Powering Innovation That Drives Human Advancement

Overview of LS-TaSC™ and New Feature Highlights

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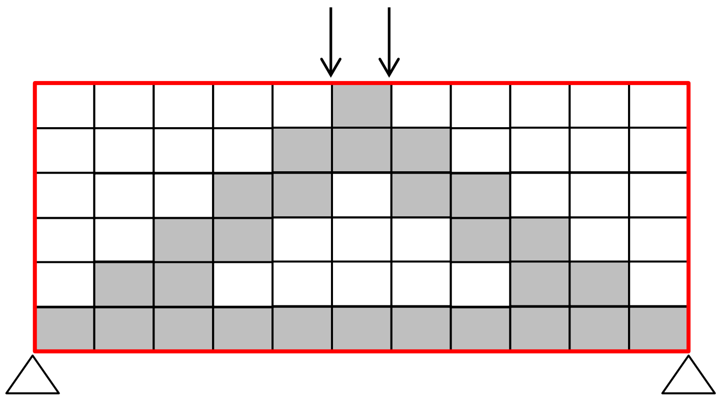
Outline

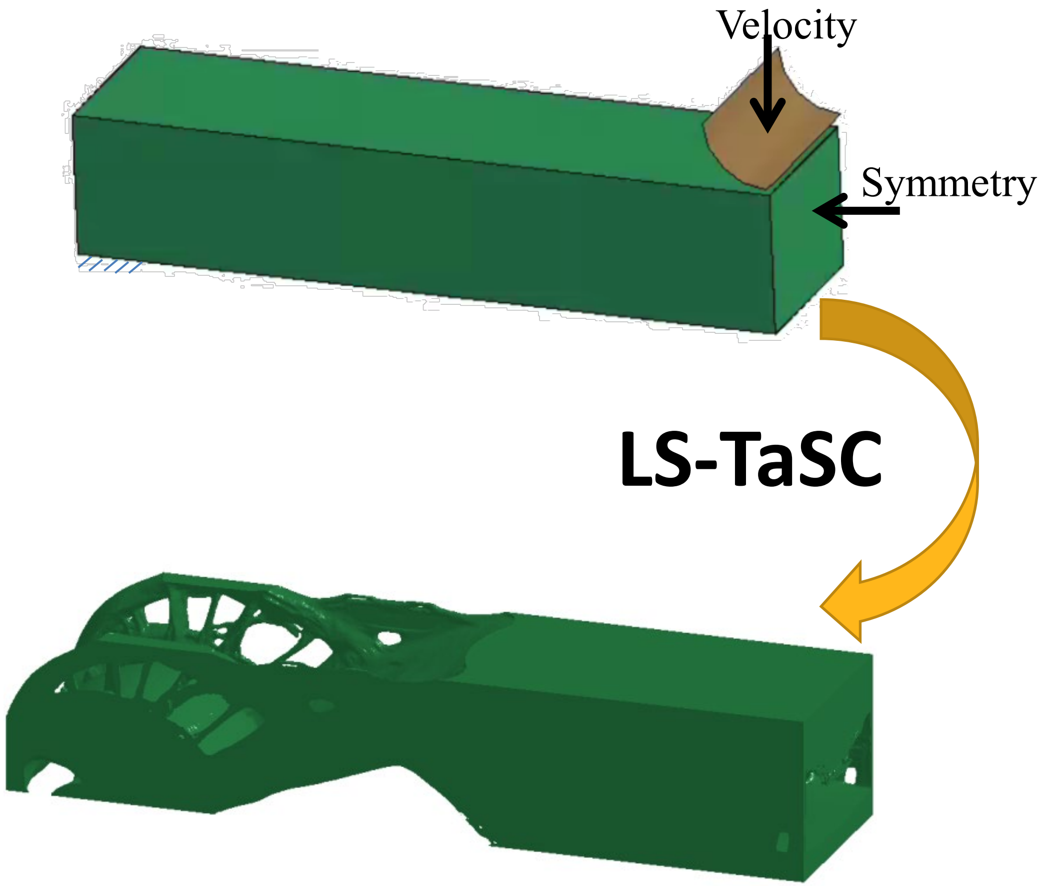
- General capabilities of LS-TaSC
- Constrained multidisciplinary topology optimization
  - Multipoint method
  - Projected subgradient method
- Highlights of new features
- Outlook: current development

