



Powering Innovation That Drives Human Advancement

Overview of LS-TaSC™ and New Feature Highlights

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¹Ansys Inc., ²DYNAmore, An Ansys Company

Outline

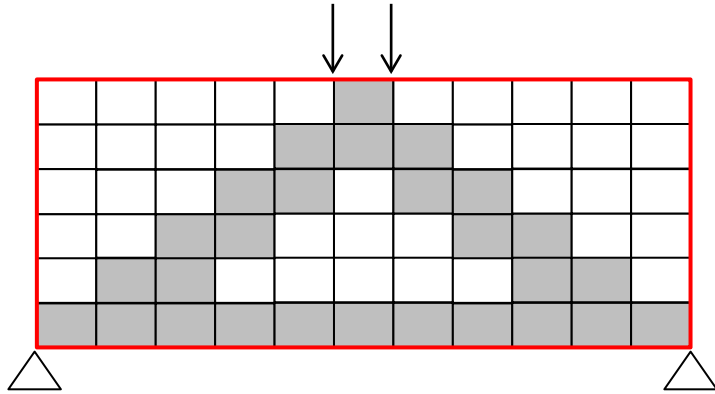
- General capabilities of LS-TaSC
- Constrained multidisciplinary topology optimization
 - Multipoint method
 - Projected subgradient method
- Highlights of new features
- Outlook: current development



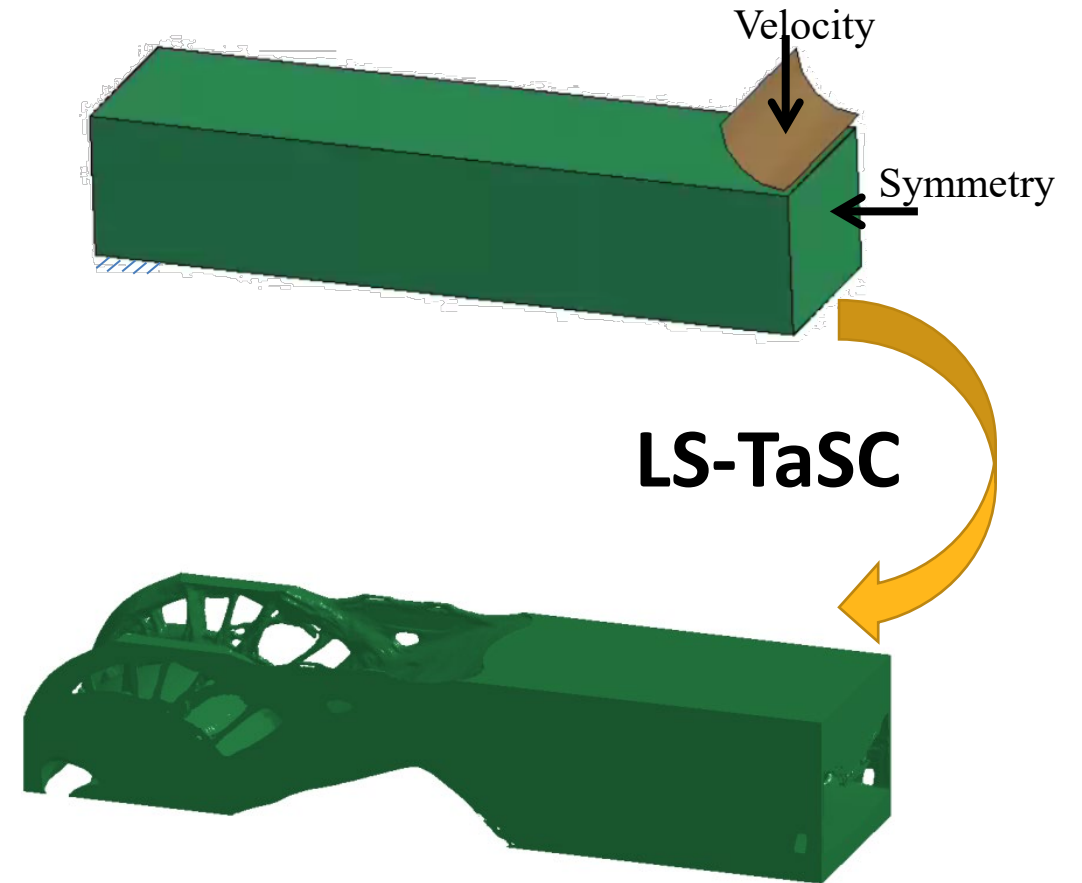
General Capabilities of LS-TaSC

Topology Optimization

- Redistribution of material within a given domain



- Design variables
 - Relative density of each element
- Result
 - New material distribution
 - New shape of structure

