15th German LS-DYNA Forum

LS-TaSC 4: Designing for the combination of impact, statics, and NVH

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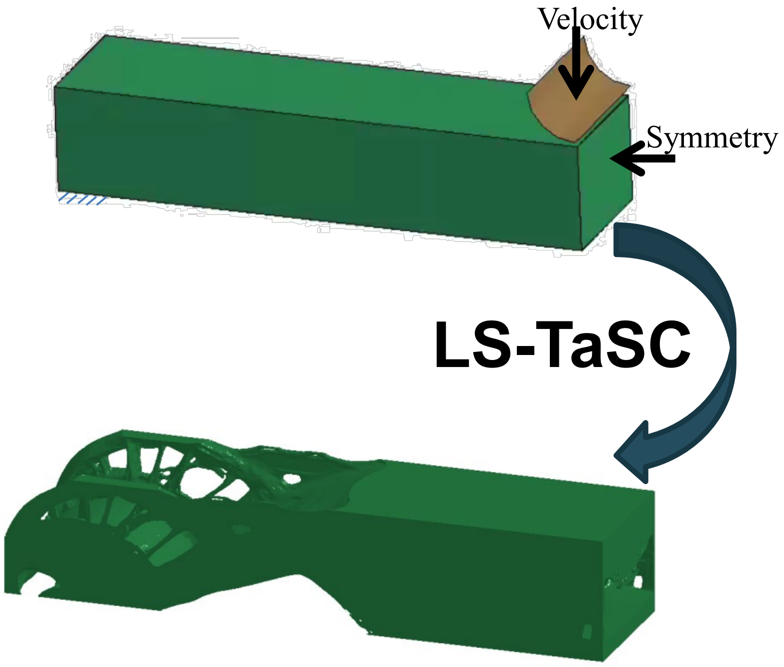
Outline

LS-TaSC 4 focuses on the design of huge models for a combination of **statics, NVH, and impact**

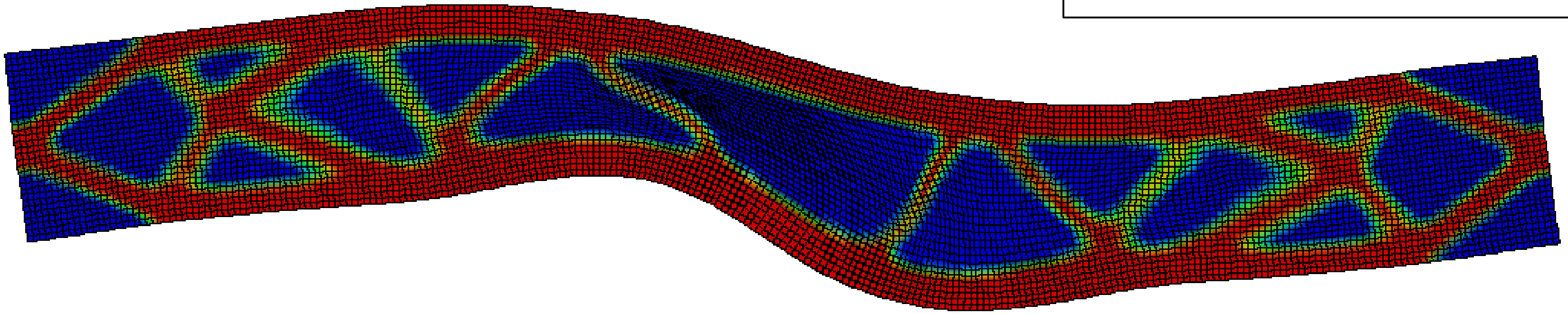
- Multidisciplinary methodology
  - Projected subgradient method
  - Multidisciplinary optimization
  - Workflow improvements
  - Visualization
- Examples
- Conclusions



Projected Subgradient Method - Motivation

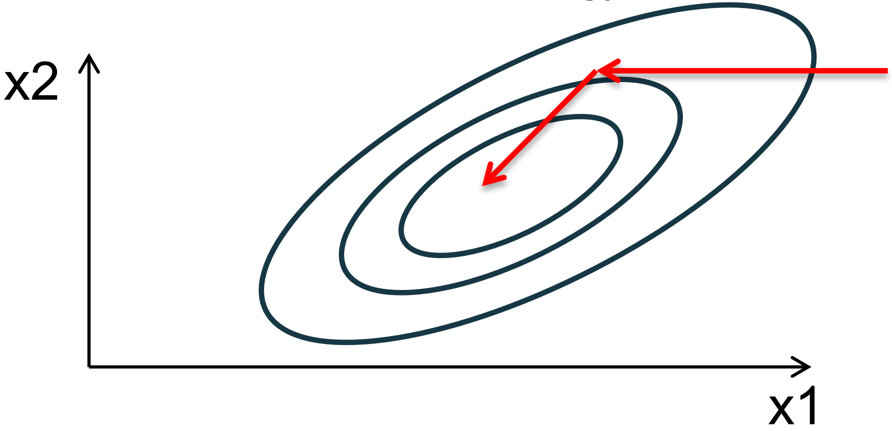
- LS-TaSC 3.2 method: Optimality Criteria for Dynamic Problems
- Objective uniform distribution of Internal Energy Density
  → static and impact load cases
  → not suitable for NVH load cases
  → we need a method that considers frequencies (maximization of fundamental frequency)
  → Projected subgradient method