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

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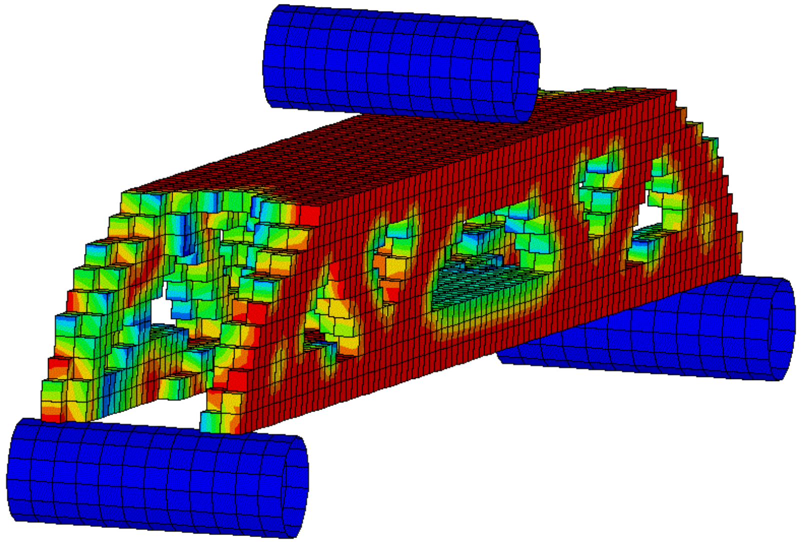
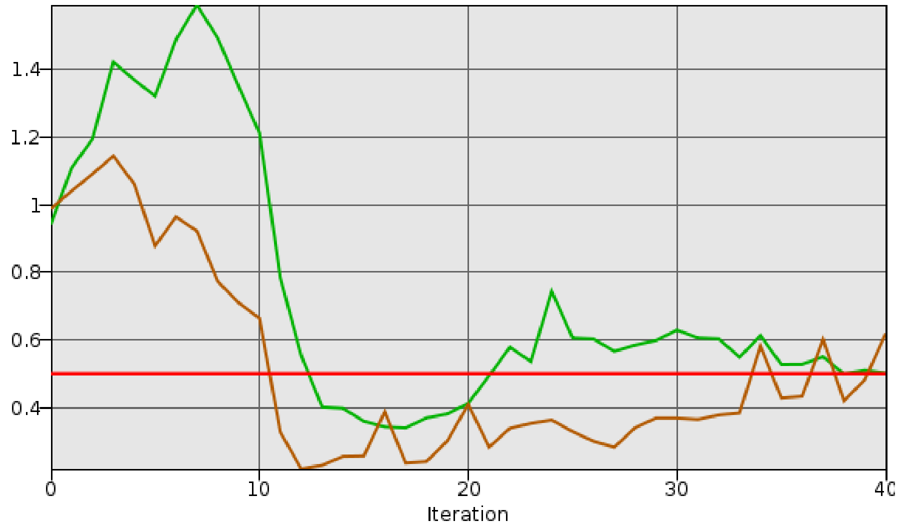
LS-TaSC General

- 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, …

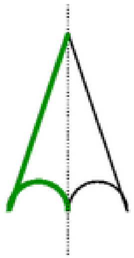
    → Multipoint optimization and metamodels



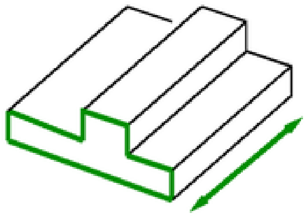


Manufacturing Constraints - Geometry Definitions

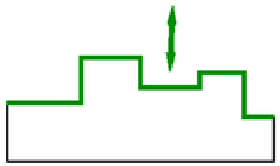
- Symmetry
- Extrusion
- Casting
  - One sided/Two sided
- Forging
  - Two-sided casting preserving a minimal thickness (no holes)
- Pattern repetition
  - Cyclic symmetry
- Thickness constraint
  - minimum or maximum thickness control for parts with casting constraints



