# Optimizing and accelerating product development efficiency with "One Model, One Solver", OptiStruct

Junji Saiki – SVP  Head of OptiStruct Development

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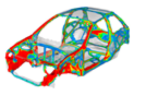
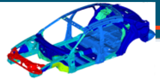
# Altair OptiStruct Evolution

| 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


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



NVH

Nonlinear



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# 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)**

# 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

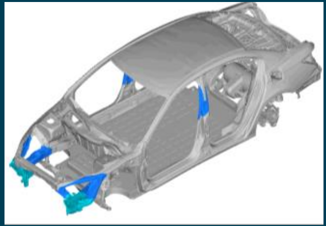
**No model conversion needed in order to run different loadcases**

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

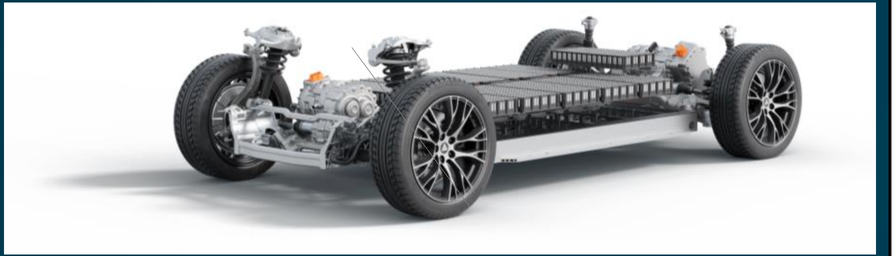
# Multi-Physics – OptiStruct

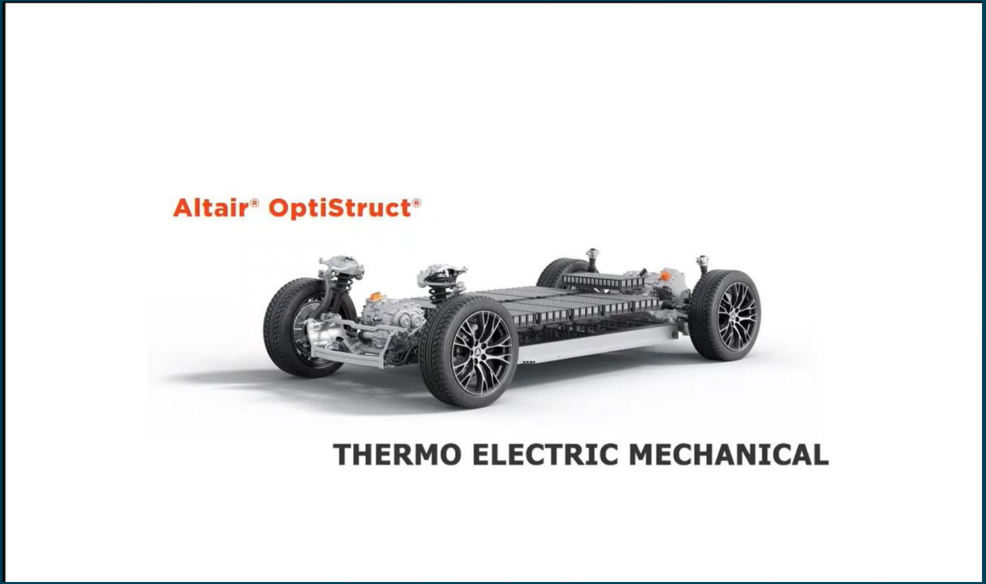
## Static Mechanical

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

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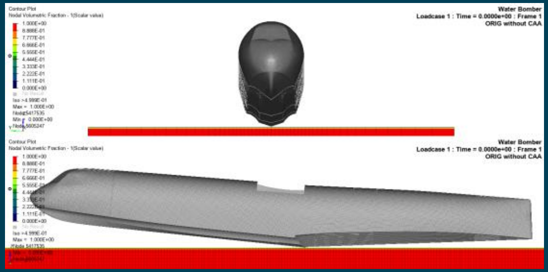
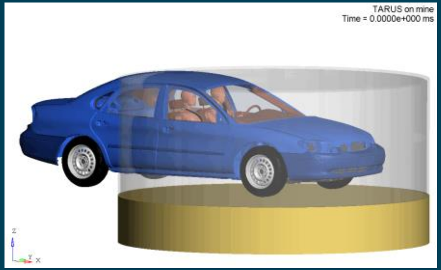
# Explicit Dynamic Analysis