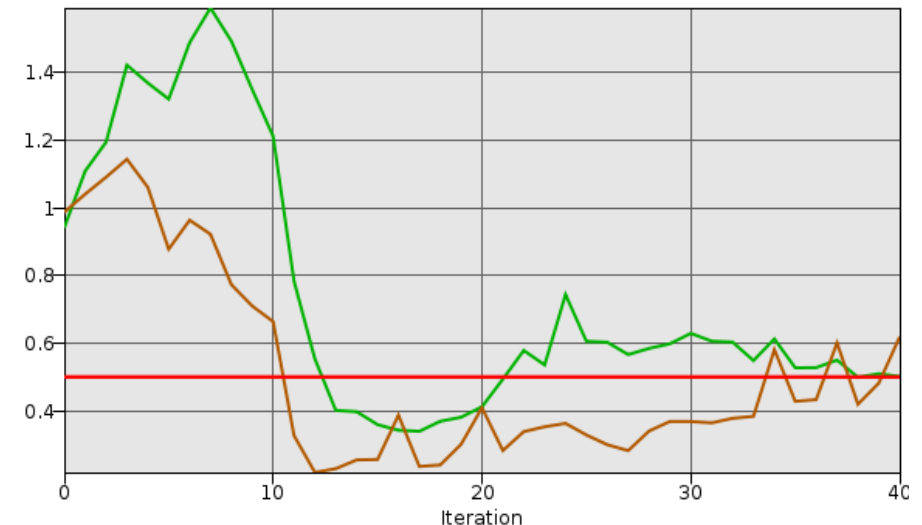
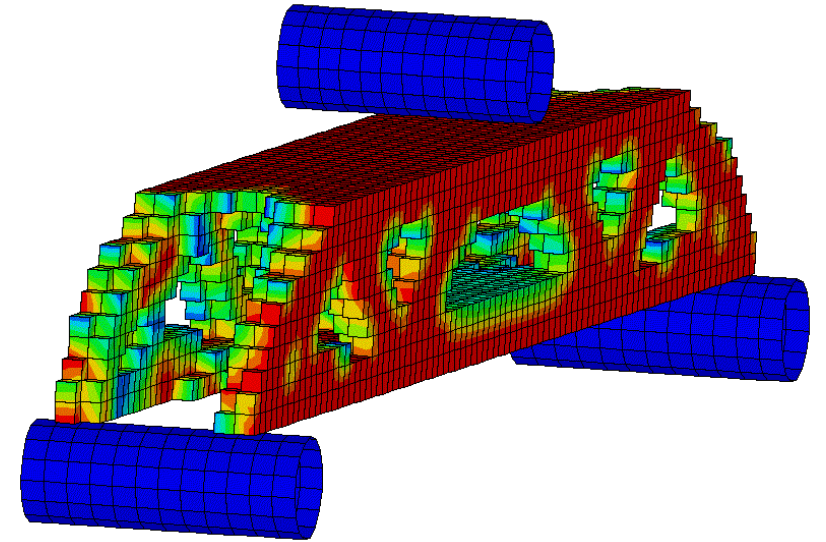


LS-TaSC General

- Topology and shape optimization of non-linear problems
 - Dynamic loads
 - Contact conditions
 - Solids and shells

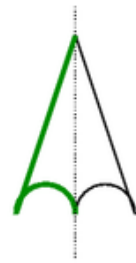
→ find a concept design for structures analyzed using LS-DYNA (implicit and explicit)
- Huge LS-DYNA models - 10 million elements
- Multiple load cases and disciplines
- Global constraint handling
 - Energy absorption, maximum reaction forces, ...

→ Multipoint optimization and metamodels



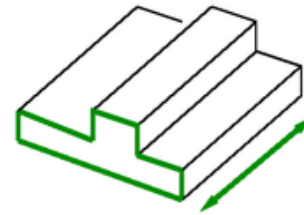
Manufacturing Constraints - Geometry Definitions

- Symmetry



Symmetry

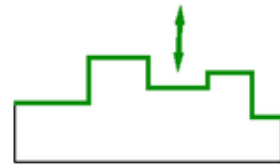
- Extrusion



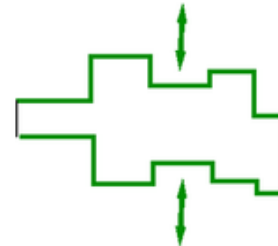
Extrusion

- Casting

- One sided/Two sided



One-sided Casting



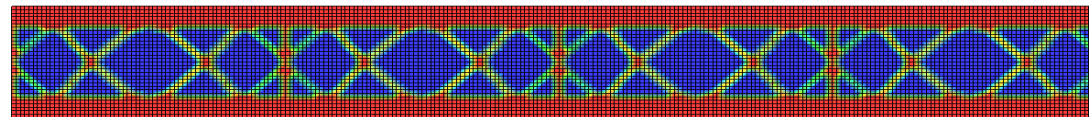
Two-sided Casting

- Forging

- Two-sided casting preserving a minimal thickness (no holes)