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



Projected Subgradient Method

- The projected subgradient method is related to the steepest descent method
  - This family of methods related to steepest descent is popular again in general, because of the *huge data sets*. Our implementation of the projected subgradient is unique to both to us and topology optimization, again because of *the huge data sets.*



$$x^{k+1} = x^{k} - \alpha_{k}\, g^{k}$$

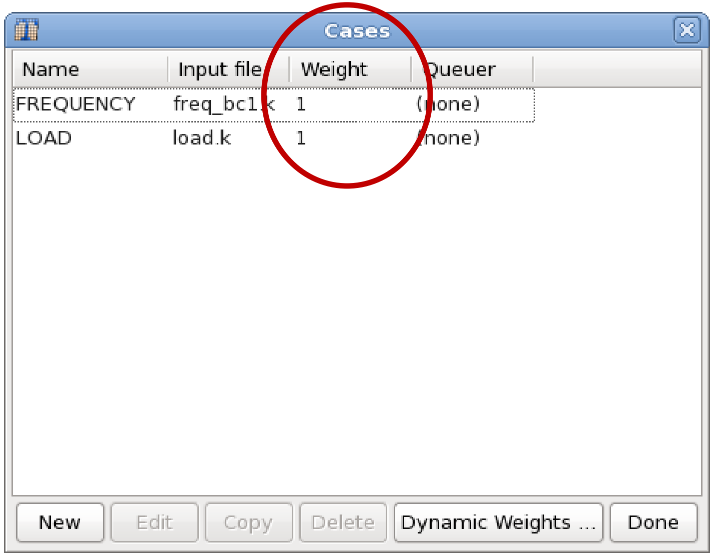
- Topology optimization requires that the mass stay constant over the iterations. The design vector is therefore mapped onto the plane of constant mass.

Multidisciplinary Optimization

- The descent vector is sourced from the various discipline descent vectors
- Combine normalized vectors using weighting:

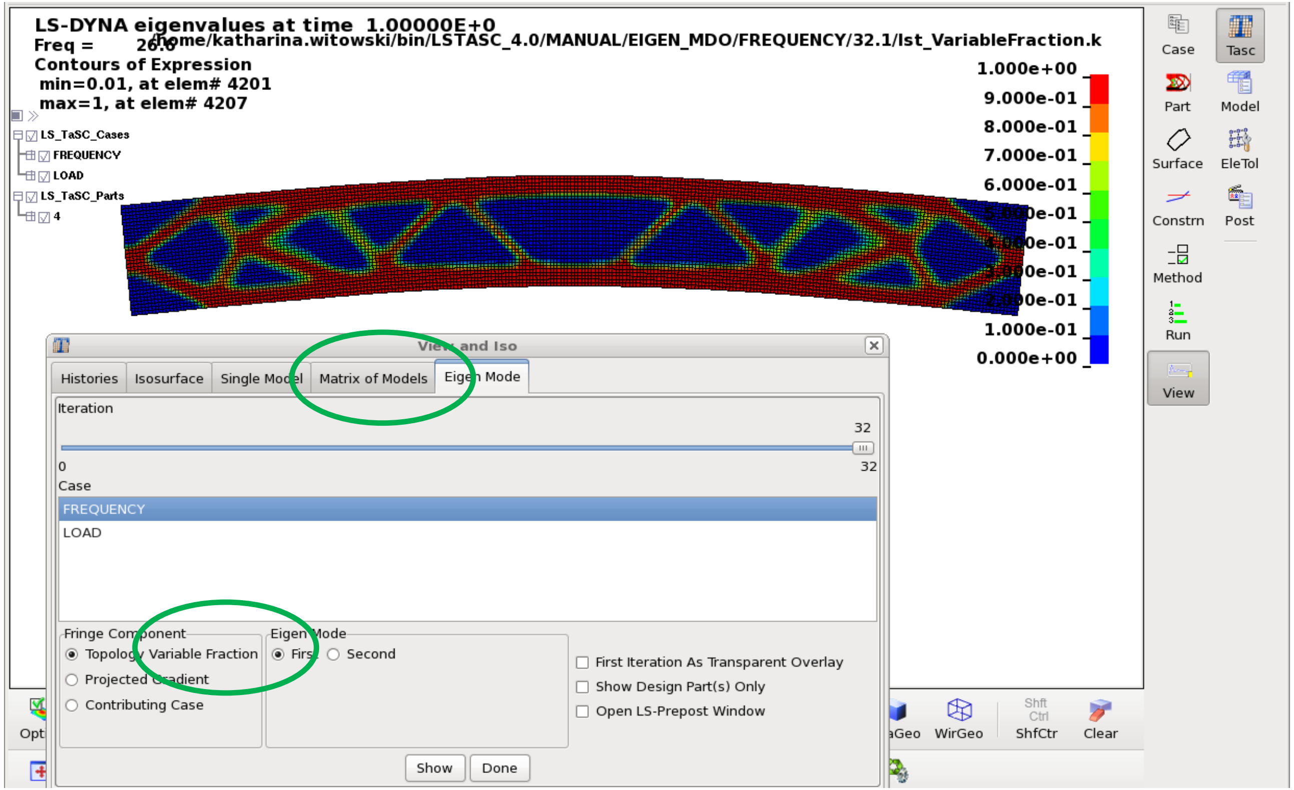
$$s = \sum_{lc=1}^{m} w_{lc} \frac{s_{lc}}{\|s_{lc}\|}$$