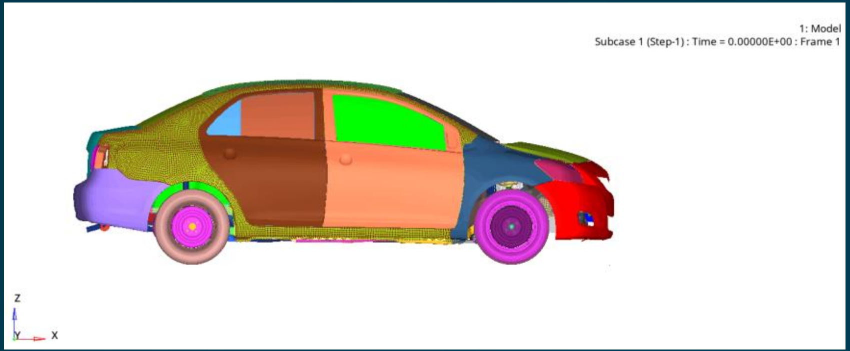
Target Use case for OptiStruct

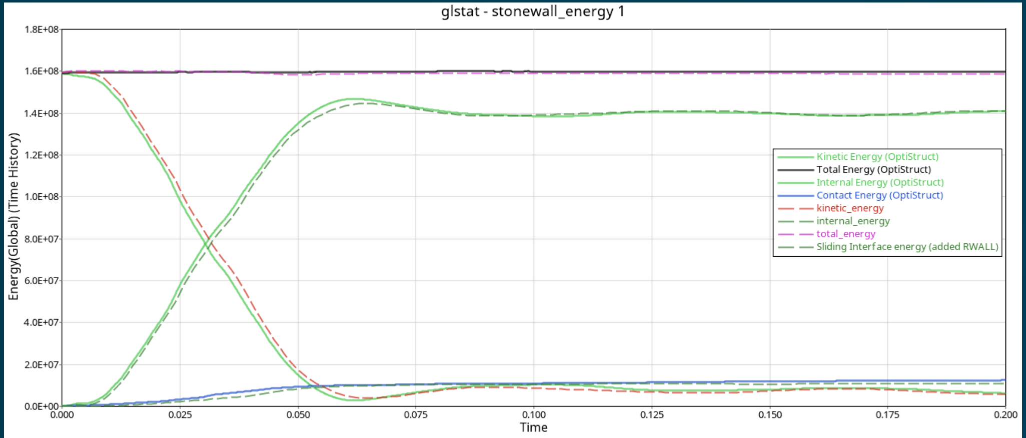
- **Impact Analysis**
  - Roof Crash, Side pole impact, Seat Belt Anchorage etc…
  - Drop tests (consumer goods, containers, …)
- **Fluid Structure Interaction**
  - Sloshing & Slamming problems especially in shipbuilding industry
  - Wave impacts on offshore structures
  - Ditching of aero planes
  - 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, …)





# 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 |

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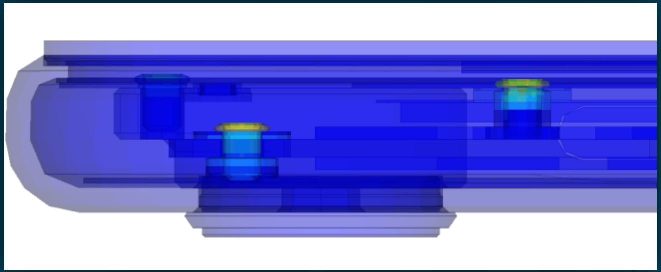
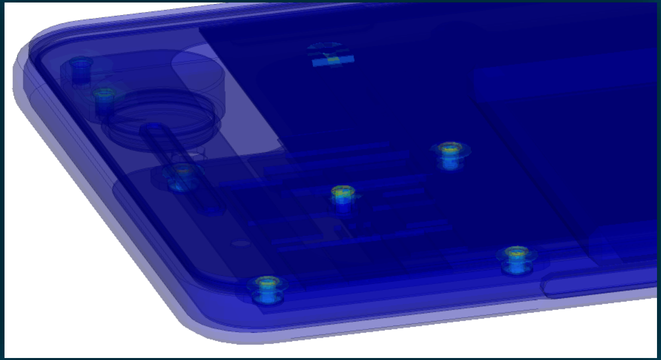
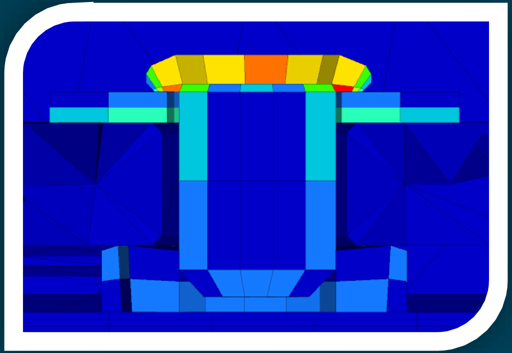
# Implicit – Explicit Continuation

Implicit subcase and Explicit subcase in single input file

Explicit subcase continues from the end of implicit simulation

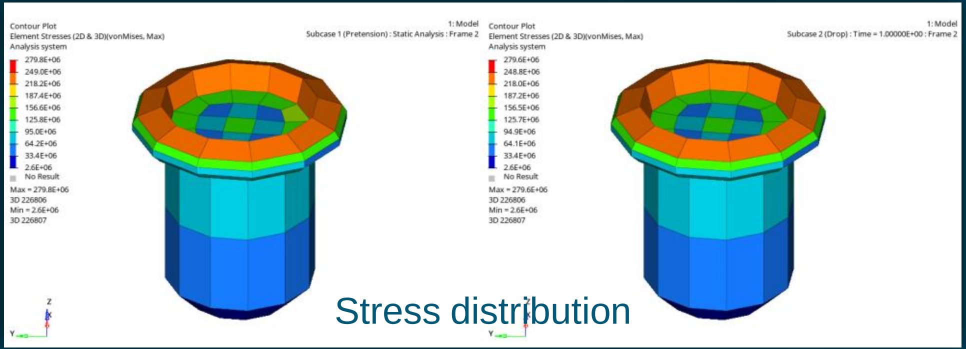






Implicit results (Tightening the screw)