- Pattern repetition

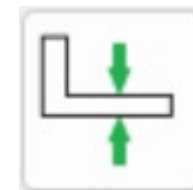
- Cyclic symmetry



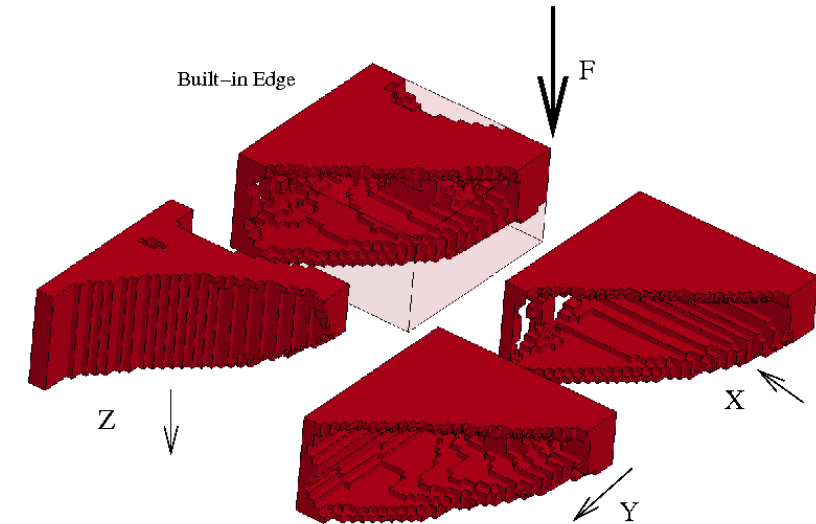
Pattern repetition

- Thickness constraint

- minimum or maximum thickness control for parts with casting constraints

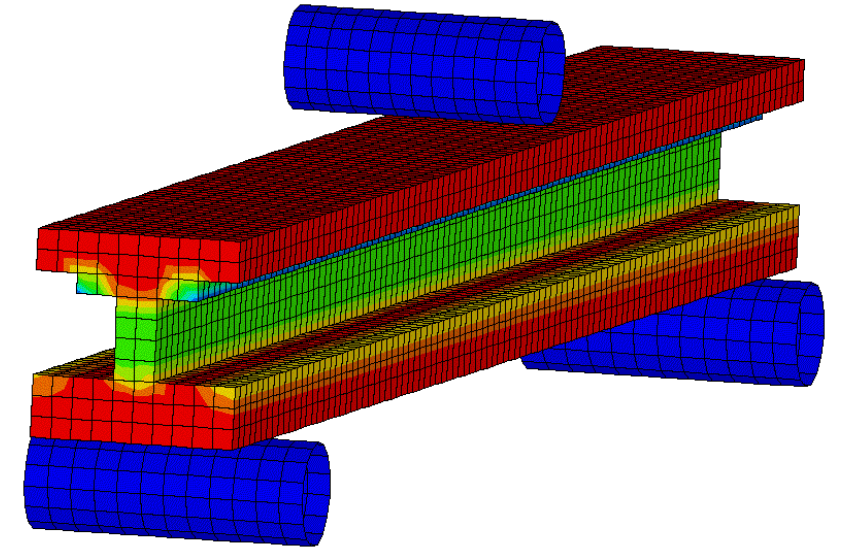


Thickness



Methodologies

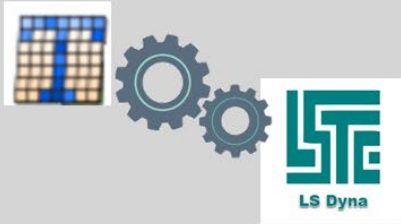
- Topology optimization
 - Optimality Criteria for Dynamic Problems
 - Objective: Homogenization of internal energy density (IED)
→ uniform loading of material for given mass
 - Projected Sub-gradient Method
 - Enables multidisciplinary optimization: Impact, Static, NVH
→ maximization of fundamental frequency for NVH load case
- Free Surface Design
 - Objective: Uniform surface stress



Integration

LS-TaSC with LS-DYNA

- no special treatment for nonlinearities



Run

Job Status

Job ID	PID	Iter	Case	Status
60	4932	59	FREQUENCY	Normal Termination
61	25584	60	FREQUENCY	Normal Termination
62	22052	61	FREQUENCY	Normal Termination
63	21444	62	FREQUENCY	Normal Termination
64	15612	63	FREQUENCY	Normal Termination
65	15868	64	FREQUENCY	Normal Termination
66	2400	65	FREQUENCY	Normal Termination
67	12624	66	FREQUENCY	Normal Termination
68	17484	67	FREQUENCY	(0%)

Engine Output

Start unconnected elements check for part 4.
Done unconnected elements check (0 seconds).

Base design part 4 variables are 17% solid, 64% gray, and 19% void.
Part designed in 0s.

Structural evaluations for iteration 67

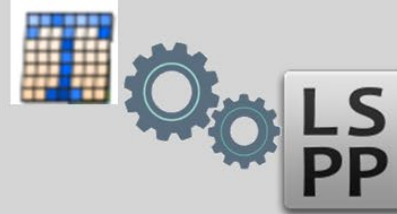
RUNNING SCHEDULER VERSION 5 (Iteration 67)

System command "C:\LSTC\LS-TaSC 4.1\scheduler5 lopt 8" successful

Run Stop Clear Done

LS-TaSC with LS-PrePost

- results visualization
- model editing



View and Iso

Iteration 0 100

Case FREQUENCY

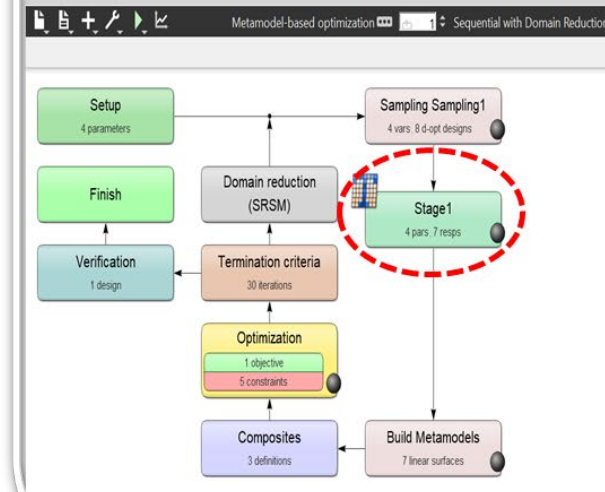
First Iteration As Transparent Overlay
Show Design Part(s) Only
Open LS-Prepost Window

First Iteration As Transparent Overlay
 Show Design Part(s) Only
 Open LS-Prepost Window