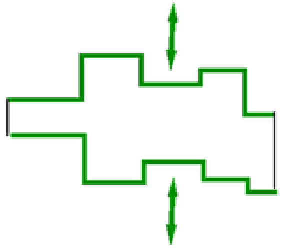
Symmetry



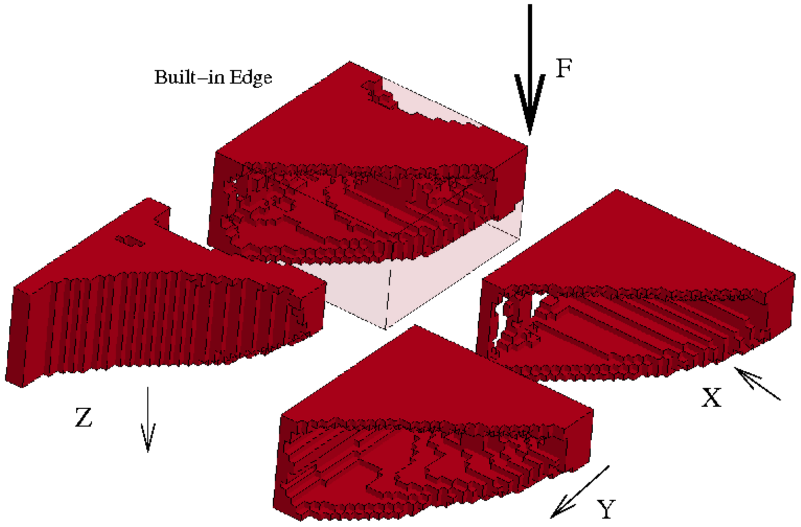
Extrusion

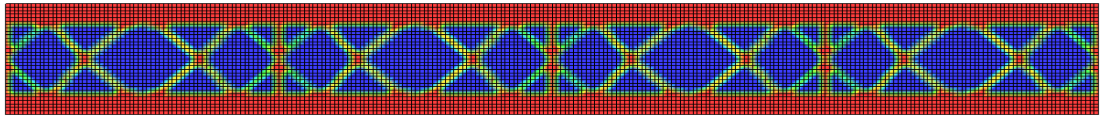


One–sided Casting

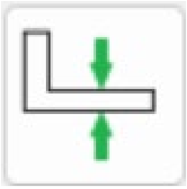


Two–sided Casting





Pattern repetition



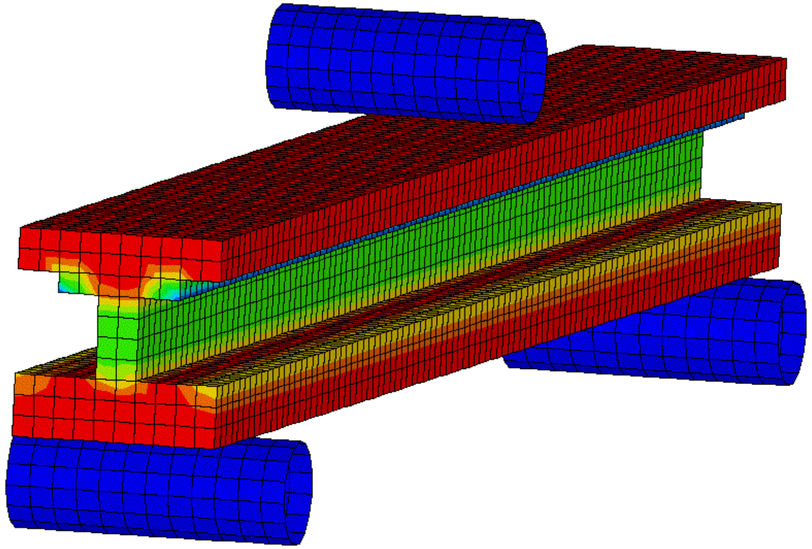
Thickness

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

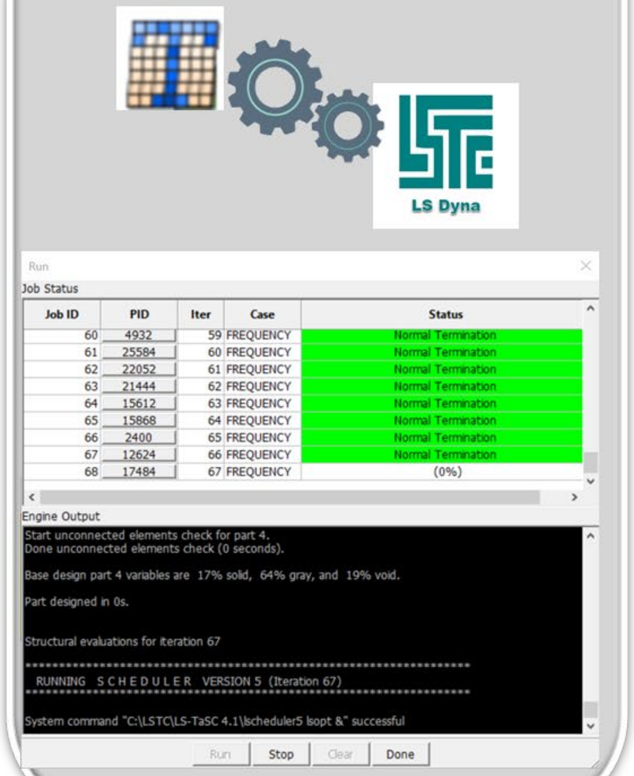
  → maximization of fundamental frequency for NVH load case
- Free Surface Design
  - Objective: Uniform surface stress