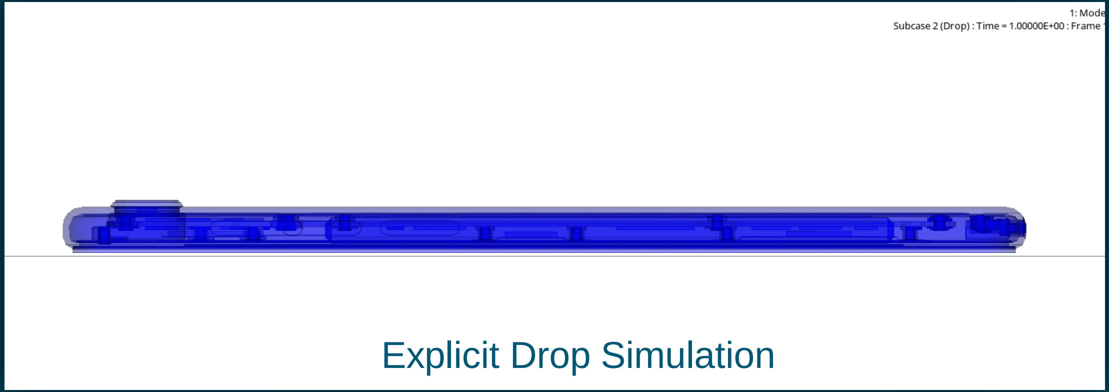
# Implicit – Explicit Continuation



Stress distribution

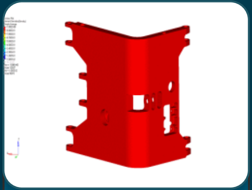
At the end of Implicit subcase

Beginning of Explicit subcase

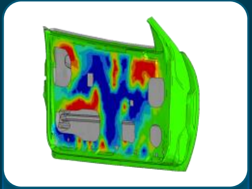


Explicit Drop Simulation

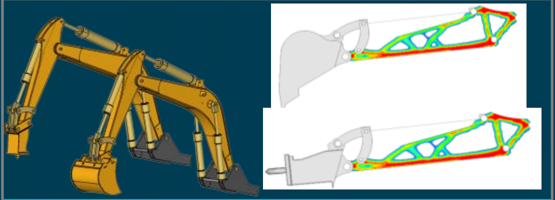
# Optimization



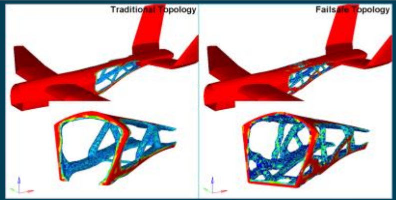
Topology



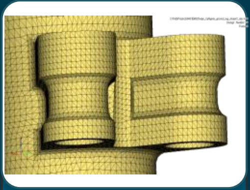
Topography



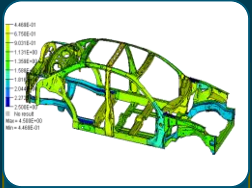
Multi Model Optimization



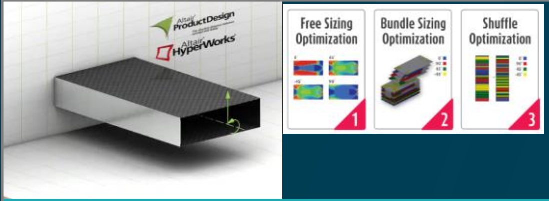
