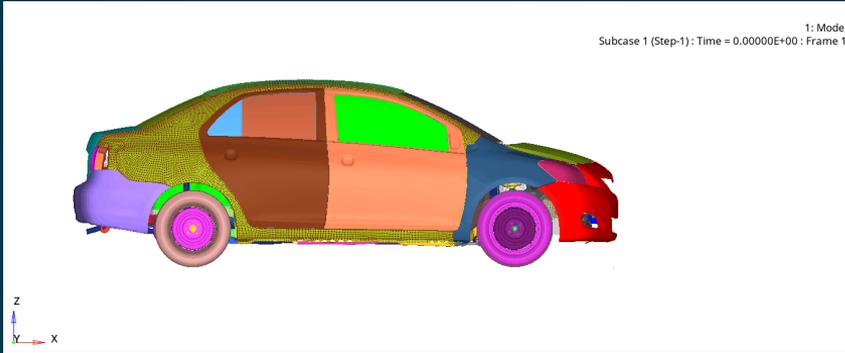 - Bird strikes, water , debris, ice impacts, ….
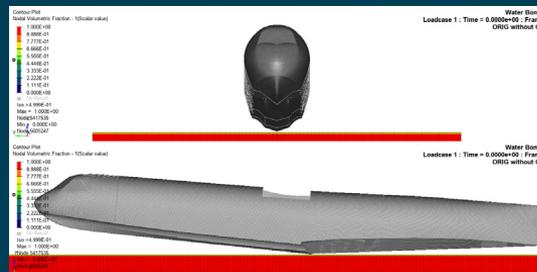
- **Blast & Hydrodynamic Impacts**
  - Explosion mechanism studies
  - Blast effects on structures (effect of a mine on a vehicle, ..)
  - Military systems functioning (shape charges, …)

ALTAIR
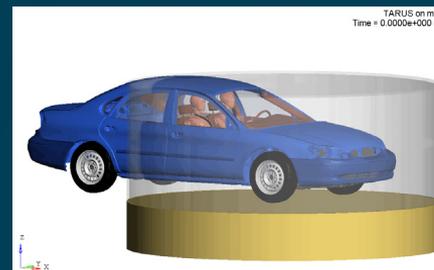
YARIS CRASH
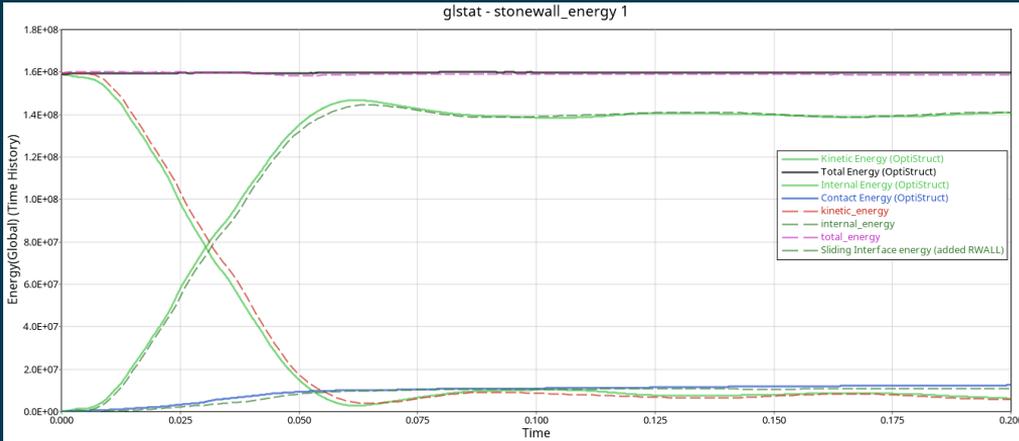
```
********************************************************

FINITE ELEMENT MODEL DATA INFORMATION :
---------------------------------------

   Total # of Grids (Structural)        :    1498230
   Total # of Elements Excluding Contact:    1612604
   Total # of N2S Contact Elements (3D) :     236516 (Explicit)
   Total # of E2E Contact Elements (3D) :      51020 (Explicit)
   Total # of Rigid Elements            :       3996
   Total # of Rigid Element Constraints :     185231
   Total # of Local Coordinate Systems  :       4564
   Total # of Degrees of Freedom        :    8022843
   (Structural)
   Total # of Non-zero Stiffness Terms
   for this Local Domain                :   46522614


   Element Type Information
   ------------------------

     CBEAM    Elements  :        313
     CHEXA    Elements  :     249668
     CTETRA   Elements  :        186
     CPENTA   Elements  :       9949
     CONM2    Elements  :     193605
     CQUAD4   Elements  :    1079146
     CTRIA3   Elements  :      63952
     CBUSH    Elements  :       4521
     JOINTG   Elements  :         44
```