Integration

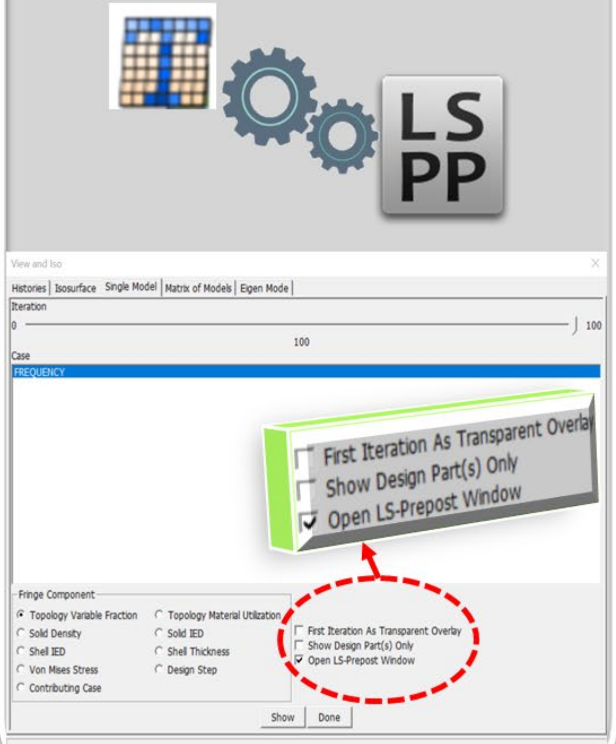
LS-TaSC with LS-DYNA

- no special treatment for nonlinearties



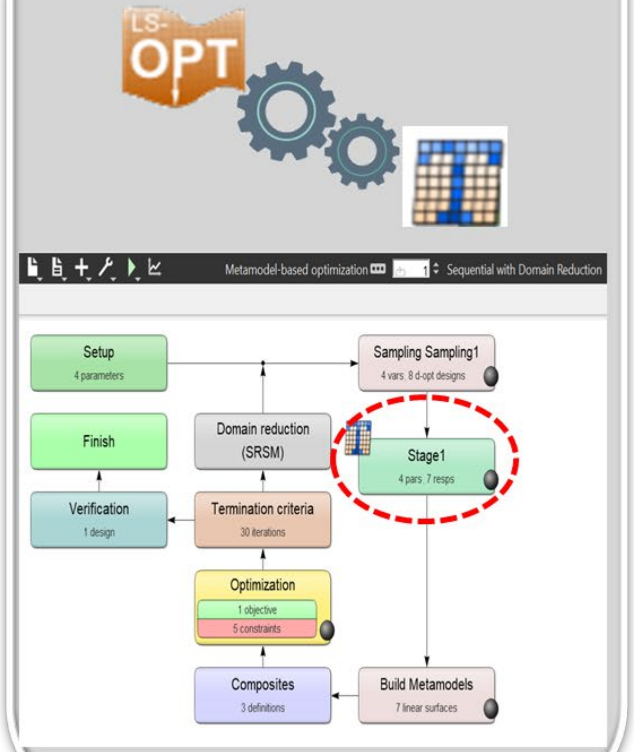
LS-TaSC with LS-PrePost

- results visualization
- model editing



LS-TaSC with LS-Opt

- multilevel and complex design schemes



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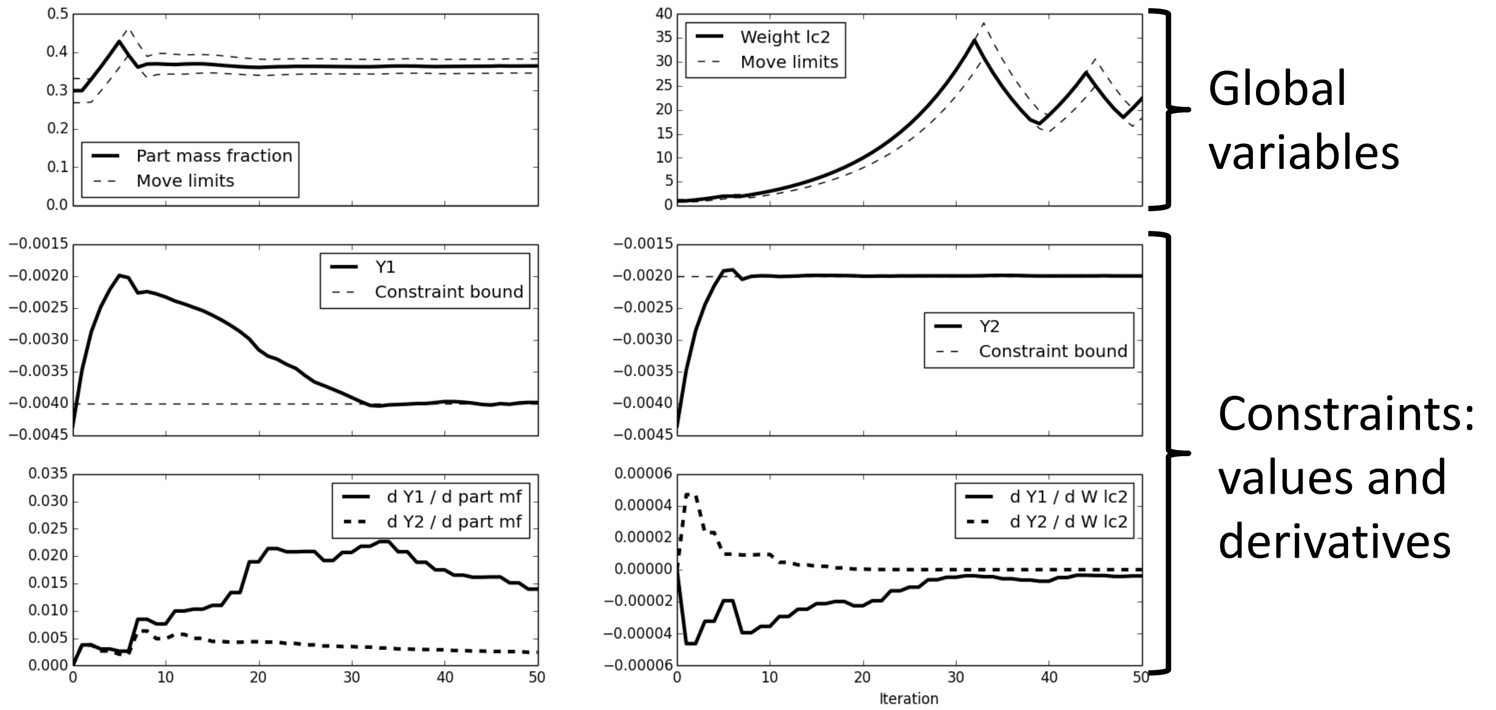
Constrained Multidisciplinary Topology Optimization

Constrained Topology Optimization

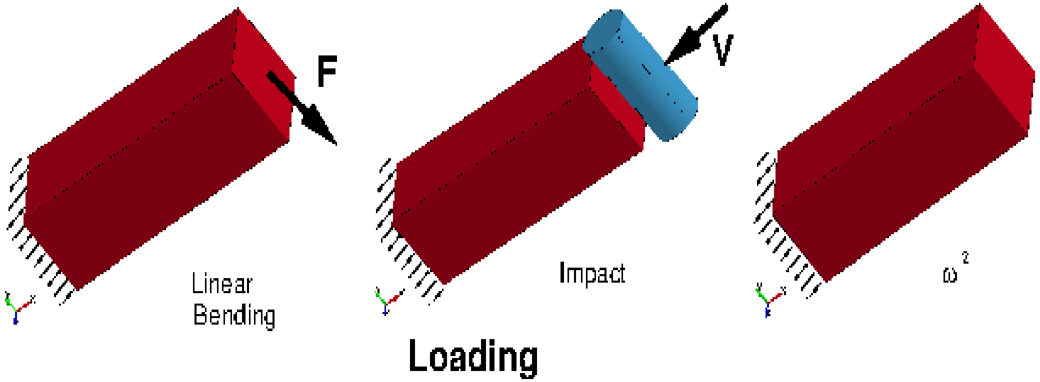
- Multipoint scheme
  → Allows more general constraints
  (e.g. energy absorption, reaction forces)
- Gradient-based optimization methods, metamodel methods, … with respect to global variables
  - Part mass fractions
  - Load case weights