Failsafe Topology



Shape

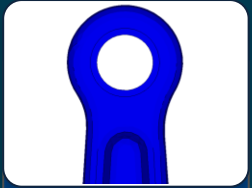


Size

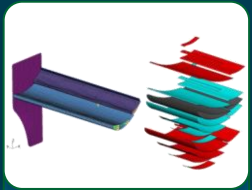



Composite Layout


Multi Material Optimization

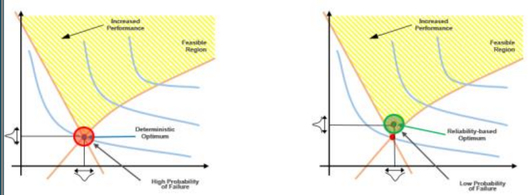


Free Shape



Free Size

Lattice Structures




Reliability-based Design Optimization

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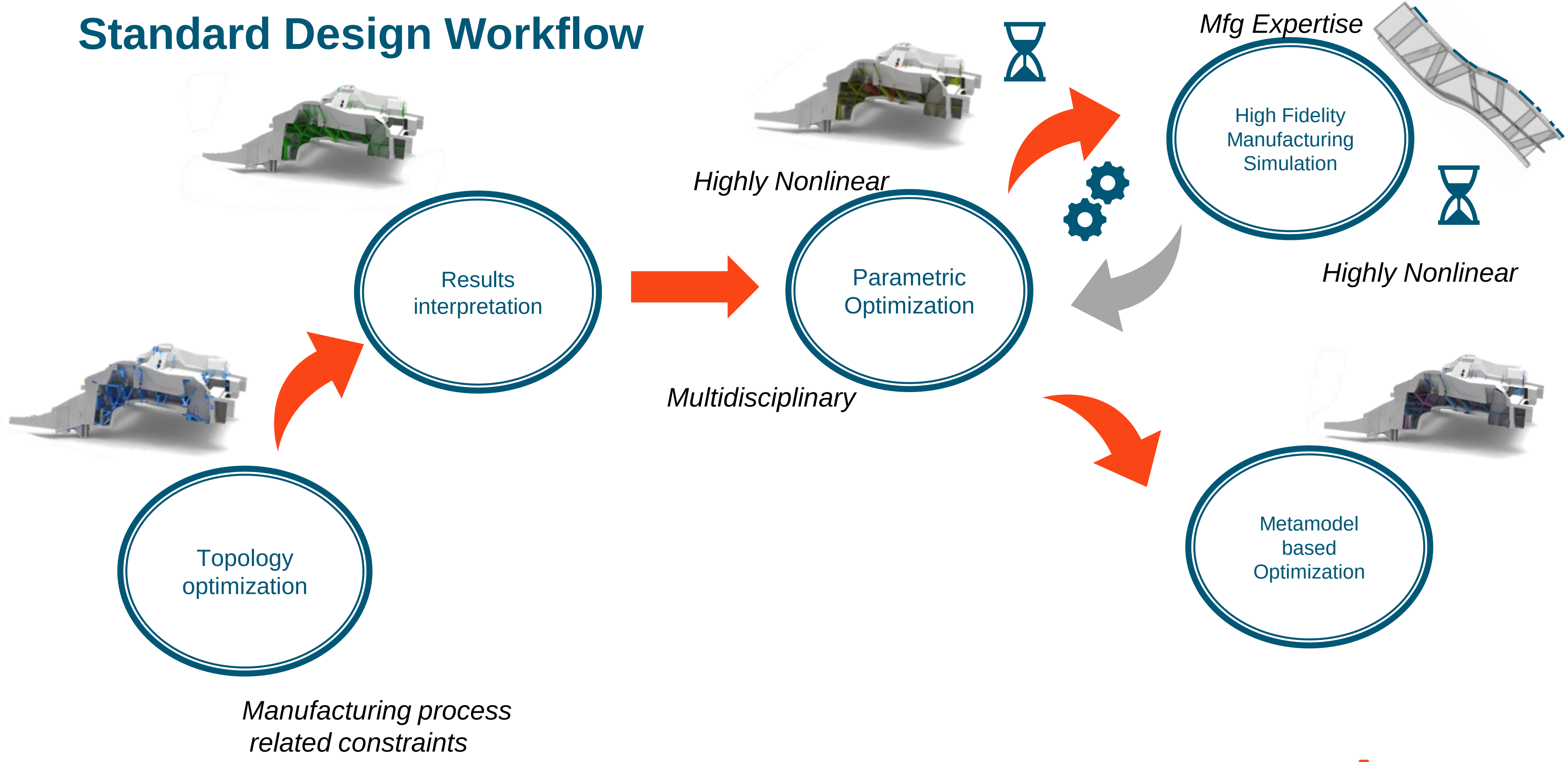
# Standard Design Workflow



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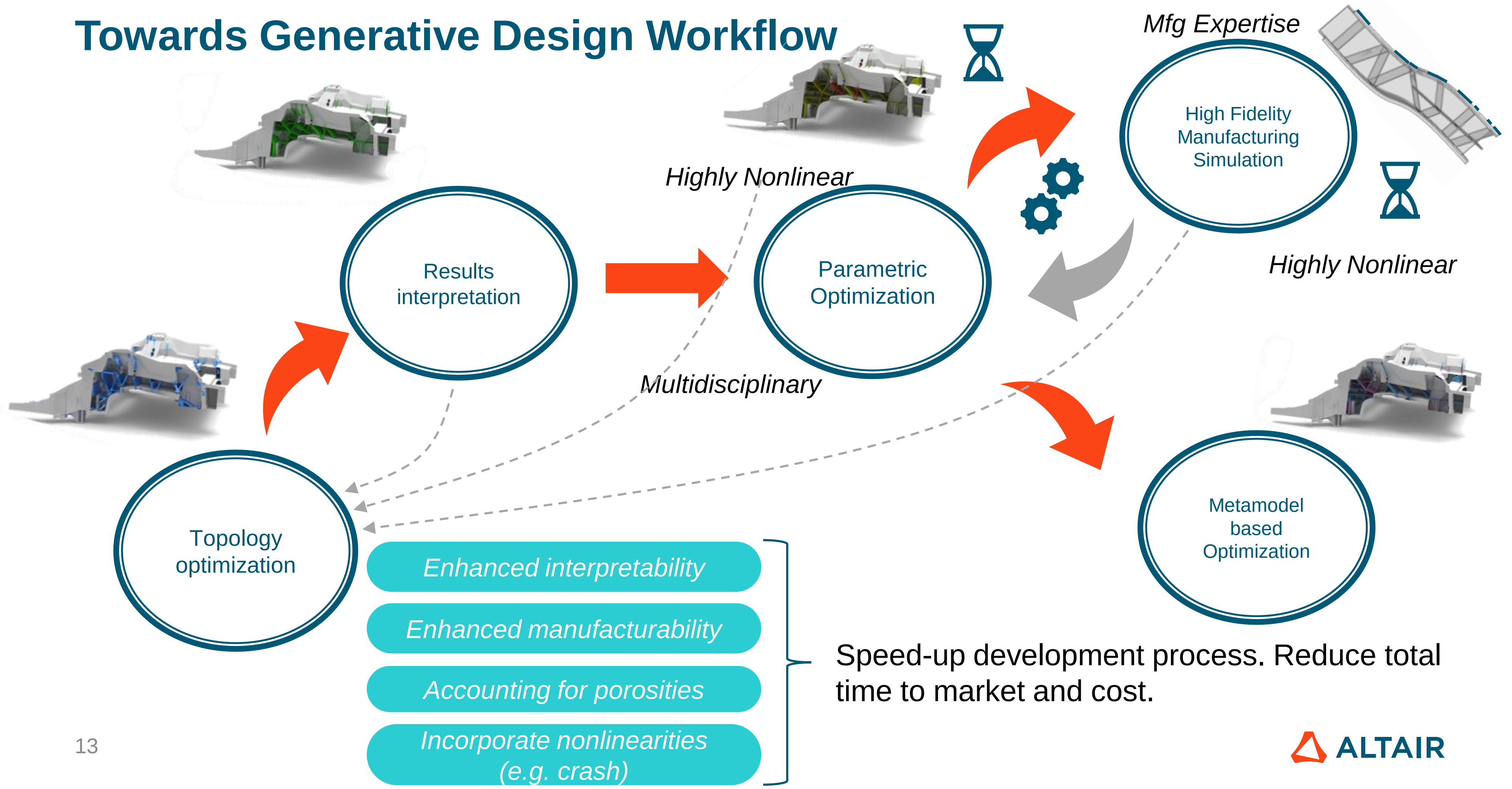
# Towards Generative Design Workflow