# of cores	OptiStruct	Radioss
32	2:27:37	2:55:50

Implicit – Explicit Continuation

Implicit subcase and Explicit subcase in single input file

Explicit subcase continues from the end of implicit simulation
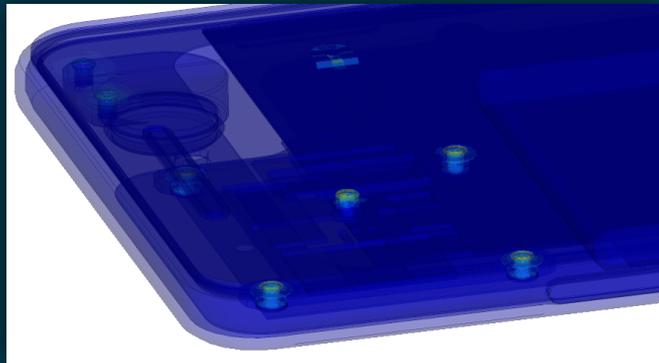
Implicit results (Tightening the screw)

Implicit – Explicit Continuation
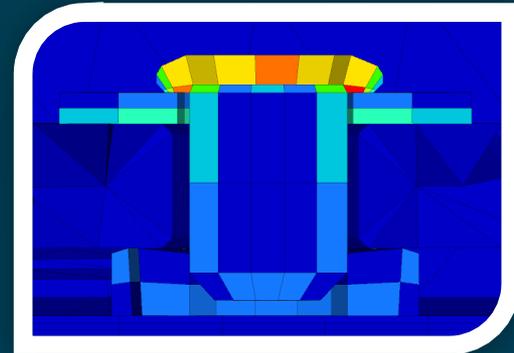
Stress distribution
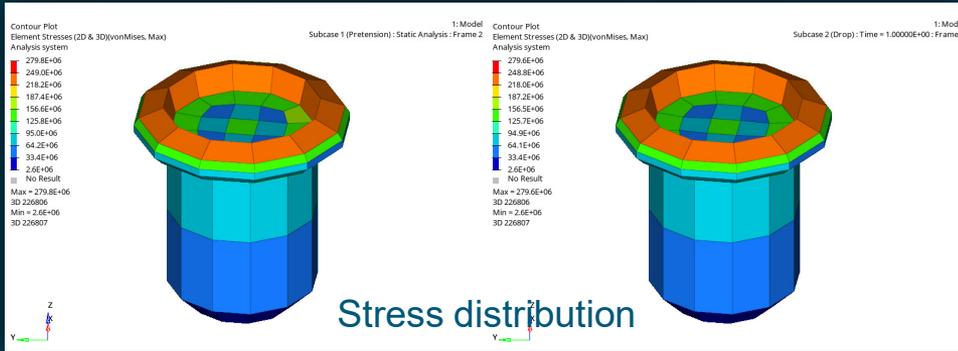
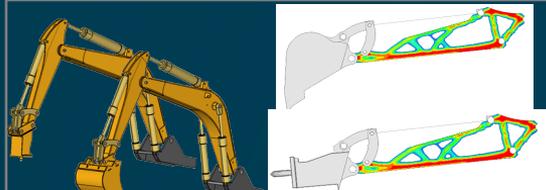At the end of Implicit subcase   Beginning of Explicit subcase
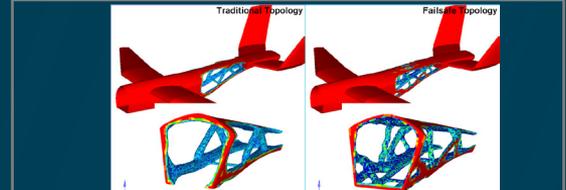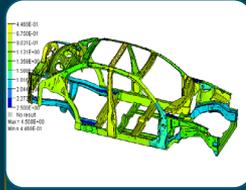

Explicit Drop Simulation

11
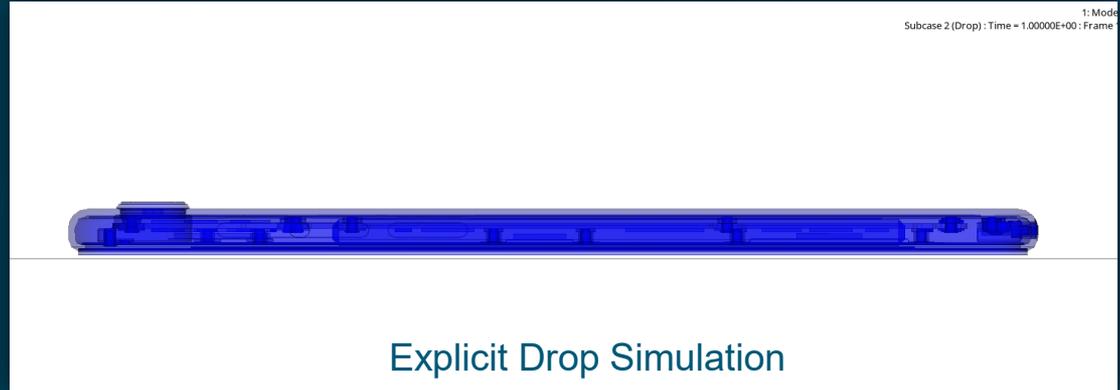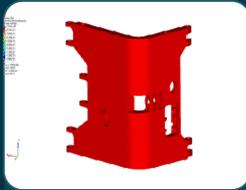
Optimization
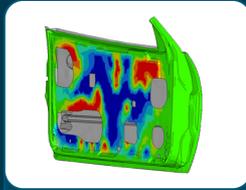
Topology