Show Done

LS-TaSC with LS-Opt

- multilevel and complex design schemes





Constrained Multidisciplinary Topology Optimization

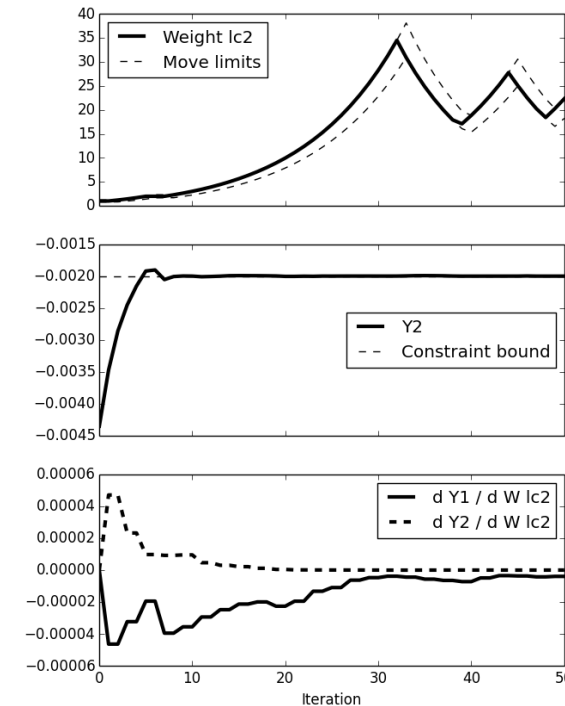
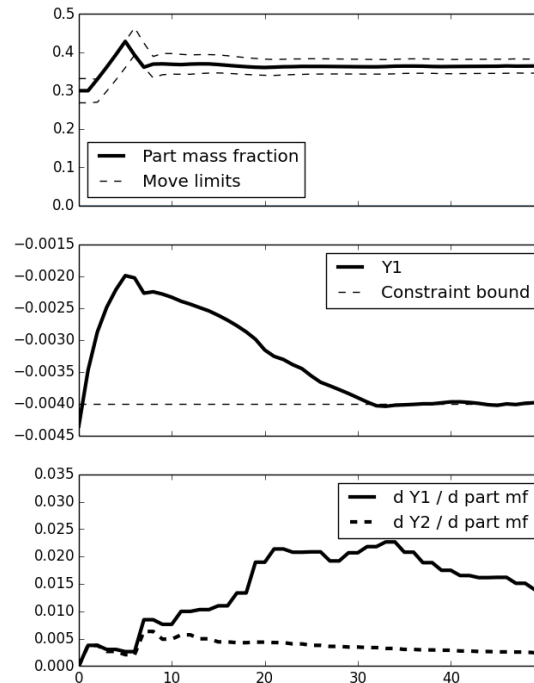
Constrained Topology Optimization

- Multipoint scheme
 - Allows more general constraints (e.g. energy absorption, reaction forces)
- Gradient-based optimization methods, metamodel methods, ...

with respect to global variables

- Part mass fractions
- Load case weights

The LS-TaSC™ Multipoint Method for Constrained Topology Optimization
 Roux, W.
 14th International LS-DYNA Users Conference

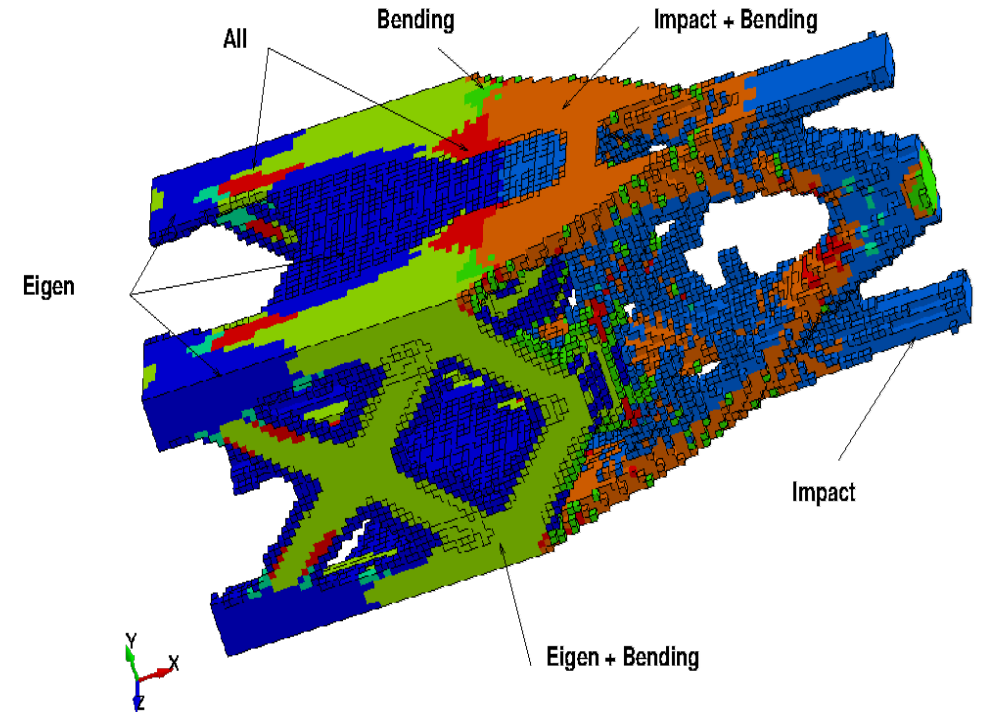
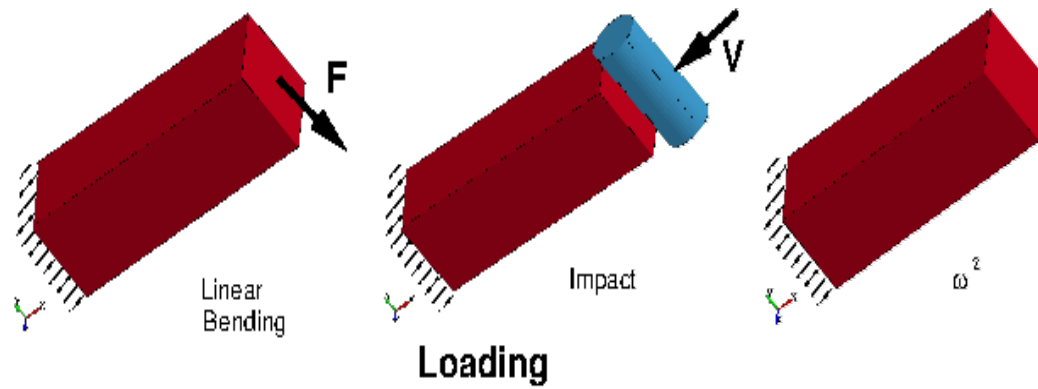