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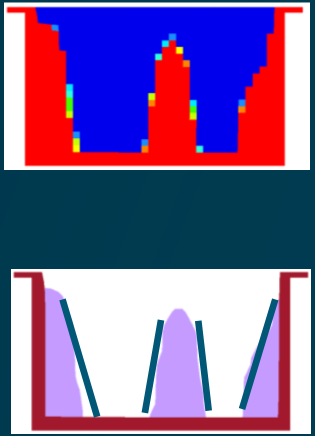
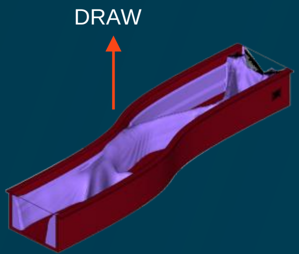
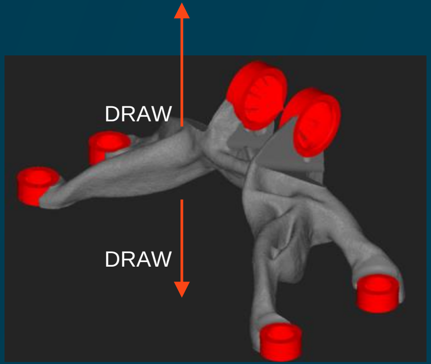
# Enhanced Manufacturability and Interpretability

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

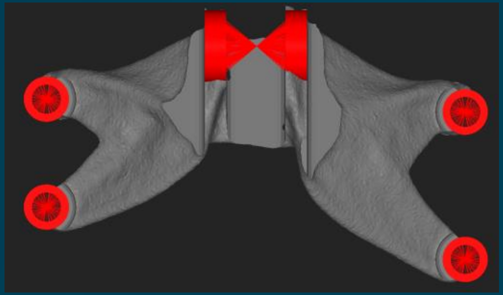


Draft Angle




Up to 10 different directions



NOHOLE option to support filling
available from 2025.1



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# Auto-Mesh Refinement in Topology Optimization

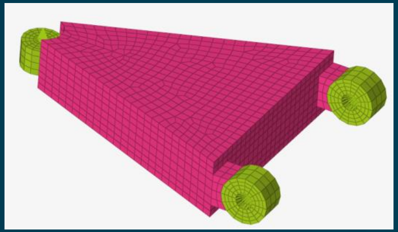
## Motivation and Capabilities

### Why?

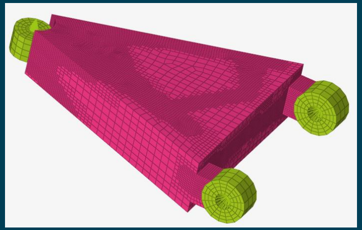
- To get more detailed results
- To reduce solution time