Topography

Multi Model Optimization

Failsafe Topology
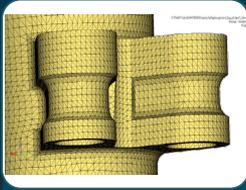
Shape

Size

Composite Layout

Multi Material Optimization

Free Shape
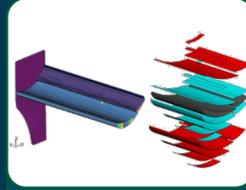

Free Size

Lattice Structures
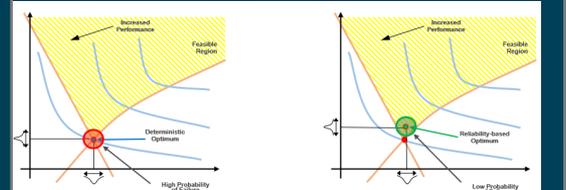
Reliability-based Design Optimization

ALTAIR

Standard Design Workflow

Mfg Expertise

High Fidelity Manufacturing Simulation

Highly Nonlinear

Results interpretation

Parametric Optimization

Highly Nonlinear

Multidisciplinary

Topology optimization

Metamodel based Optimization

Manufacturing process related constraints

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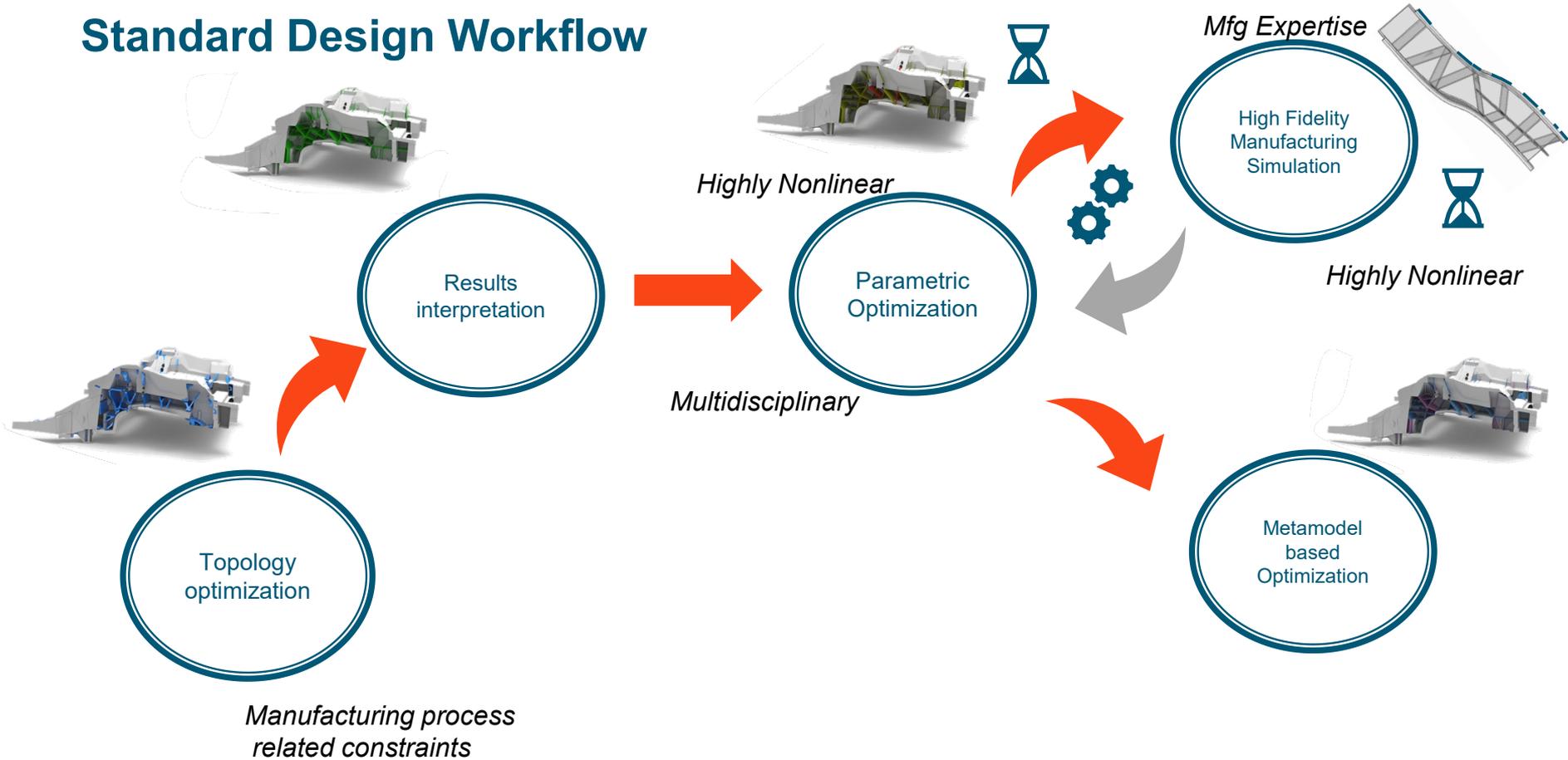
Towards Generative Design Workflow

Mfg Expertise

Highly Nonlinear

Results interpretation

Parametric Optimization

High Fidelity Manufacturing Simulation

Highly Nonlinear

Multidisciplinary

Topology optimization

Enhanced interpretability

Enhanced manufacturability

Accounting for porosities

Incorporate nonlinearities (e.g. crash)

Metamodel based Optimization

Speed-up development process. Reduce total time to market and cost.