Global variables

Constraints: values and derivatives

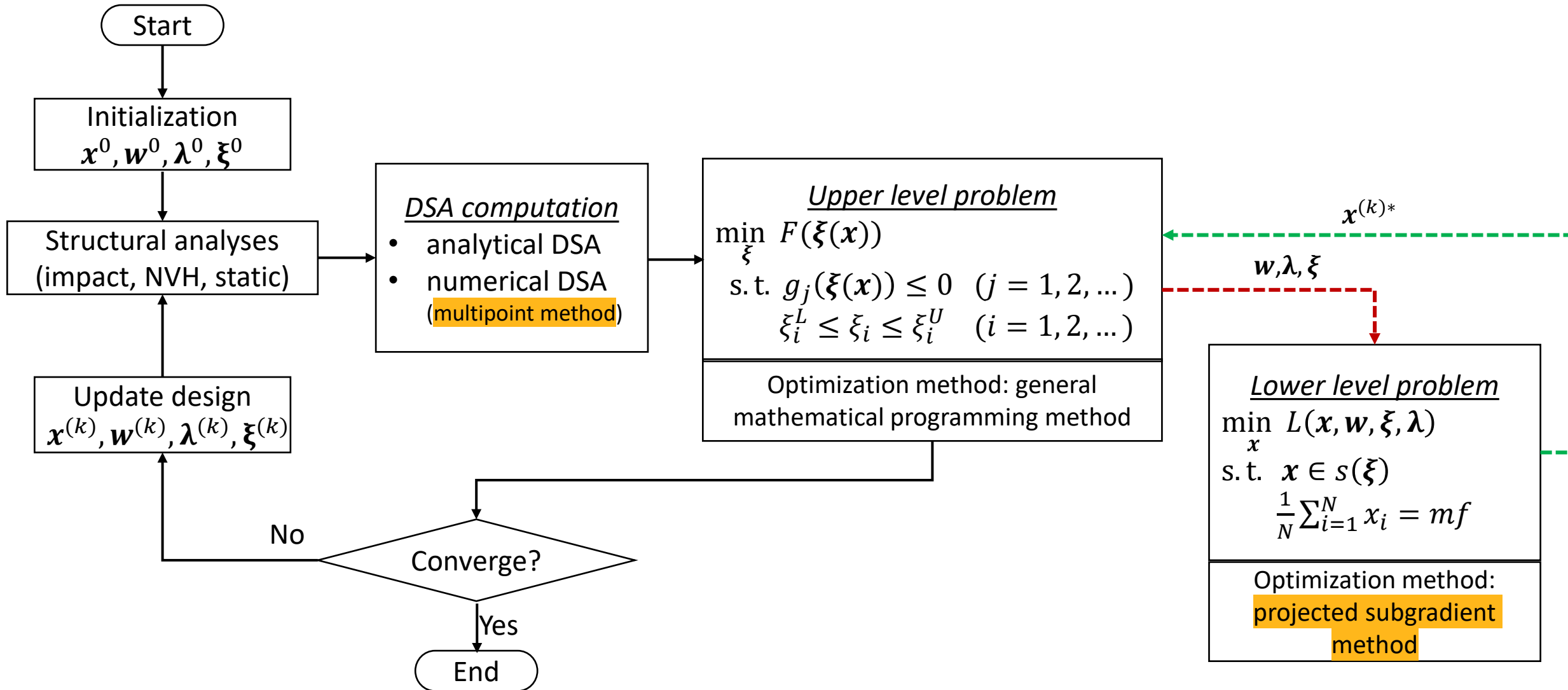
Multidisciplinary Topology Optimization

- Projected sub-gradient method
 - Enables topology optimization of NVH load cases
 - Multidisciplinary topology optimization:
 - Static
 - Impact
 - NVH



Implementation of the Projected Subgradient Method in LS-TaSC™
Roux, W., Yi, G., Gandikota, I.
15th International LS-DYNA Users Conference

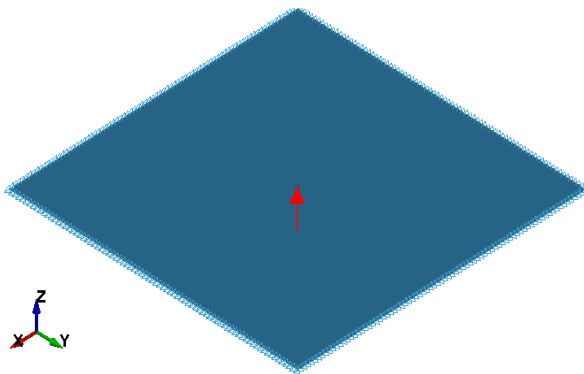
Constrained Multidisciplinary Topology Optimization