### 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)

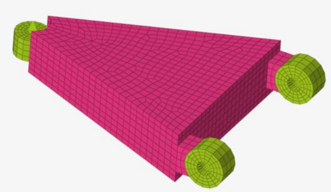


*Initial Mesh*

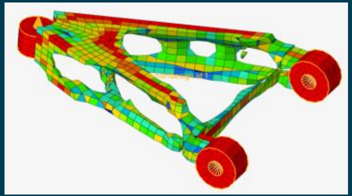


*Automatically Refined Mesh*

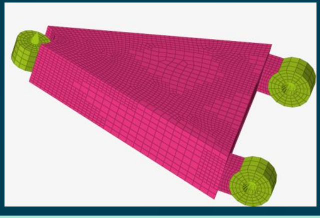
# Auto-Mesh Refinement Example



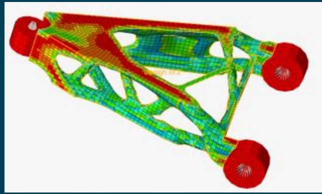
Element size 12 mm



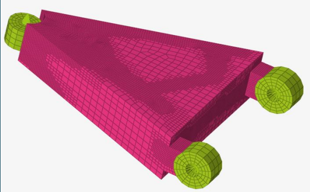
Topology 0



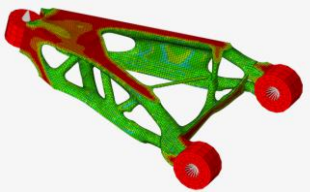
Element size 6-12 mm



Topology Refinement 1



Element size 3-12 mm



Topology Refinement 2

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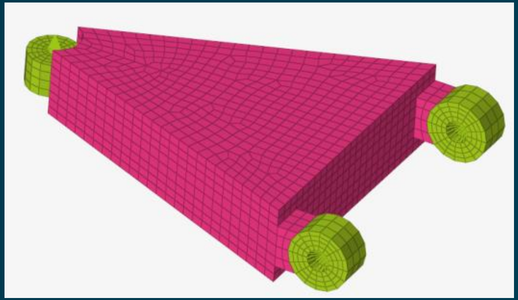
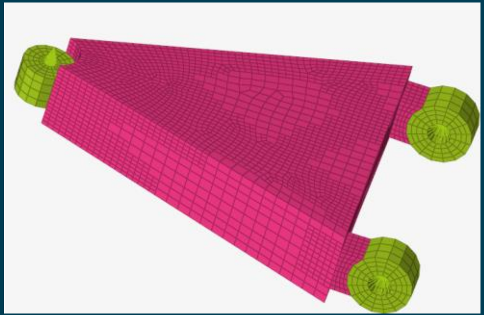
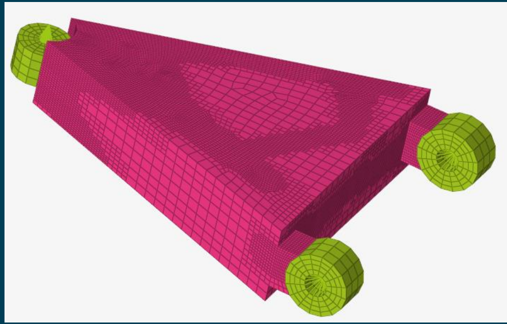
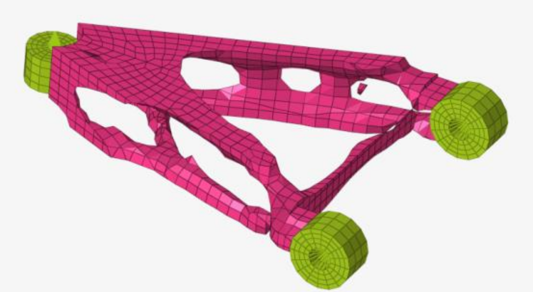
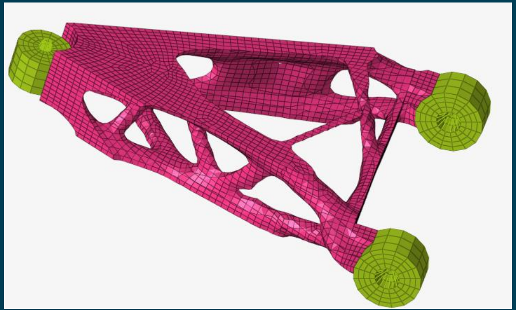
# Auto-Mesh Refinement Example

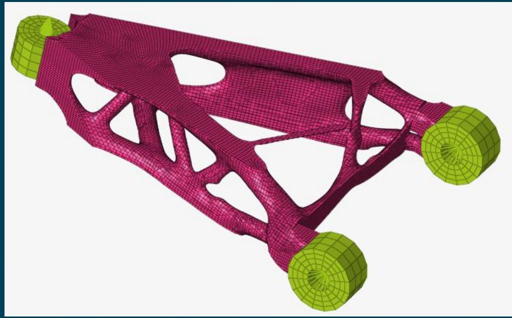












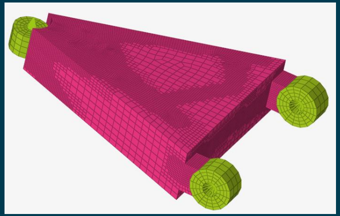
Topology 0

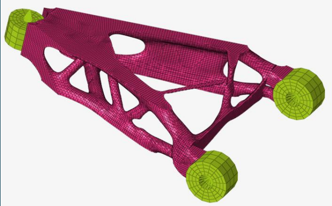
Topology Refinement 1

Topology Refinement 2

# Performance Comparisson

## Refinement 2

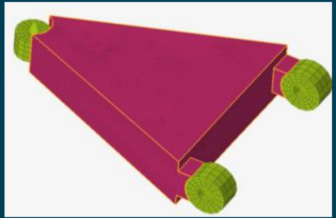




```
-------------------------------------------------------------------------------
     1 VOLUM Volume         --       --  TOTL 1.395E+06 MIN
     2 DISPL DISP            1     2699  TXYZ 1.991E-02  <   2.000E-02   0.0 A
     2 DISPL DISP            2     2699  TXYZ 4.983E-02  <   5.000E-02   0.0 A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

| | |
|---|---|
| **Element size** | 3 to 12 mm |
| **# elements** | 99,020 |
| **# iterations** | 64 (including ref 1 and 0) |
| **Run time** | **1 h 1 min (all runs)** |

## Refence Solution using Fine mesh