- The weights are provided by the engineer, or computed from information provided by the engineer
  - Solution depends on weights



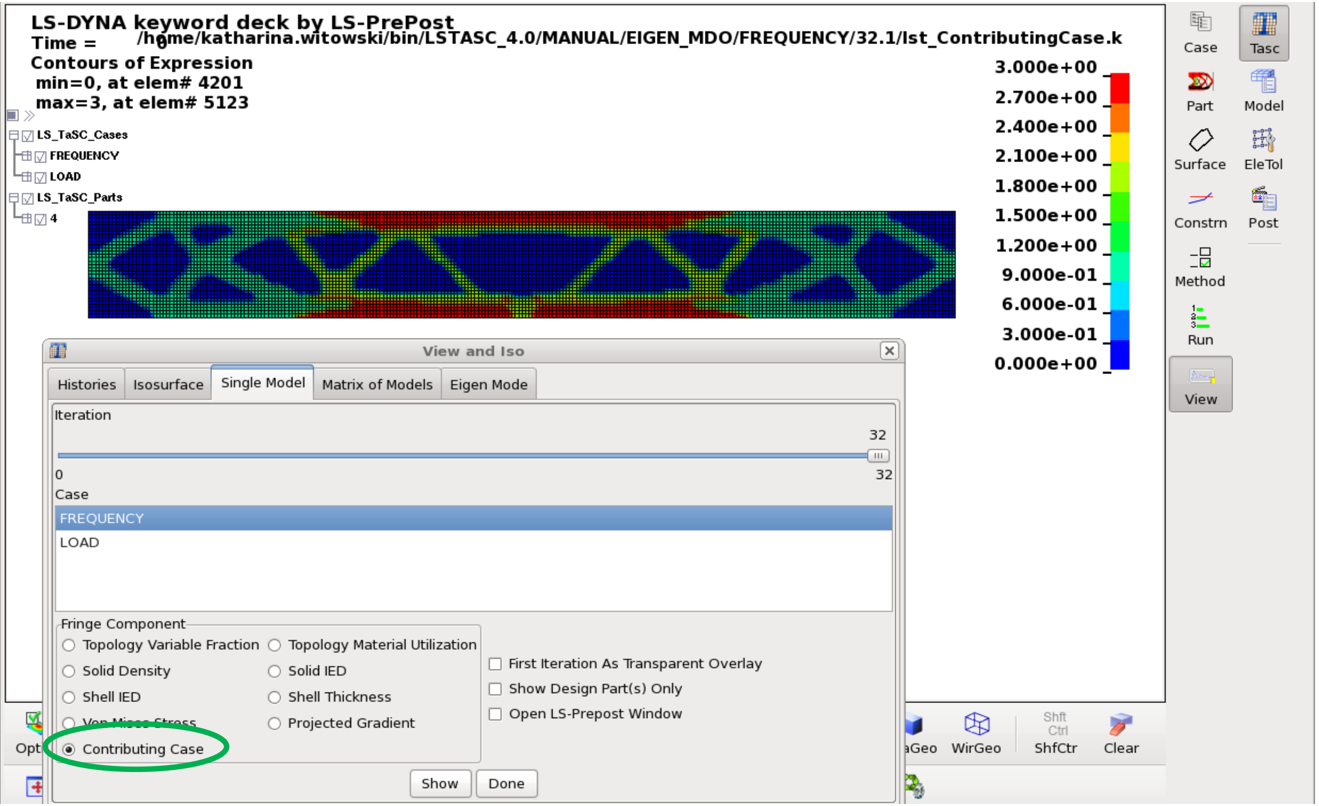
New Visualization Features

- NVH load cases: Eigen Modes



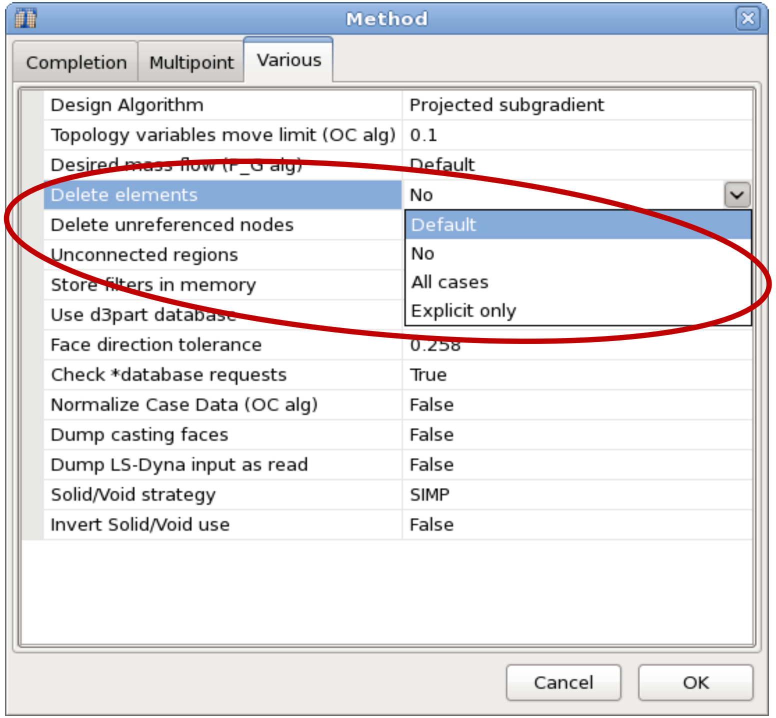
New Visualization Features

- MDO: Contributing Case
  - 0 = none
  - 1 = LC 1
  - 2 = LC 2
  - 3 = LC 1+2
  - …



Workflow improvements

- Different element deletion for implicit vs explicit cases
  - Option of deletion for explicit but not implicit
  - Automatic deletion of loose regions/elements
- Different materials between cases