Highlights of new Features

Multidisciplinary Design Optimization for Shell Thickness

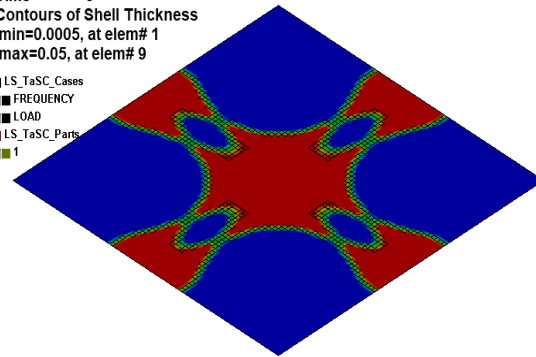
- Optimization of NVH load cases for shells
 - MDO: impact, static, and NVH load cases for shells
- Example: MDO of a fully clamped plate with combined static and NVH load cases



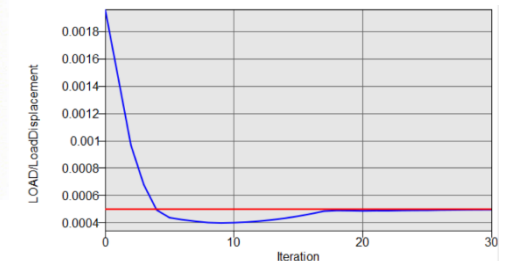
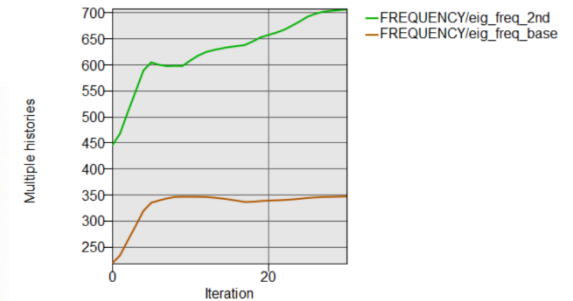
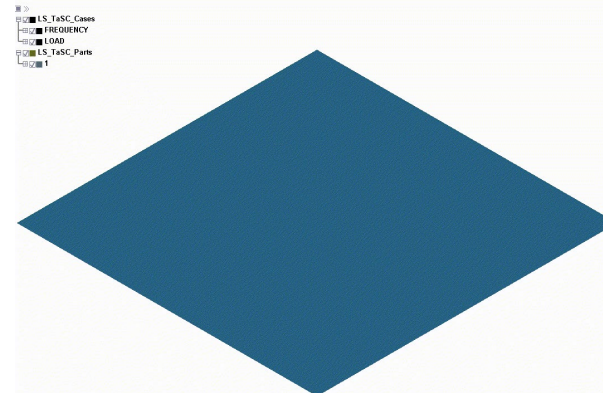
NVH and static load

LS-DYNA keyword deck by LS-PrePost
Time = 0
Contours of Shell Thickness
min=0.0005, at elem# 1
max=0.05, at elem# 9

LS-TaSC_Cases
FREQUENCY
LOAD
LS-TaSC_Parts
1

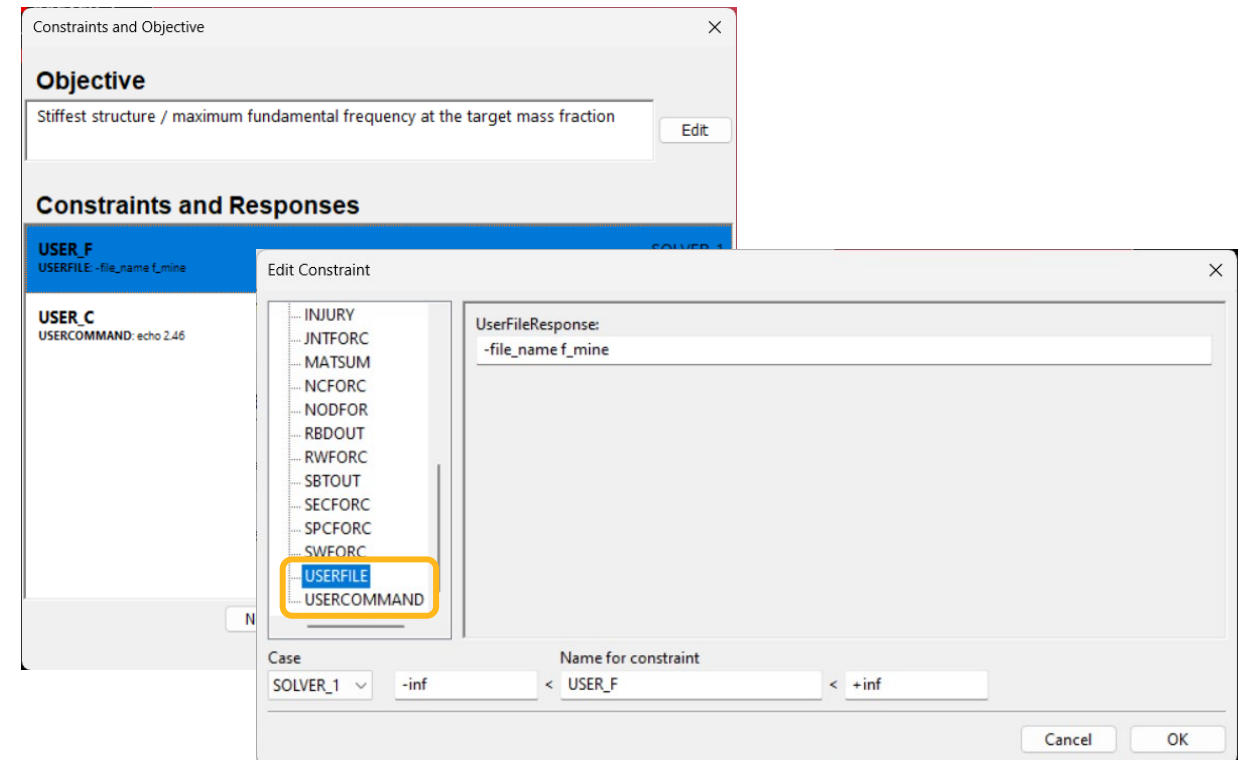


Shell Thickness
5.000e-02
4.505e-02
4.010e-02
3.515e-02
3.020e-02
2.525e-02
2.030e-02
1.535e-02
1.040e-02
5.450e-03
5.000e-04