```
-------------------------------------------------------------------------------
     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
-------------------------------------------------------------------------------
```

| | |
|---|---|
| **Element size** | 3 mm |
| **# elements** | 223 872 |
| **# iterations** | 41 |
| **Run time** | **4 h 20 min** |

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



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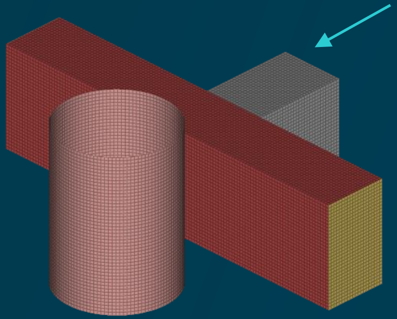
# Topology Optimization with Explicit Analysis

## Extruded Rocker

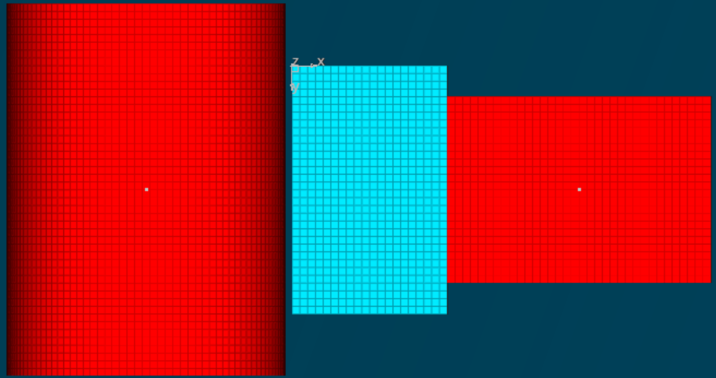
$\mathbf{min}\ compl,$
$s.t.\ vf \leq 0.3$

*Manu. Constr.:*
- *Extrusion*

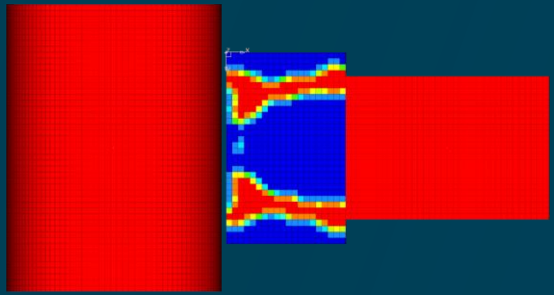
$v_0 = 8\ m/s$



*Design-space*



Optimized design



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



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# Topology Optimization with Explicit Analysis

## Battery Pack

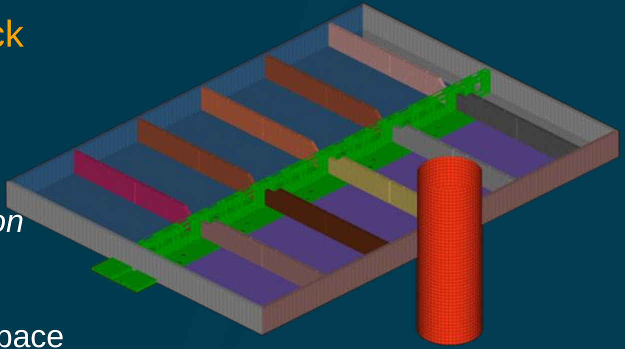
$\mathbf{min}\ compl,$

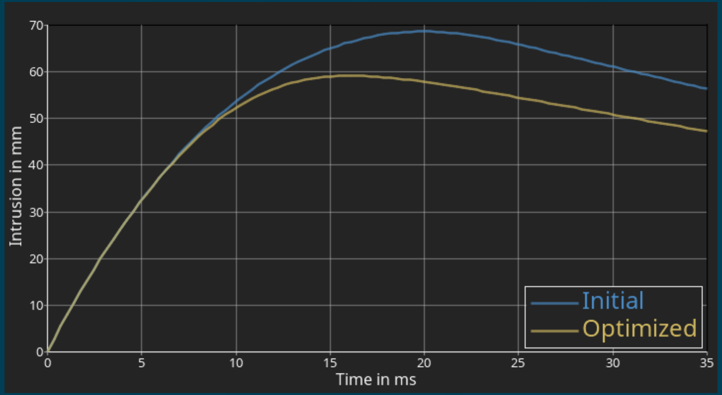
$s.t.\ vf \leq 0.3$

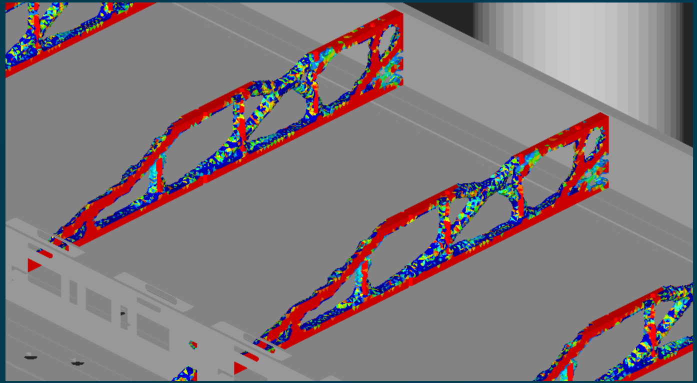
*Manu. Constr.:*

- *Pattern Repetition*

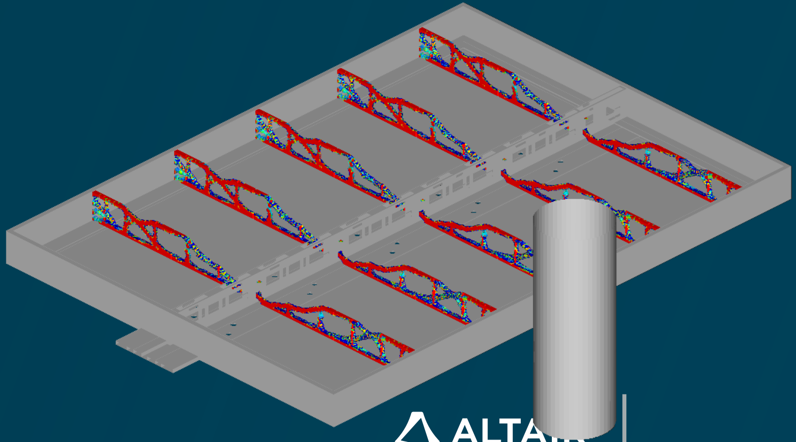
≈ 1 M. elements
500k tetra design-space
550k shell elements





Determine Location of Ribs





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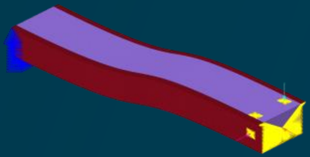