  - Allow different materials for each case, such that the one case is linear, the other nonlinear, or heat transfer. This allows for example one case to be at a different temperature than the other.



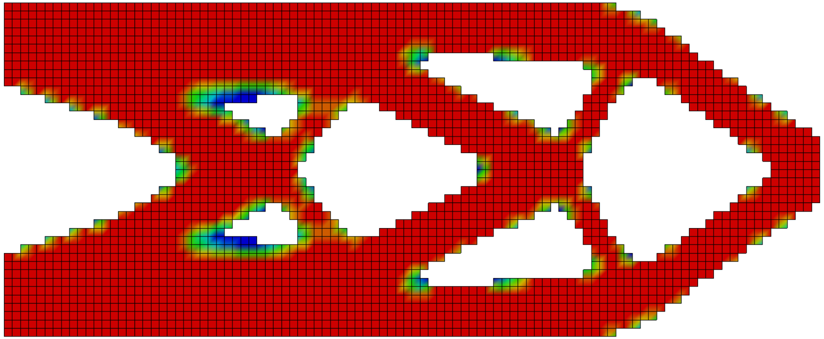
Examples

The benchmark problems demonstrate the new multidisciplinary solver:

- Huge models
- NVH benchmark problems
- Multi-disciplinary design optimization considering NVH and static
- Impact, static, and NVH

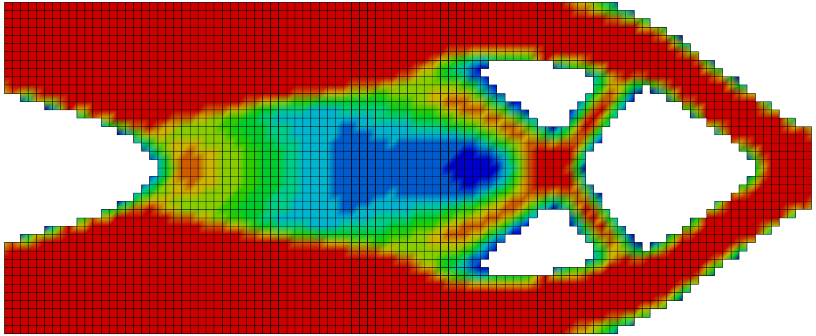
Performance relative to previous method

- Mathematical programming techniques allow many power-ups



Projected subgradient (new):