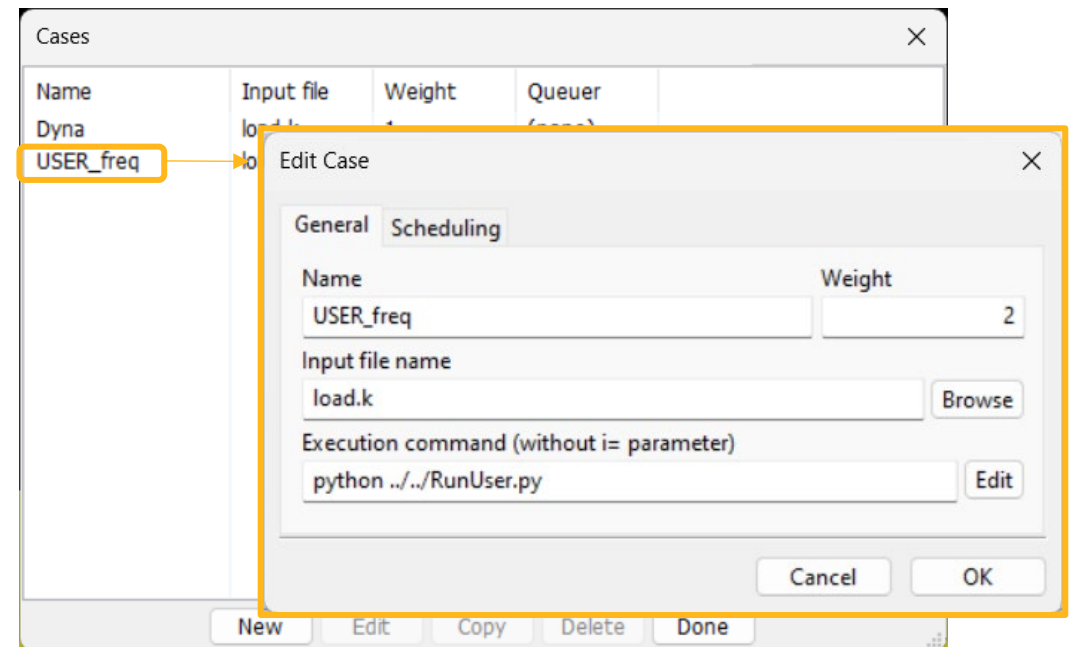
User Customization

- Editing the LS-DYNA input deck
 - user program to add modifications to the input deck that are specific to a design iteration, e.g. adding glue or spotwelds to the current boundary of the design
- User responses
 - user program to provide different responses for a load case
- Redesigning the structure
 - user program to employ his own design procedure to compute the design variables



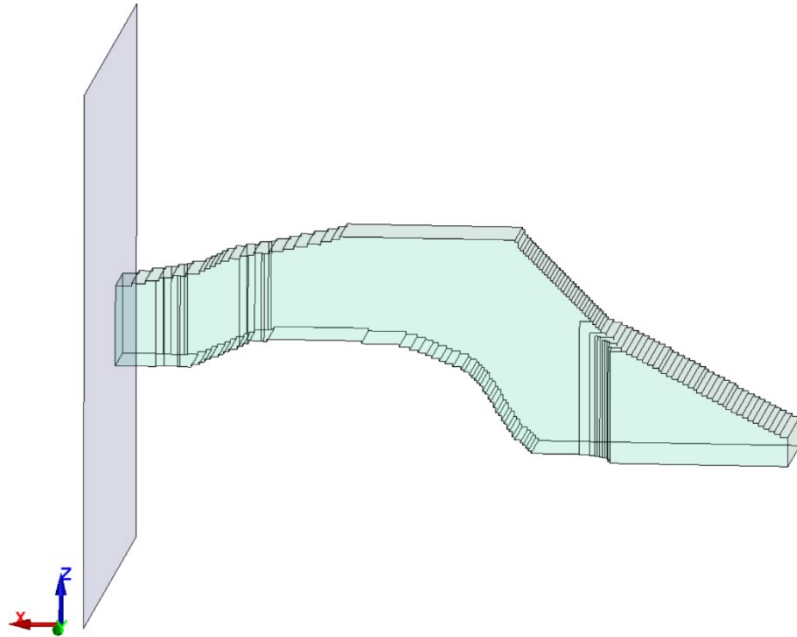
User Analysis and DSA

- User-defined load cases
 - Import results from other analysis software (Ansys Mechanical, MSC Nastran, ...)
 - Variable values provided by LS-TaSC in text file
 - Gradients of the objective and constraints and response values provided by user
 - Data file formats:
 - TEXT
 - JSON
 - LS-DYNA keyword
- First load case must be LS-DYNA load case