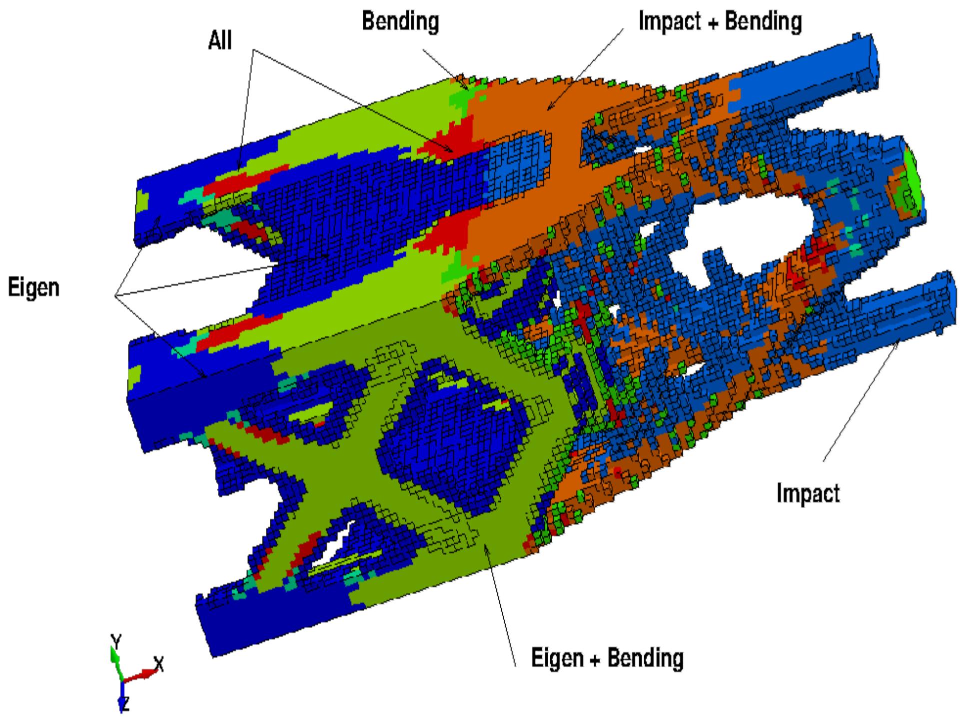
The LS-TaSC™ Multipoint Method for Constrained Topology Optimization
Roux, W.
14th International LS-DYNA Users Conference



Multidisciplinary Topology Optimization

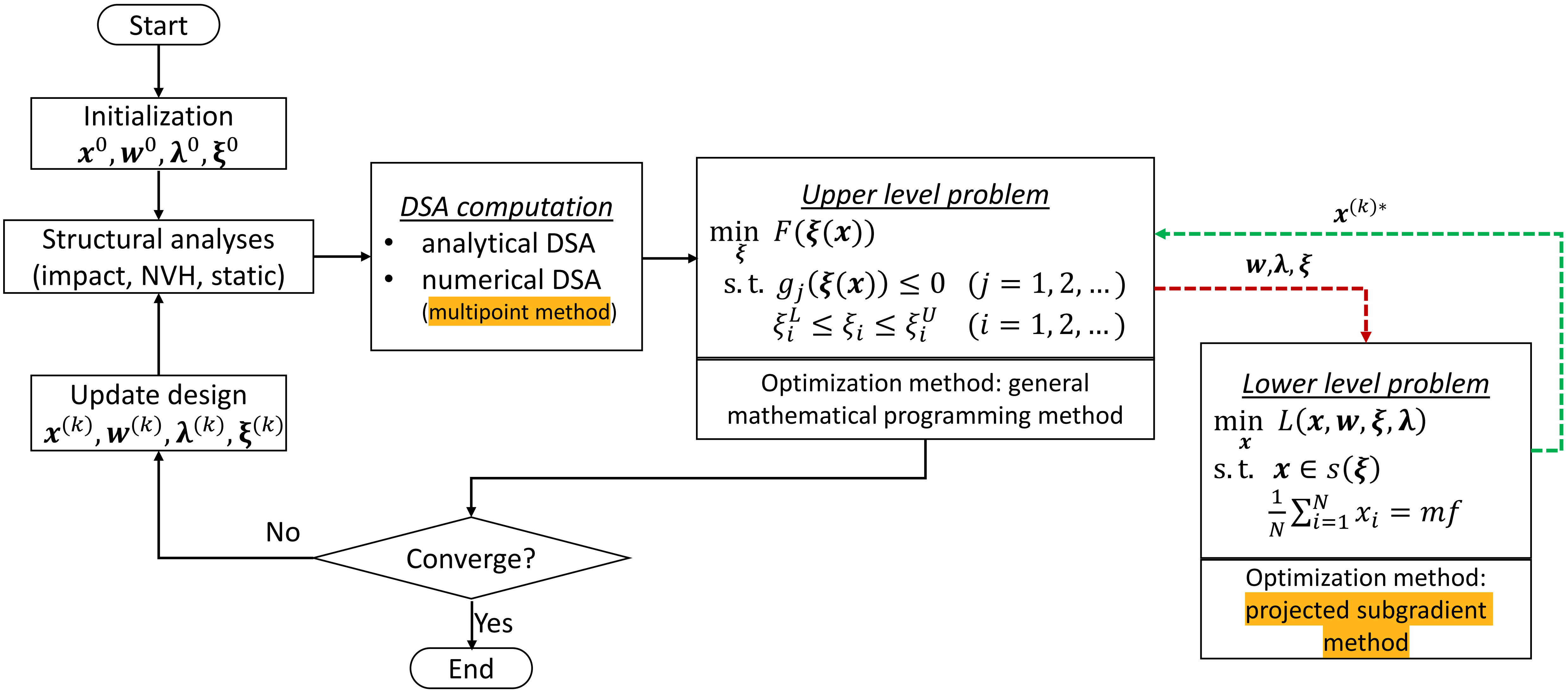
- Projected sub-gradient method
  → Enables topology optimization of NVH load cases
  → Multidisciplinary topology optimization:
    - Static
    - Impact
    - NVH