- 30 FEA calls
- 0.1 step size

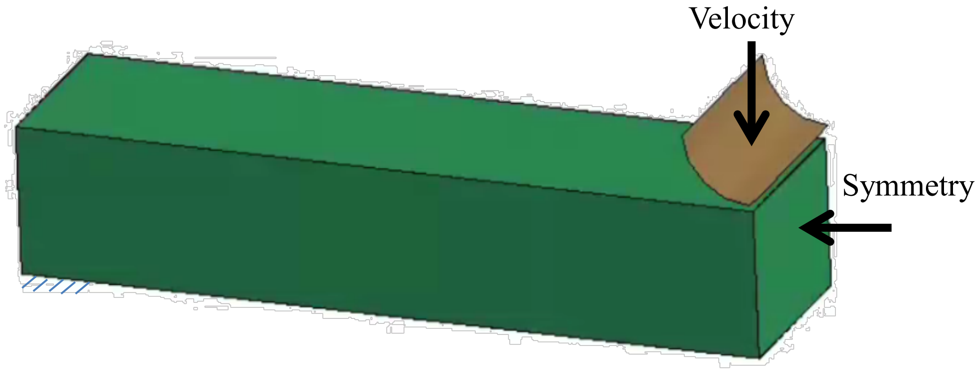


Optimality Criteria (old):

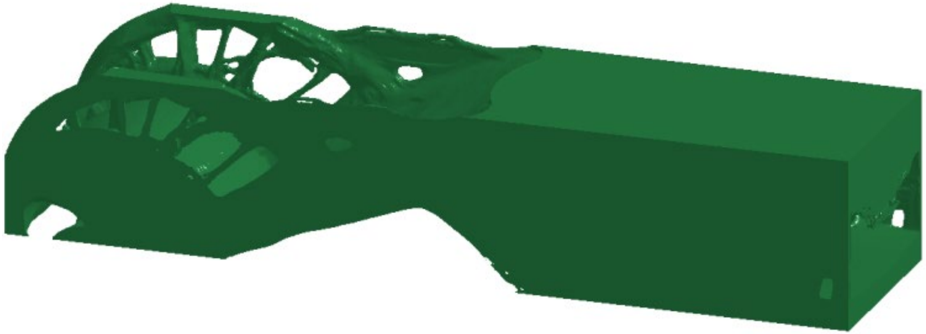
- 30 FEA calls
- 0.1 step size
- Needs about 50 iterations to match the new algorithm

Huge model performance

- Impact load case
  - 13.1 million elements
- Mass fraction: 0.25
- Projected subgradient method
  - 30 Iterations