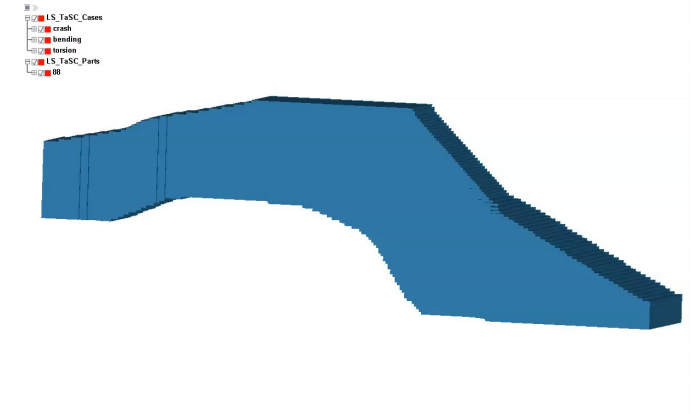


Minimum and Maximum Feature Size Controlling

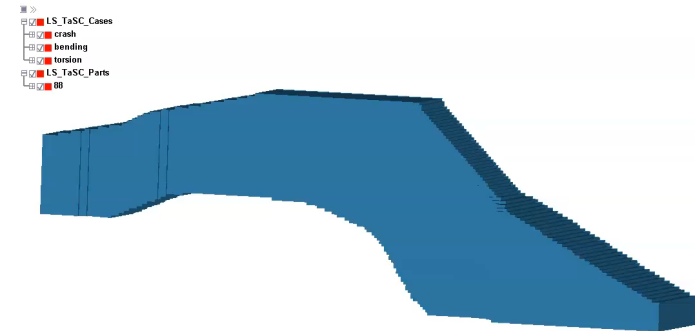
- Enforce Minimum and maximum part thicknesses
→ mega-casting to integrate with energy absorption



(a) Base structure of a rear torque box for bending, torsion, and impact load cases



(b) Casting design without thickness constraints



(c) Casting design with thickness constraints

Application Customization Toolkit (ACT) extension in Workbench

- Run a single load case unconstrained nonlinear topology optimization using LS-TaSC in Workbench

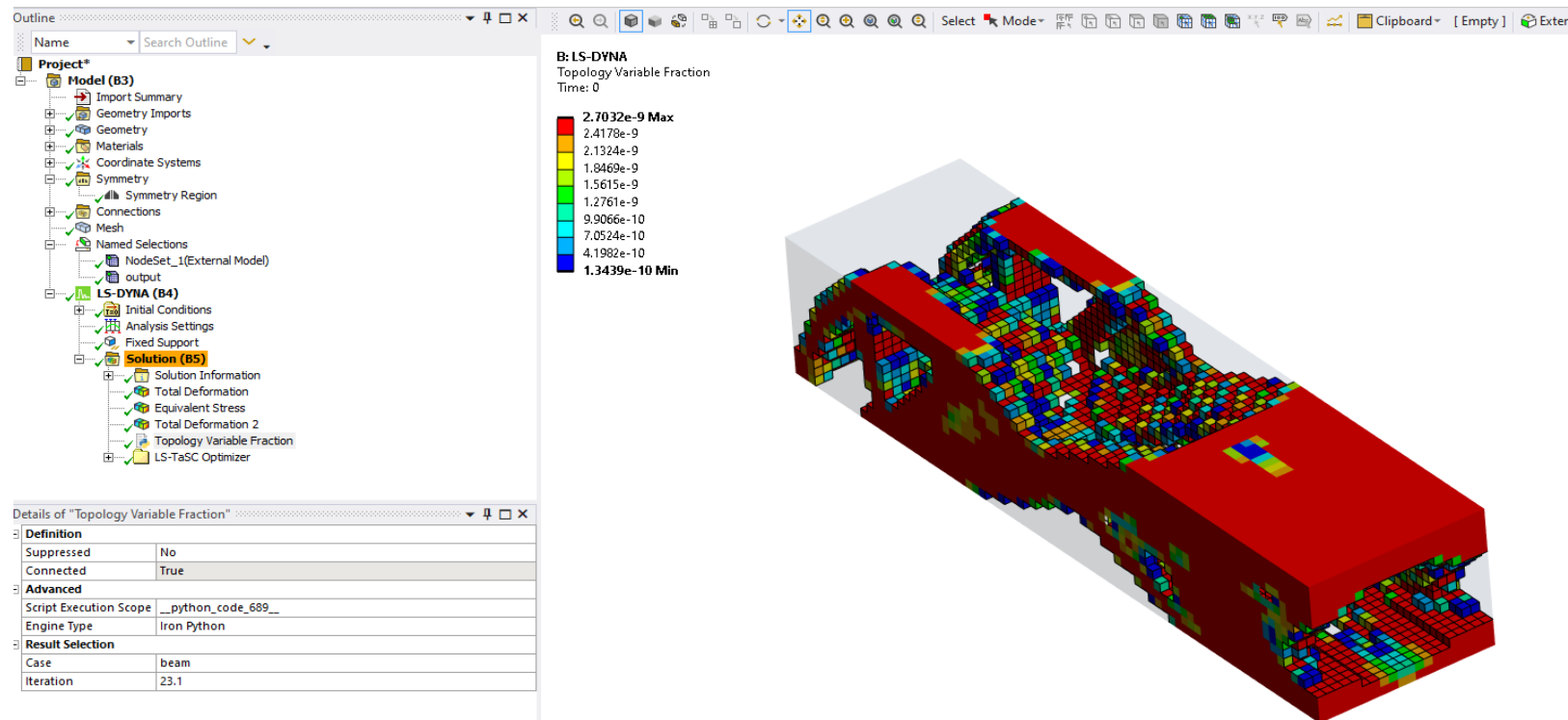


Figure courtesy of Rajesh Meena, Imtiaz Gandikota, and Ram Gopiseti

Outlook: Current Development

- Shape optimization for shells
→ bead optimization
- Iso-surface of shell structures (3D with thickness)

Minor features:

- Additional injury criteria as constraints (a3ms)

The Ansys logo consists of a yellow slanted bar followed by the word "Ansys" in a bold, black, sans-serif font.