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



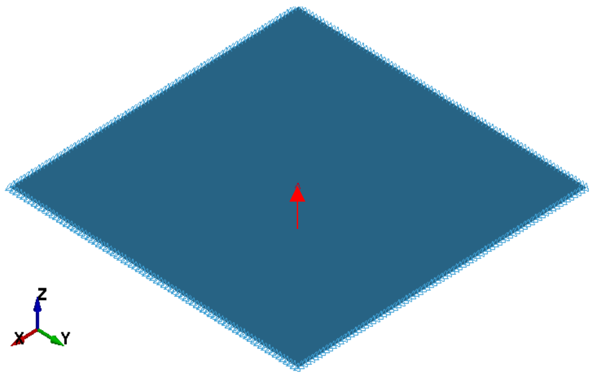
Highlights of new Features

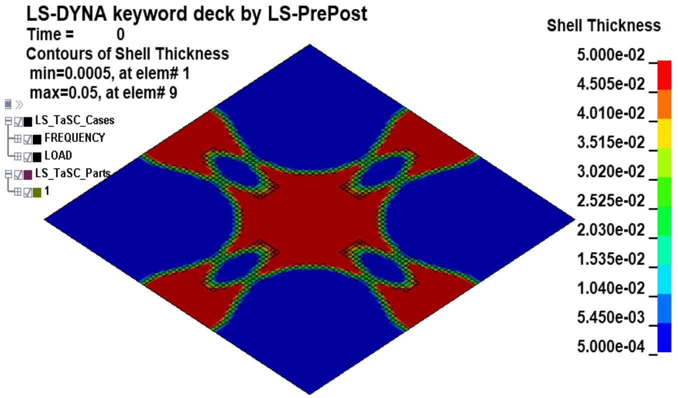
Multidisciplinary Design Optimization for Shell Thickness

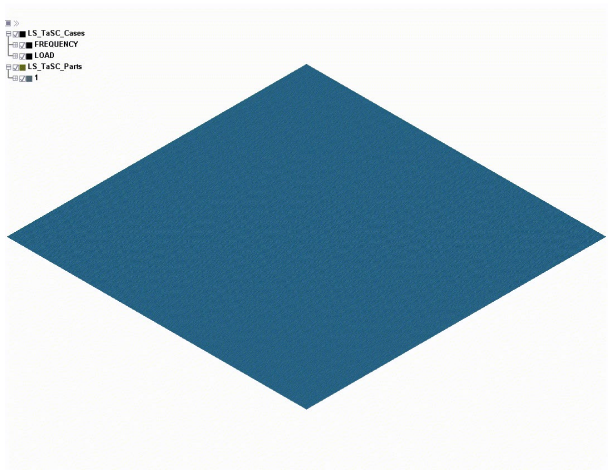
- Optimization of NVH load cases for shells

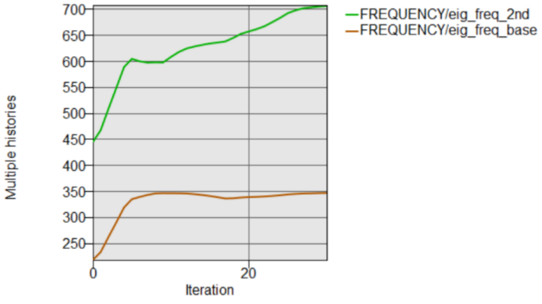
  → MDO: impact, static, and NVH load cases for shells

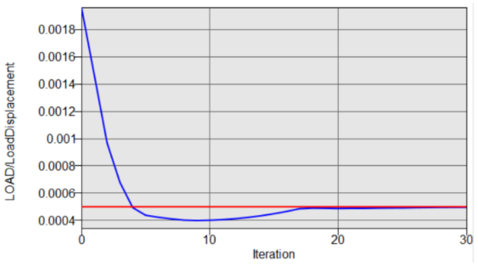
- Example: MDO of a fully clamped plate with combined static and NVH load cases











NVH and static load

User Customization

- Editing the LS-DYNA input deck

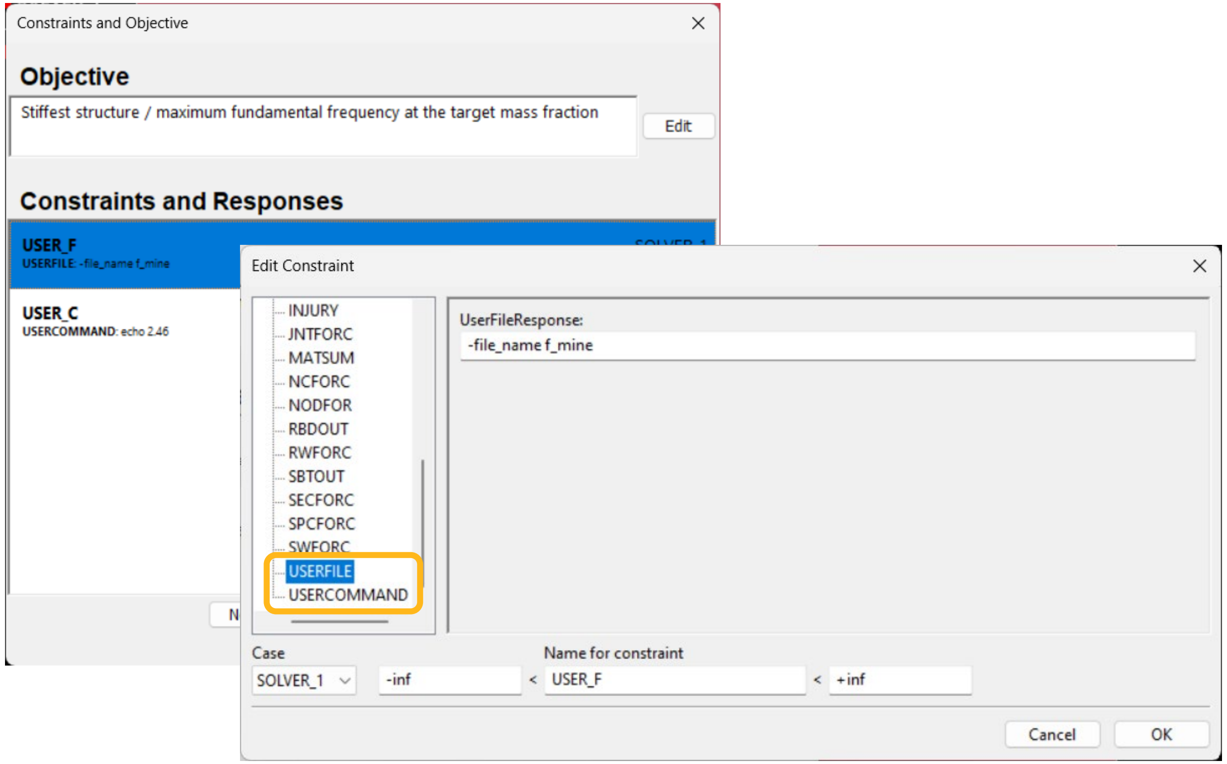
  → user program to add modifications to the input deck that are specific to a design iteration, e.g. adding glue or spotwelds to the current boundary of the design