Isosurface plot
of optimal design



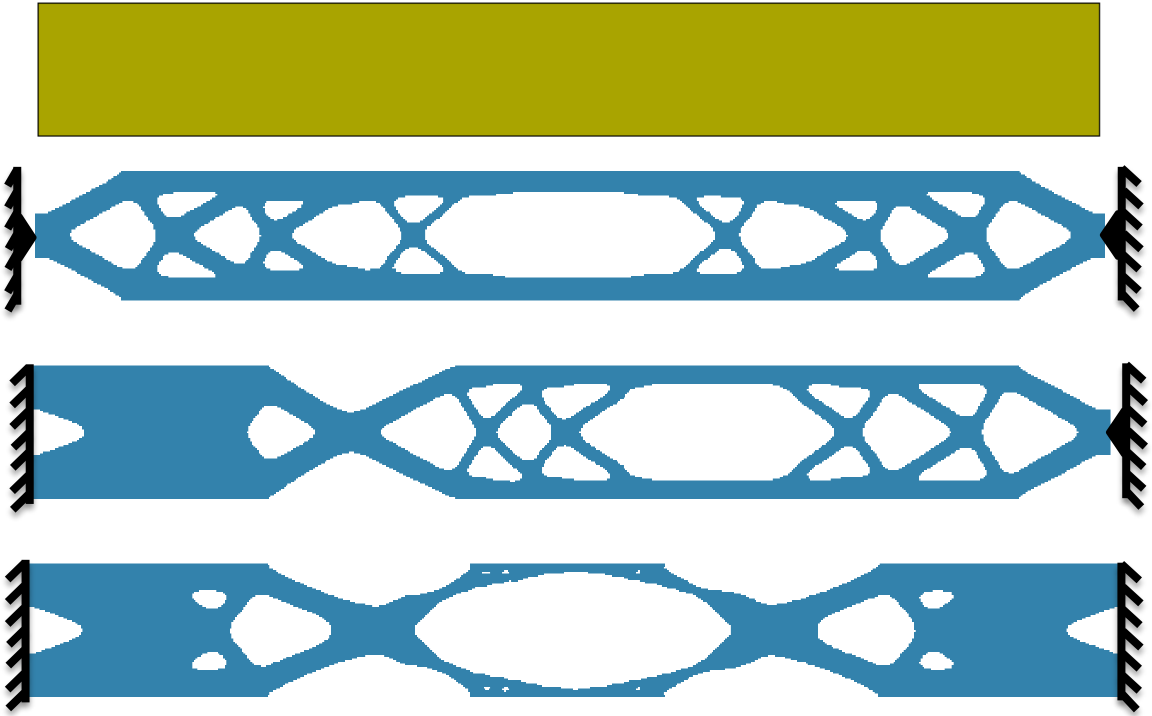
Huge model performance

- Computational cost for huge problem

HUGE MODEL PERFORMANCE	
Model size	**13.1 million elements**
Physics	Explicit impact analysis
LS-DYNA analysis time for one iteration	600 CPU hours (5 hours using 120 CPUs on a remote cluster)
Part design time – first iteration	25 CPU minutes (1 CPU)
Part design time – all other iterations	2 CPU minutes (1 CPU)
Peak memory use by LS-TaSC	15 GB

NVH Benchmarks

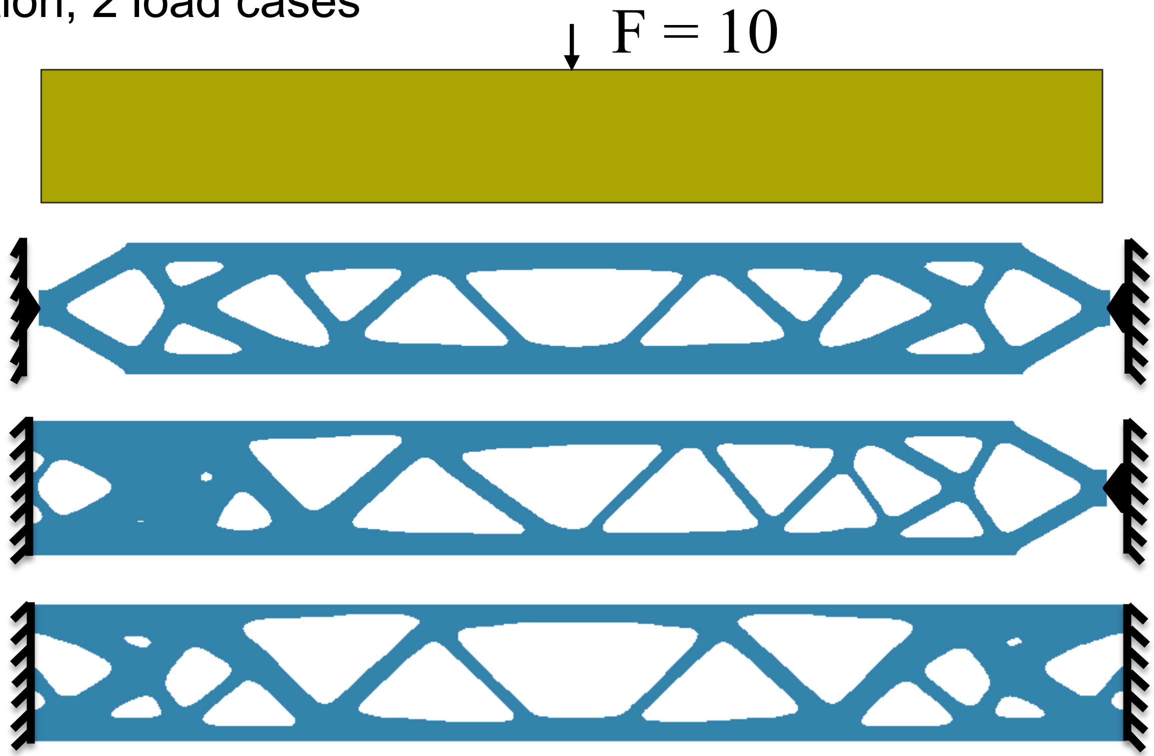
- Maximization of Fundamental Frequency
- Mass fraction: 0.5
- 3 different boundary conditions