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Enhanced Manufacturability and Interpretability

- **Draft-Angle Constraint**
  - **Ease of part removal, Minimize Mold damage etc…**

DRAW

Draft Angle

DRAW

DRAW
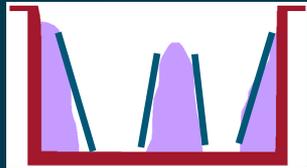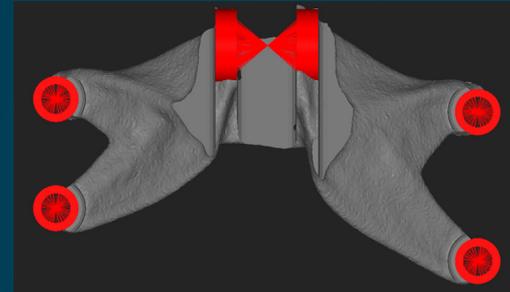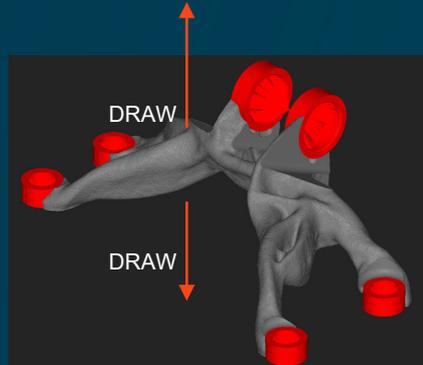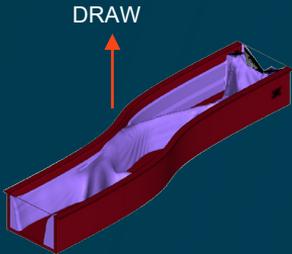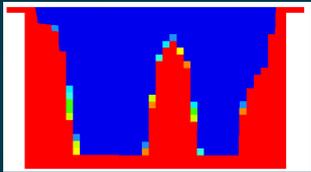
Up to 10 different directions

NOHOLE option to support filling
available from 2025.1

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Auto-Mesh Refinement in Topology Optimization

Motivation and Capabilities

Why?

➤ To get more detailed results

➤ To reduce solution time

How?

➤ Use coarse meshes but internally and automatically refine them iteratively based on topology optimization results. Utilize the power of HyperMesh meshing capability.
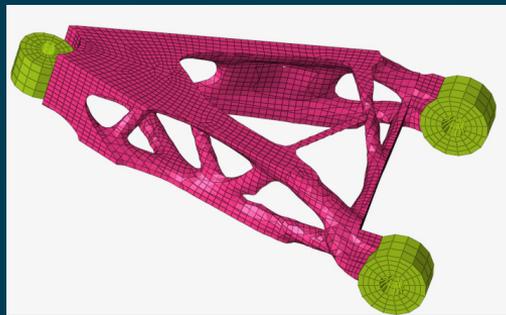
➤ Target Release : v2026 (end of the year)
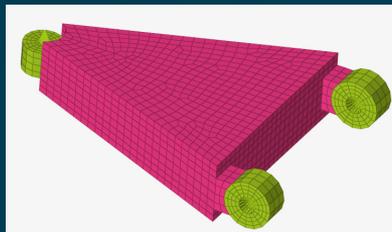
Initial Mesh
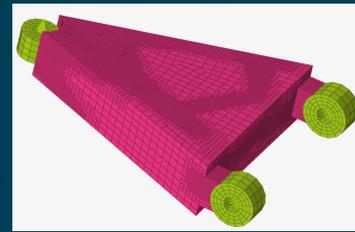
Automatically Refined Mesh