- User responses

  → user program to provide different responses for a load case

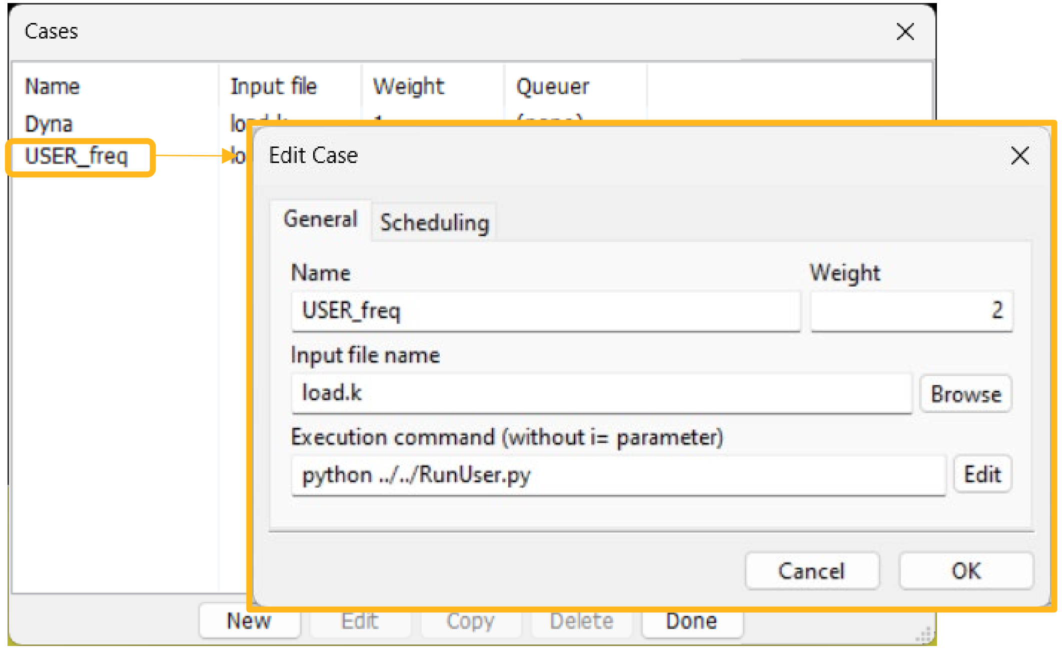
- Redesigning the structure

  → user program to employ his own design procedure to compute the design variables