Symmetric boundary conditions
→ Symmetric results

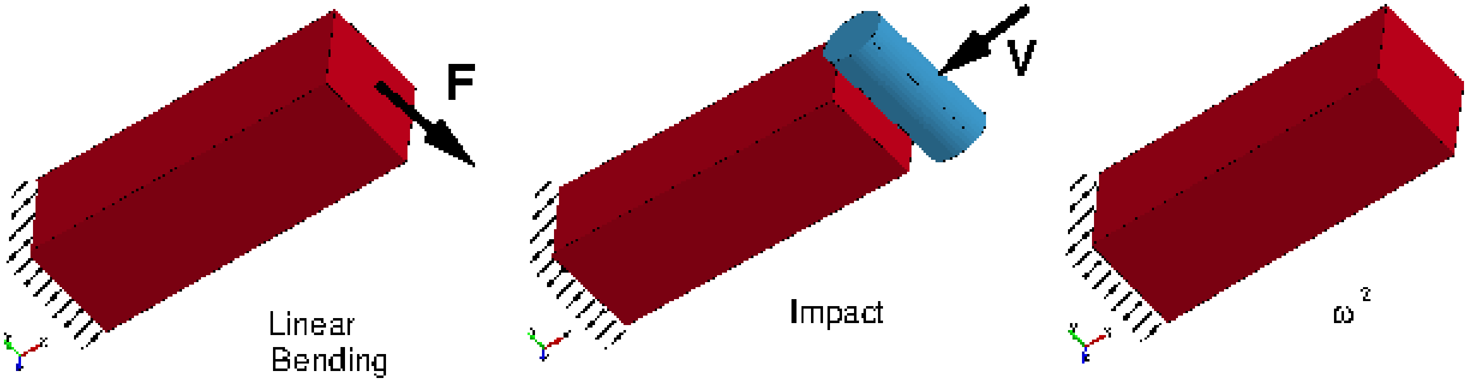
NVH Benchmarks

- Multi-disciplinary optimization, 2 load cases
  - fundamental frequency
  - linear static load
- Mass fraction: 0.5
- 3 different boundary conditions



Impact, statics, and NVH

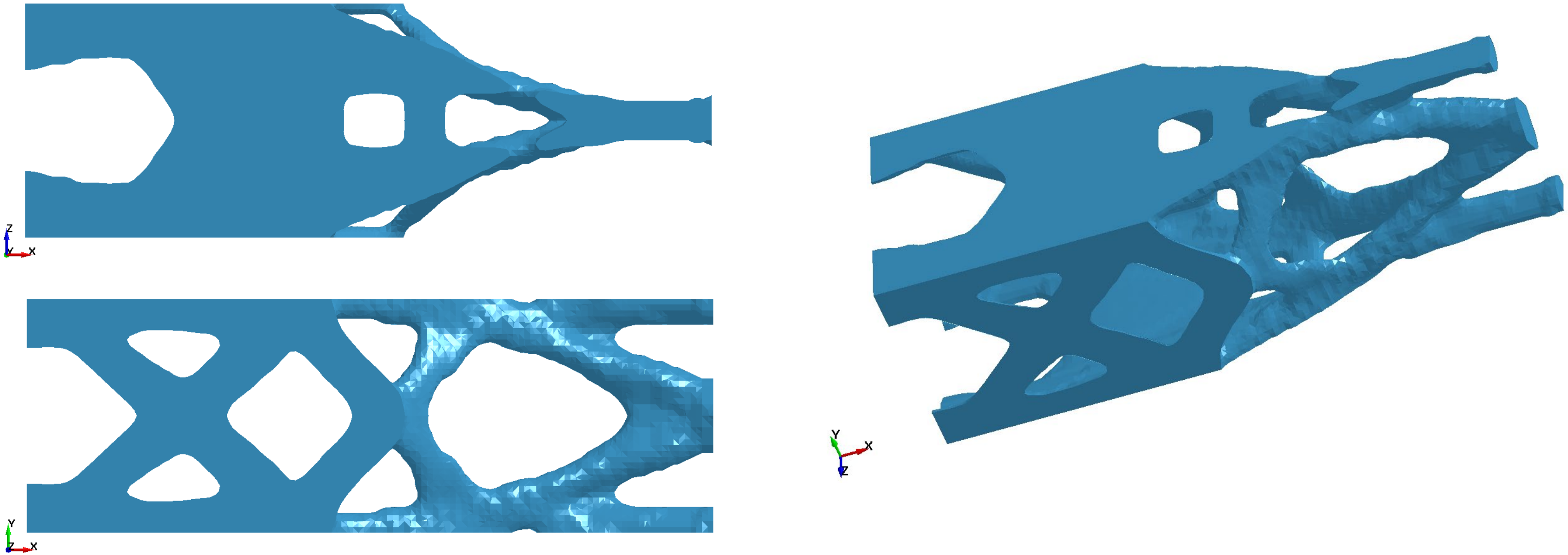
- Multi-disciplinary optimization, 3 load cases
  - Equal weights
- Mass fraction: 0.1