ALTAIR

Auto-Mesh Refinement Example

Element size   12 mm

Topology   0

Element size   6-12 mm

Topology   Refinement 1

Element size   3-12 mm

Topology   Refinement 2
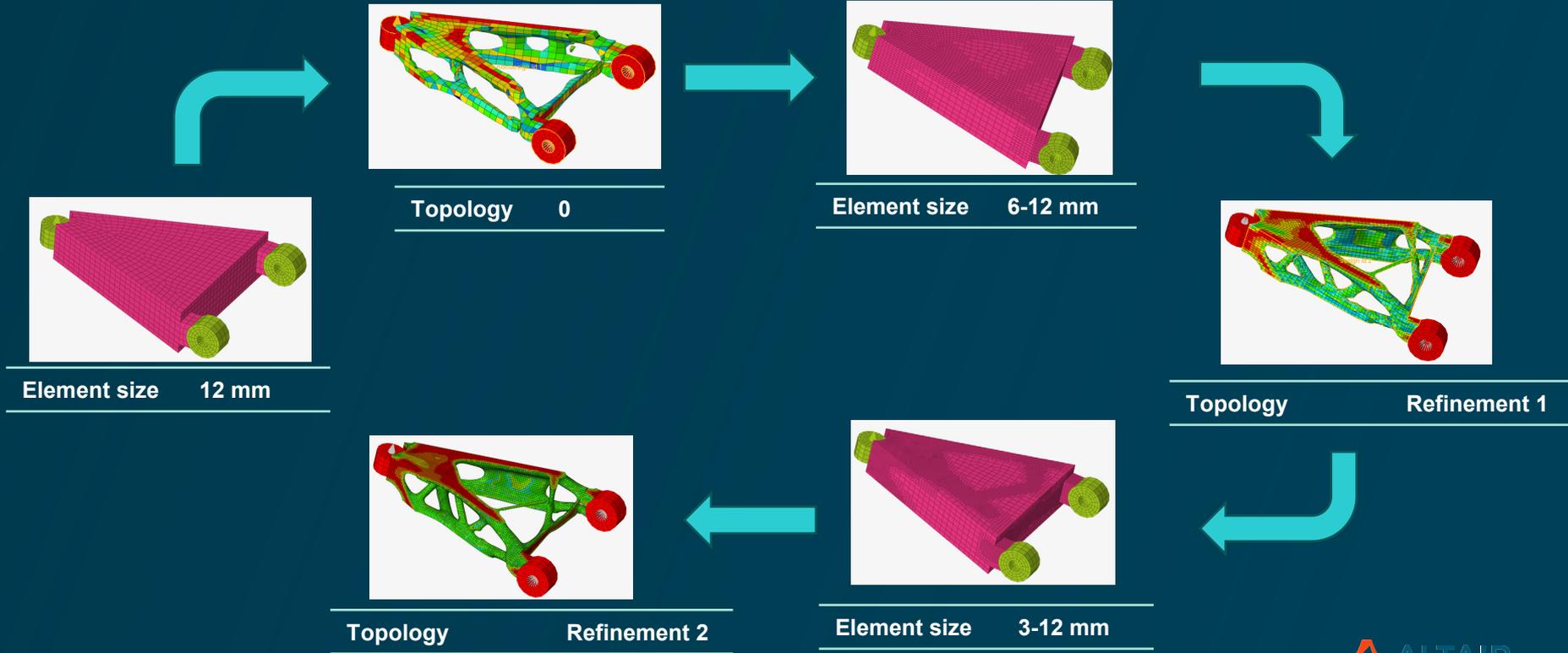
Auto-Mesh Refinement Example
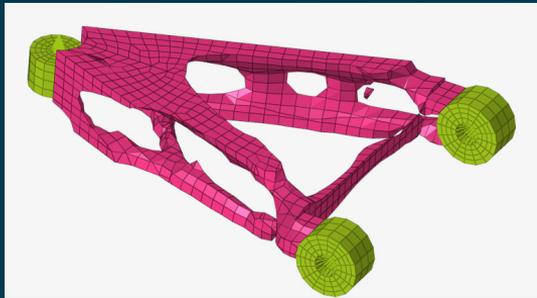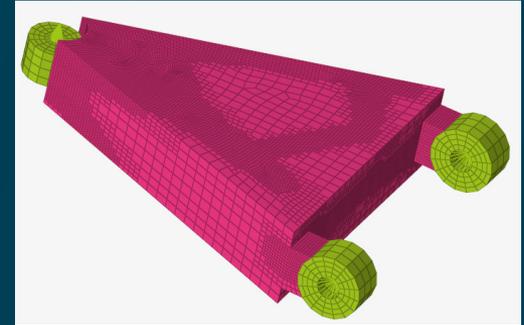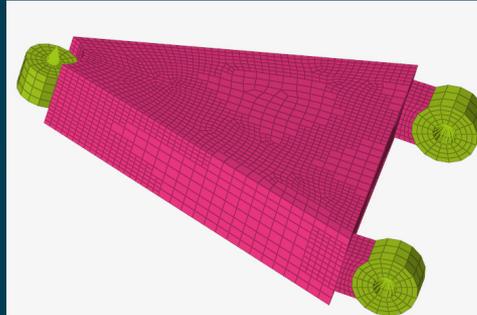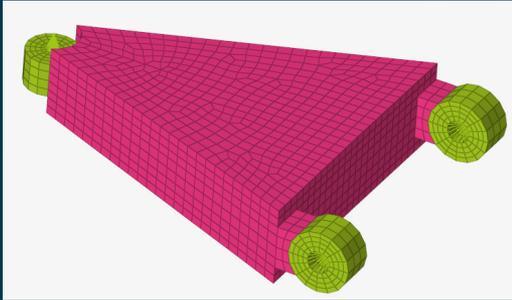
Topology	0
Topology	Refinement 1
Topology	Refinement 2
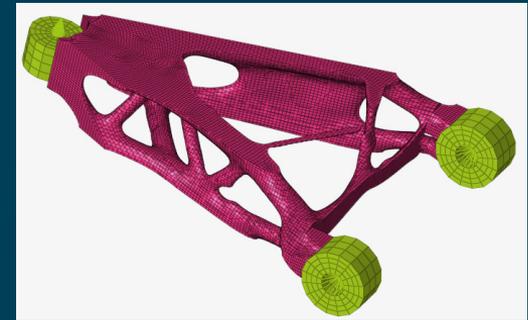
Performance Comparisson