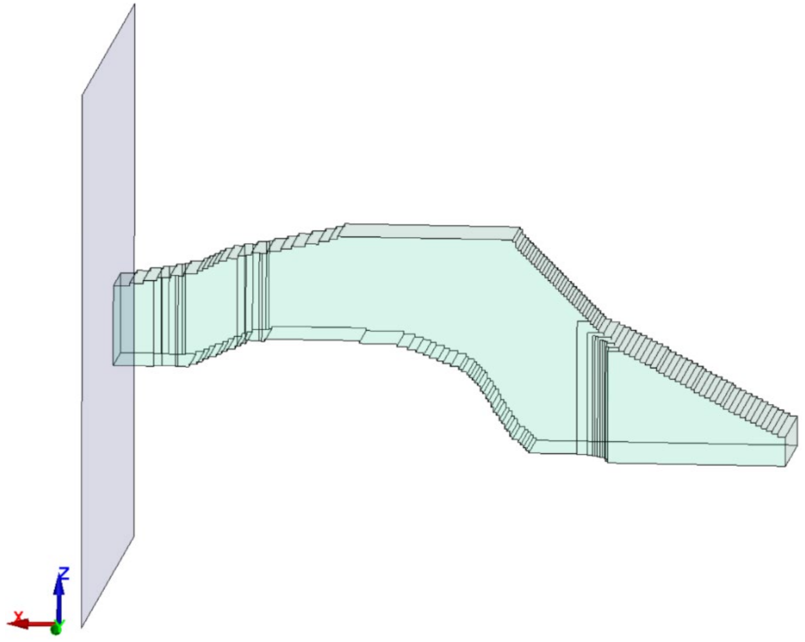
User Analysis and DSA

- 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

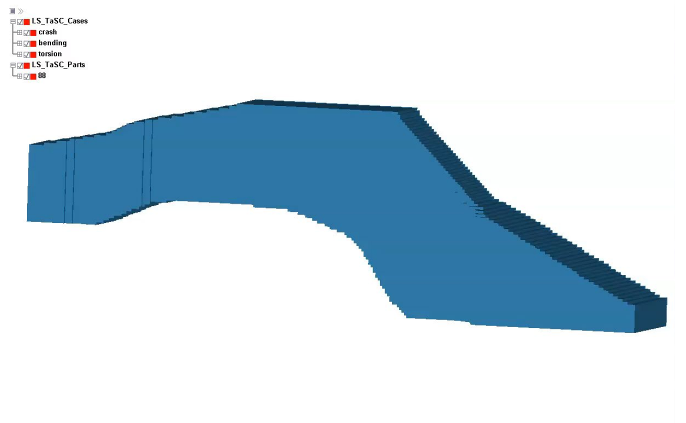


Minimum and Maximum Feature Size Controlling

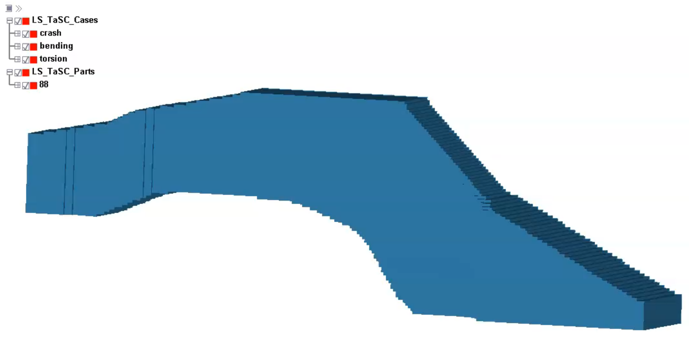
- Enforce Minimum and maximum part thicknesses
  →mega-casting to integrate with energy absorption



(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

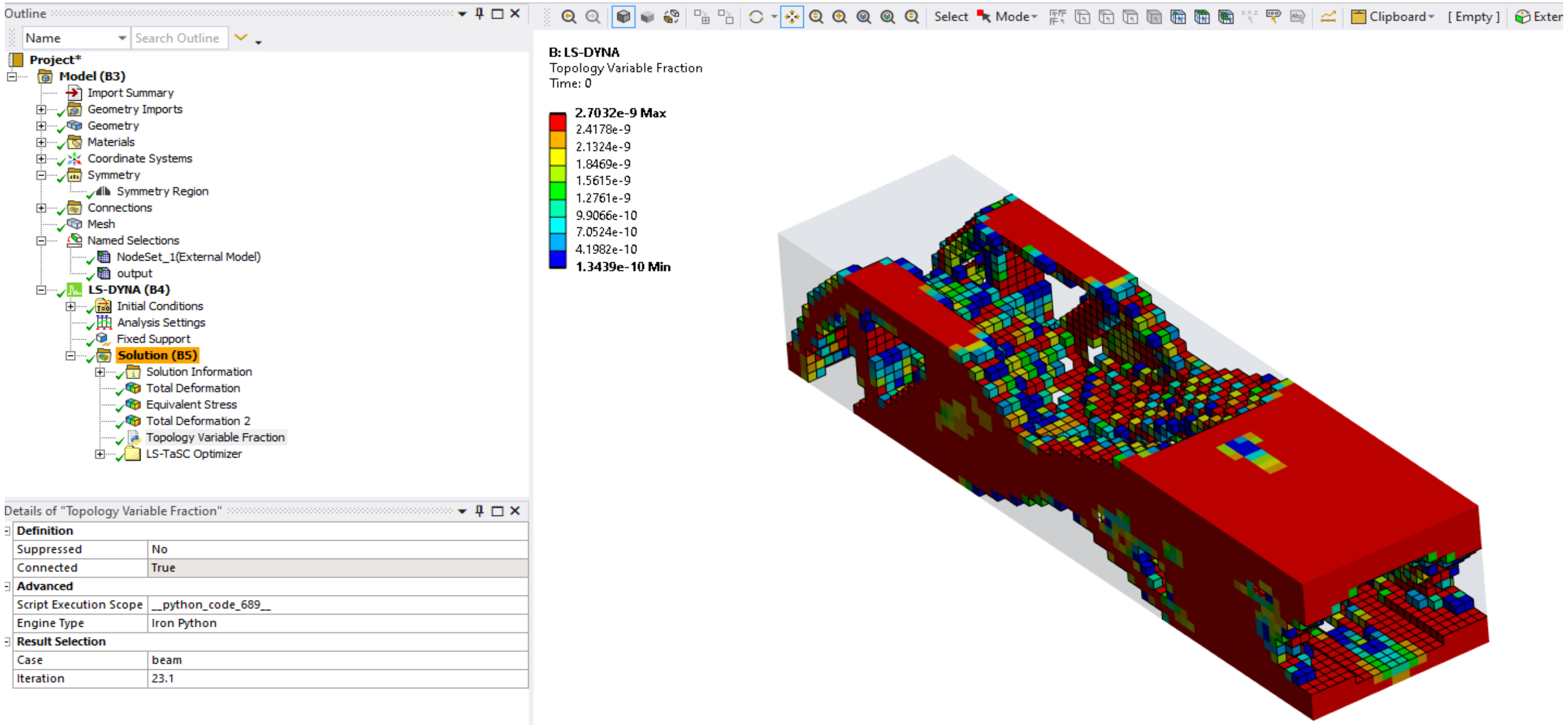


Figure courtesy of Rajesh Meena, Imtiaz Gandikota, and Ram Gopisetti

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)

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