Loading

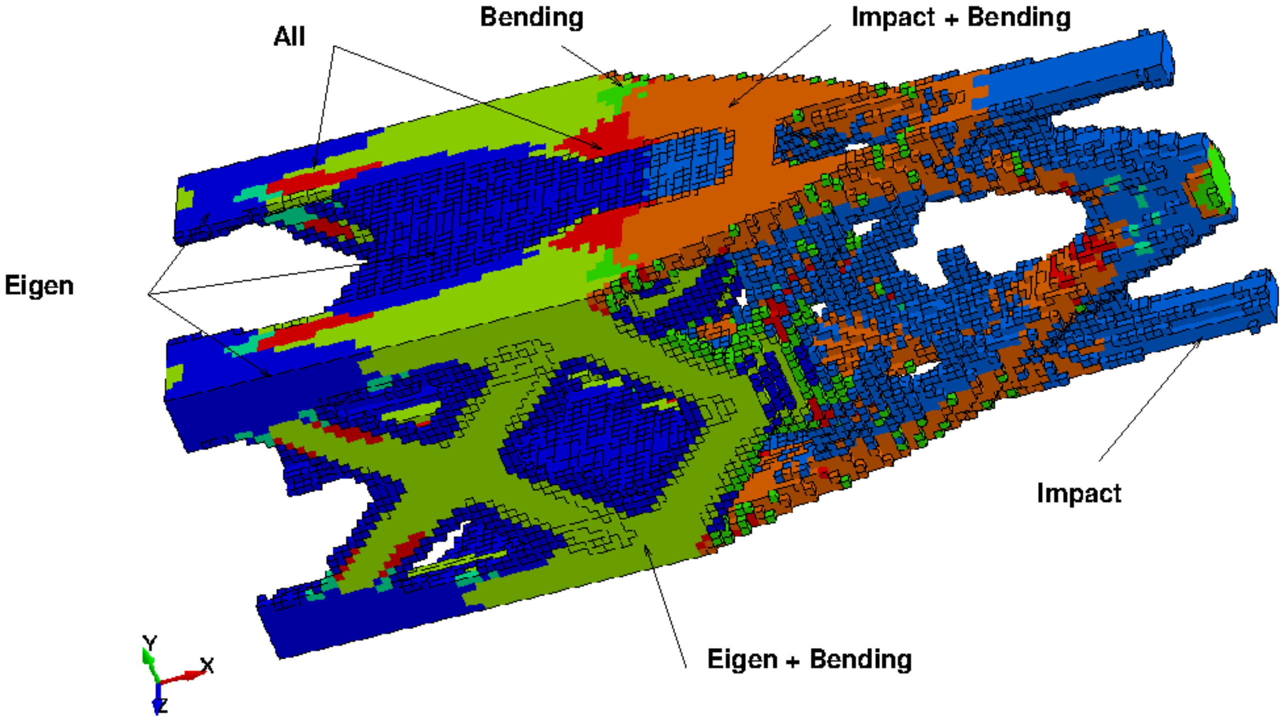
Impact, statics, and NVH

- Results (80 Iterations)
  - Optimal geometry



Impact, statics, and NVH

- New plot type shows which load case contributes the material used in the part.



Conclusions

- The Projected subgradient method provides option to run MDO
  - combines the disparate crash and NVH design disciplines
- It ran 10 000 000+ solid element crash models out of the gate
- The Beta version of LS-TaSC version 4 is available

More Information on the LSTC Product Suite

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  - Support / Tutorials / Examples / FAQ
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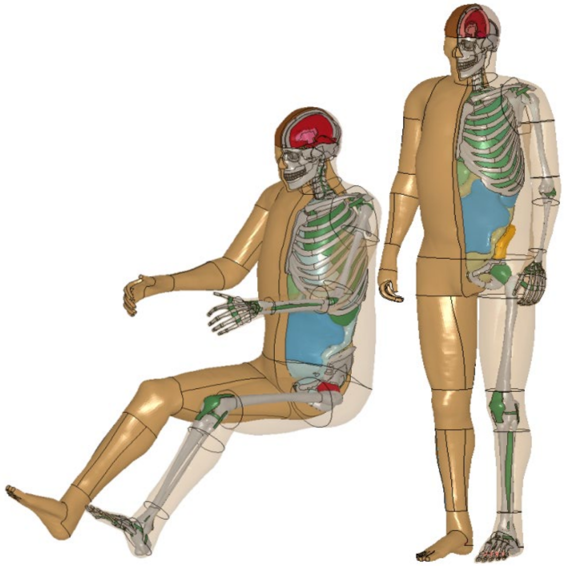

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