Refinement 2

Refence Solution using Fine mesh
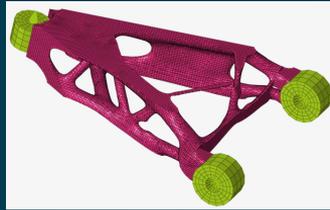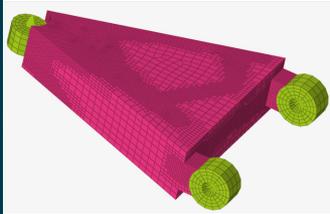

```
1 VOLUM Volume      --      --  TOTL 1.395E+06 MIN
2 DISPL DISP     1   2699   TXYZ 1.991E-02 <  2.000E-02  0.0 A
2 DISPL DISP     2   2699   TXYZ 4.983E-02 <  5.000E-02  0.0 A
2 DISPL DISP     3   2699   TXYZ 3.986E-02 <  4.000E-02  0.0 A
```
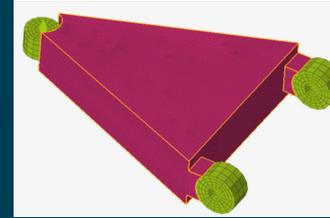
```
1 VOLUM Volume      --      --  TOTL 1.415E+06 MIN
2 DISPL DISP     1   2699   TXYZ 1.992E-02 <  2.000E-02  0.0 A
2 DISPL DISP     2   2699   TXYZ 4.986E-02 <  5.000E-02  0.0 A
2 DISPL DISP     3   2699   TXYZ 3.985E-02 <  4.000E-02  0.0 A
```

|	Refinement 2	Reference Solution
Element size	3 to 12 mm	3 mm
# elements	99,020	223 872
# iterations	64 (including ref 1 and 0)	41
Run time	**1 h 1 min (all runs)**	**4 h 20 min**

Topology shape, volume and constrains are similar in both results, but the refined answer was about 4 times faster.

19

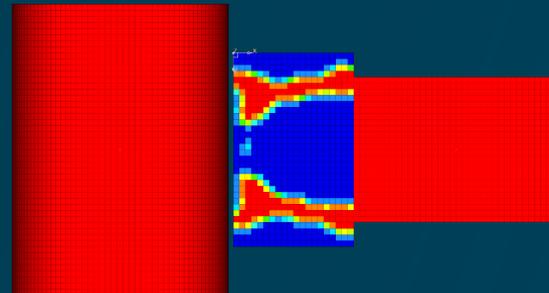# Topology Optimization with Explicit Analysis

Extruded Rocker

$v_0 = 8\,m/s$

$$\min compl,$$
$$s.t.\ vf \le 0.3$$

Manu. Constr.:
- *Extrusion*

Design-space
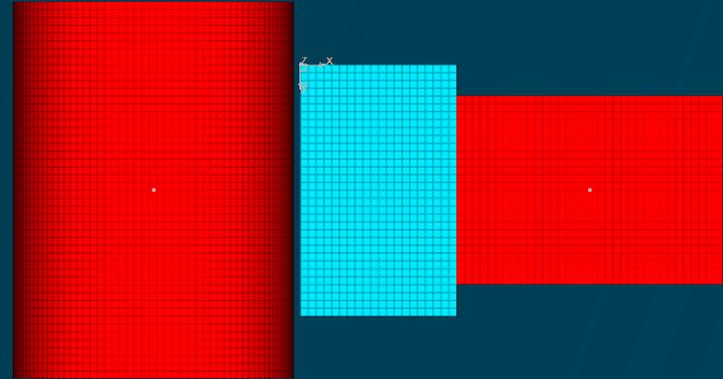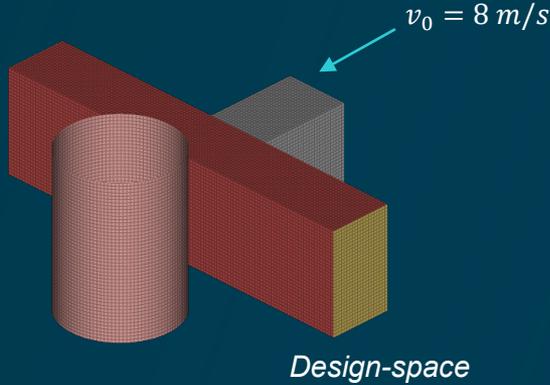
Optimized design

Summary:
- 17 design iteration
- Shell interpretation necessary for further evaluation