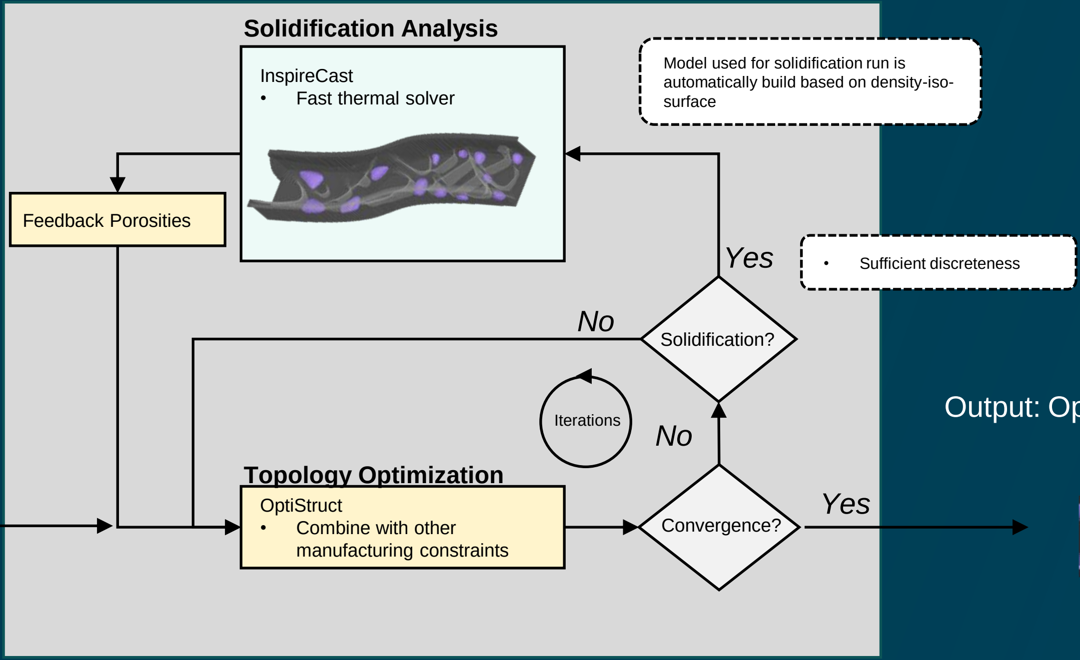
# Topology Optimization coupled with Inspire Cast

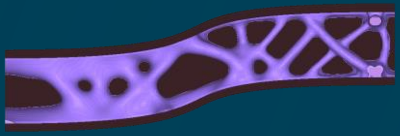
Topology Optimization to take into account the porosities from Casting Solver

Input: OptiStruct Model

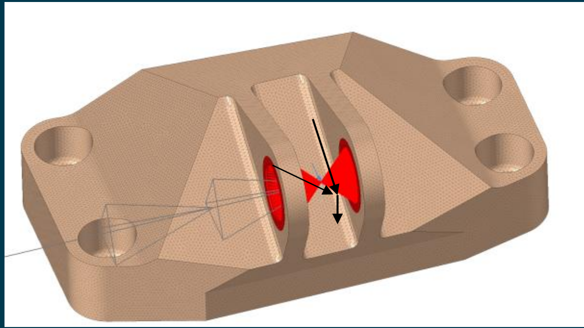





Output: Optimized manufacturable Design



# Example – Jet Engine Bracket



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

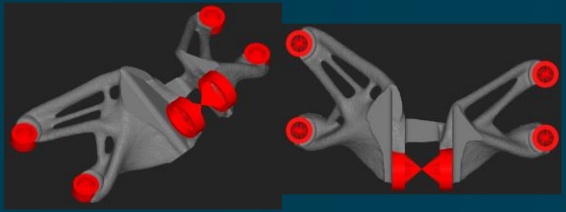
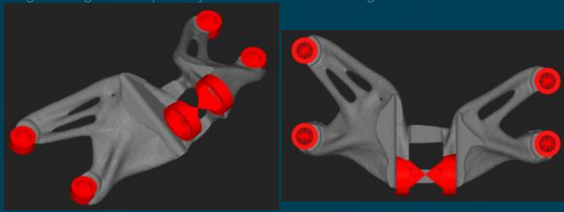
*Manu. Constr.:*

- *Mindim*
- *Split Draw*
- *Draft Angle*

Summary:

- Standard result is infeasible due to stresses
- Similar number of iterations
- Best compliance with coupling



| | Standard Top.-Opt. | Coupled with Casting Solver |
| --- | --- | --- |
| Final Design |  |  |

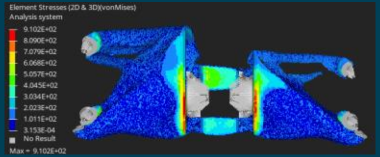
**Standard Top.-Opt.**

Converged design
comp: 5.311E4,
constraint violation: 0.4 % A
Discreteness: 70.%

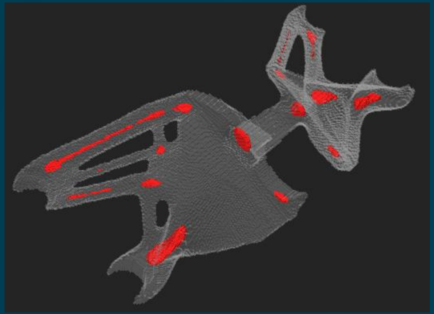
Post-processed design
comp: 5.583E4 ,
**constraint violation: 5.2% V**

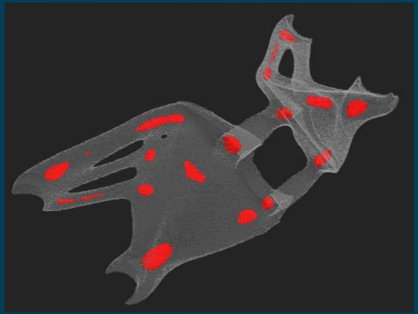
**Coupled with Casting Solver**

Converged / Post-processed design
compl: **5.297E+04**
**constraint violation: 0.8% A**
Discreteness: 71.%




Porosities







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# 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