△ ALTAIR

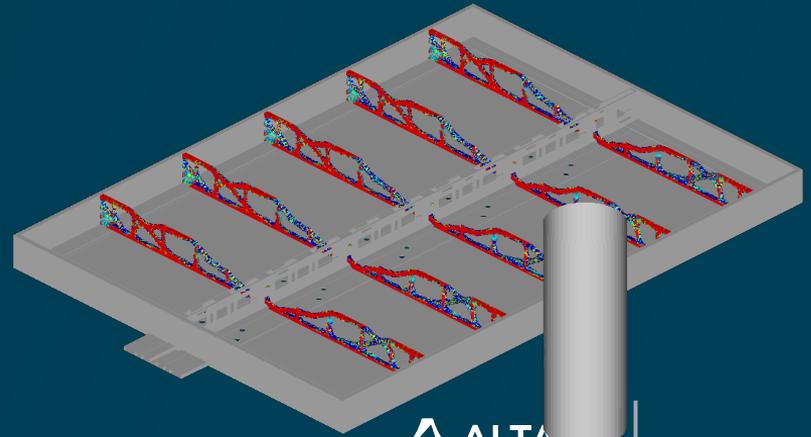# Topology Optimization with Explicit Analysis
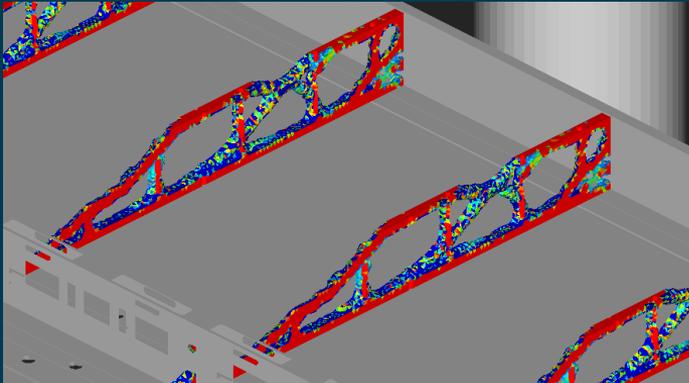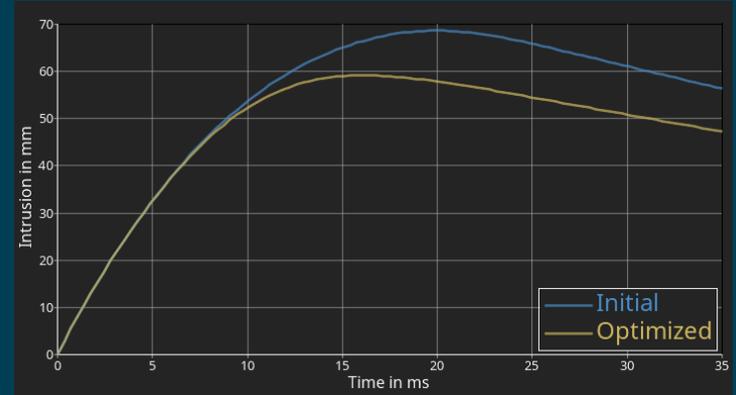
Battery Pack

$\mathbf{min}\ compl,$

$\qquad s.t.\ vf \leq 0.3$

Manu. Constr.:
- *Pattern Repetition*

$\approx$ 1 M. elements
500k tetra design-space
550k shell elements

Determine Location of Ribs
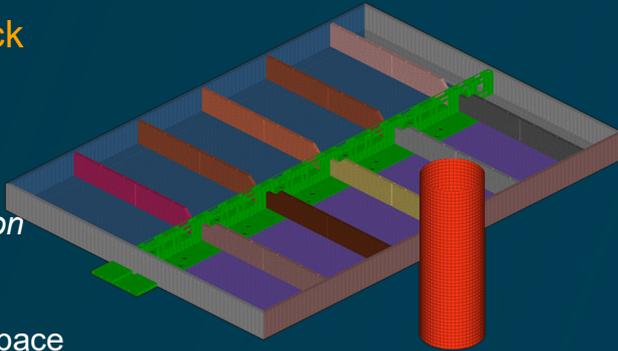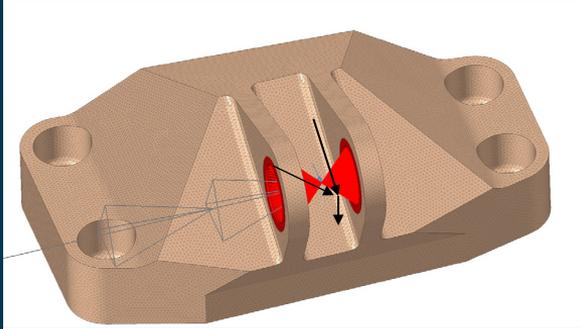
Topology Optimization coupled with Inspire Cast

Topology Optimization to take into account the porosities from Casting Solver
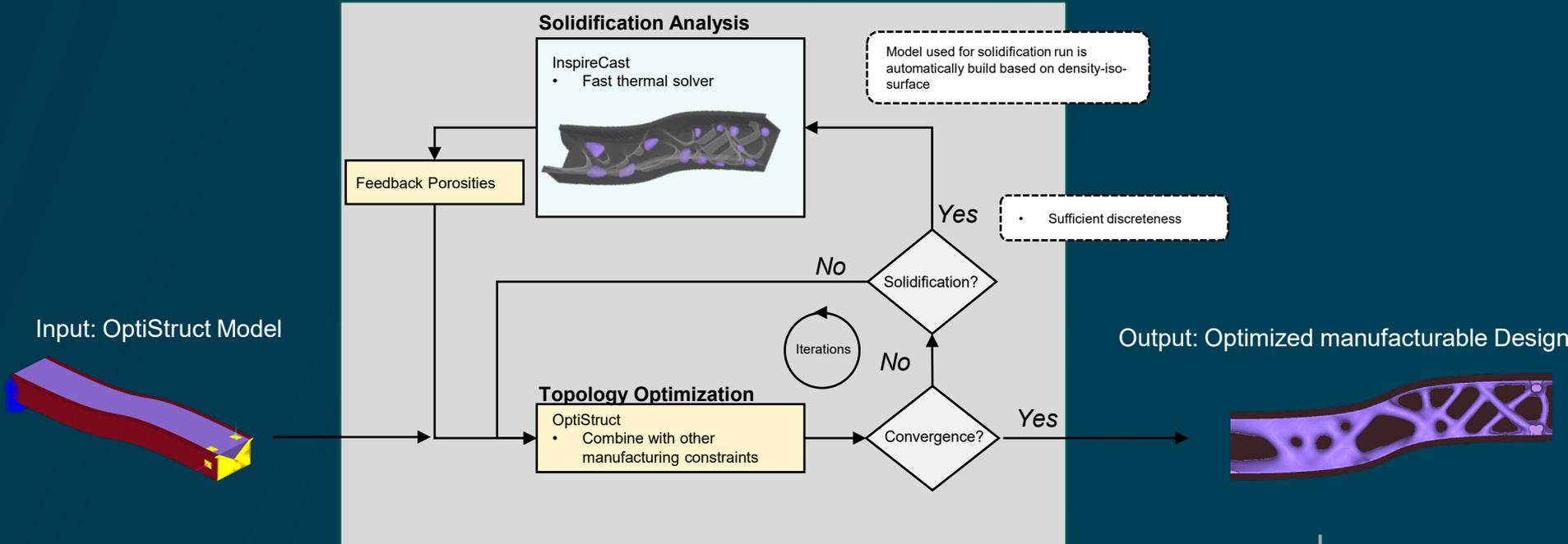
Example – Jet Engine Bracket

Final Design

$$\min comp,$$
$$s.t.\ vf \le 0.1$$
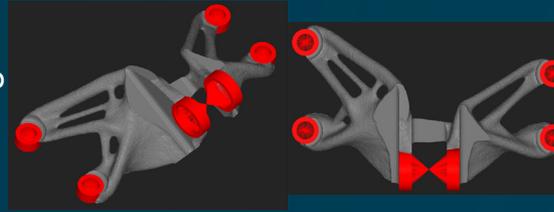$$v.m.str \le 903.$$

Manu. Constr.:
- *Mindim*
- *Split Draw*
- *Draft Angle*

Summary:
- Standard result is infeasible due to stresses
- Similar number of iterations
- Best compliance with coupling
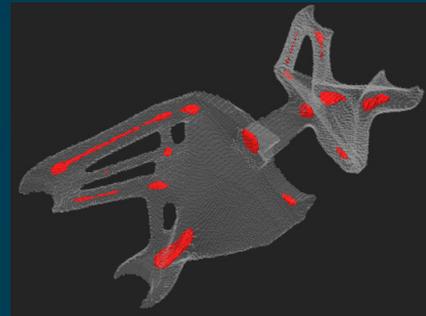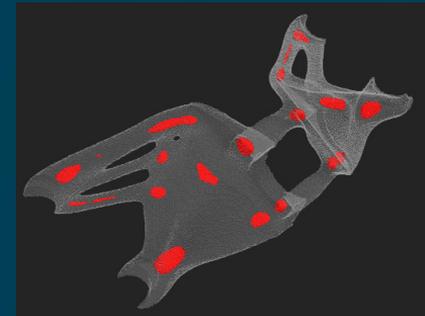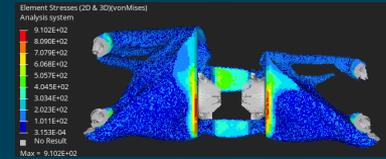
Converged design
comp: 5.311E4,
constraint violation: 0.4 % A
Discreteness: 70.%

Post-processed design
comp: 5.583E4 ,
constraint violation: 5.2% V
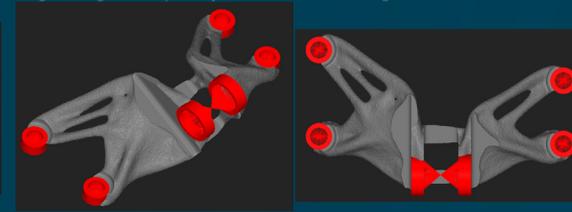
Converged / Post-processed design
compl: **5.297E+04**
constraint violation: 0.8% A
Discreteness: 71.%

Porosities

23

△ **ALTAIR**

Why OptiStruct?

Injecting Efficiencies and Innovation

Process Improvement

1

Multi-Physics

One model, multiple attributes, one solver.

NVH, Durability, Electrical, Thermal, Multiphysics, etc.

2

Optimization

Innovation

Weight reduction

Sustainability

3

Accurate Results

Open Solutions

Physics, "do it right"

Interface with 3rd parties

4

Business Model

Power of Unique License model

Partnership with support and special development

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Thank You

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