SAND2018-3213D

ANALYSIS-DRIVEN DESIGN WITH PLATO TOPOLOGY OPTIMIZATION

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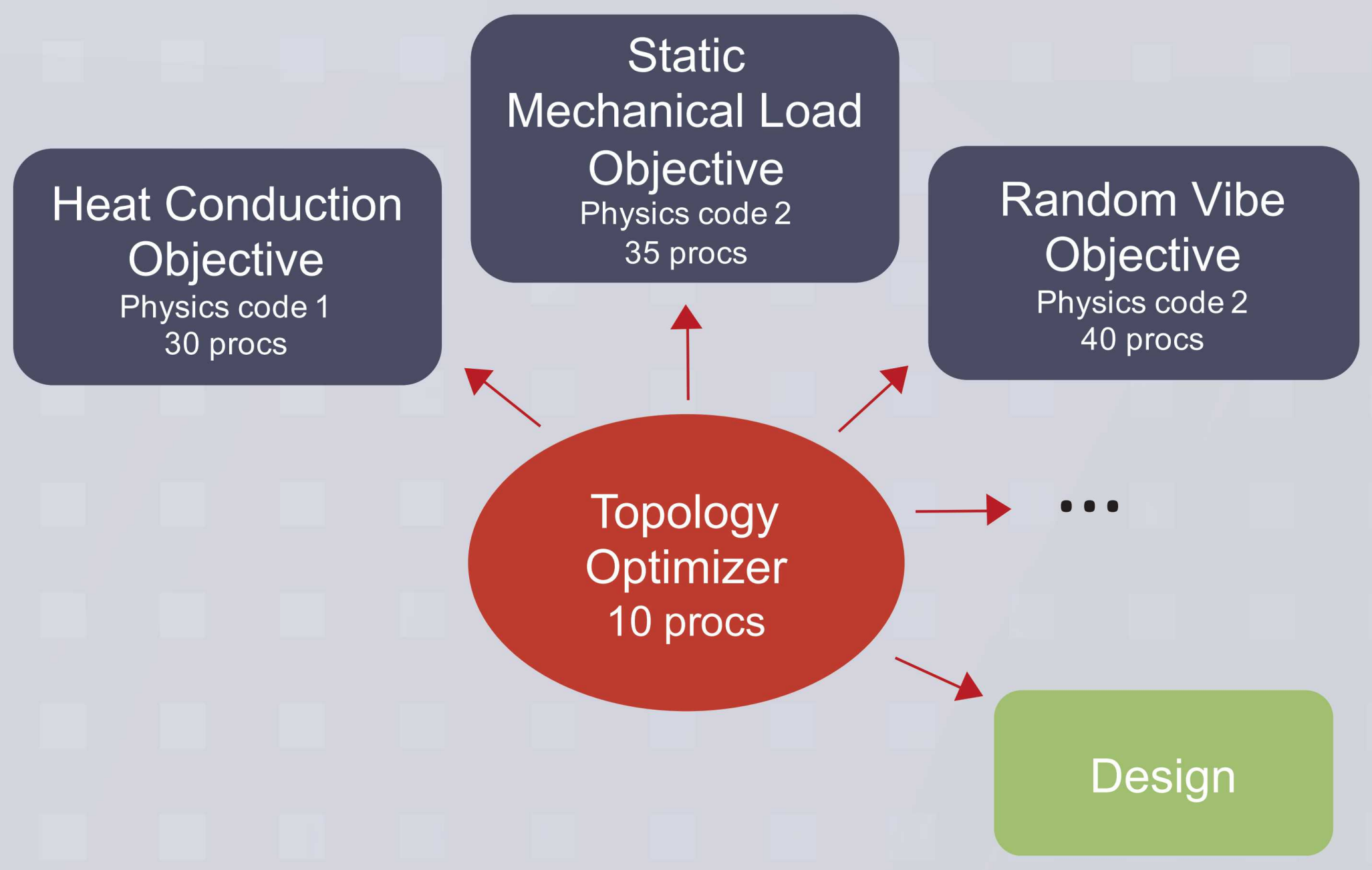
PLATO ENGINE

Plato has been newly architected to support the combination of multiple physics solvers in a single optimization run. We leverage a Multiple Program Multiple Data programming model to allow each physics engine to run independently of one another while still collaborating on a single problem. Data communication is handled in such a way that each physics engine can run on a different number of processors and in turn have different decompositions of the work.


Heat Conduction Objective
Physics code 1
30 procs

Static Mechanical Load Objective
Physics code 2
35 procs

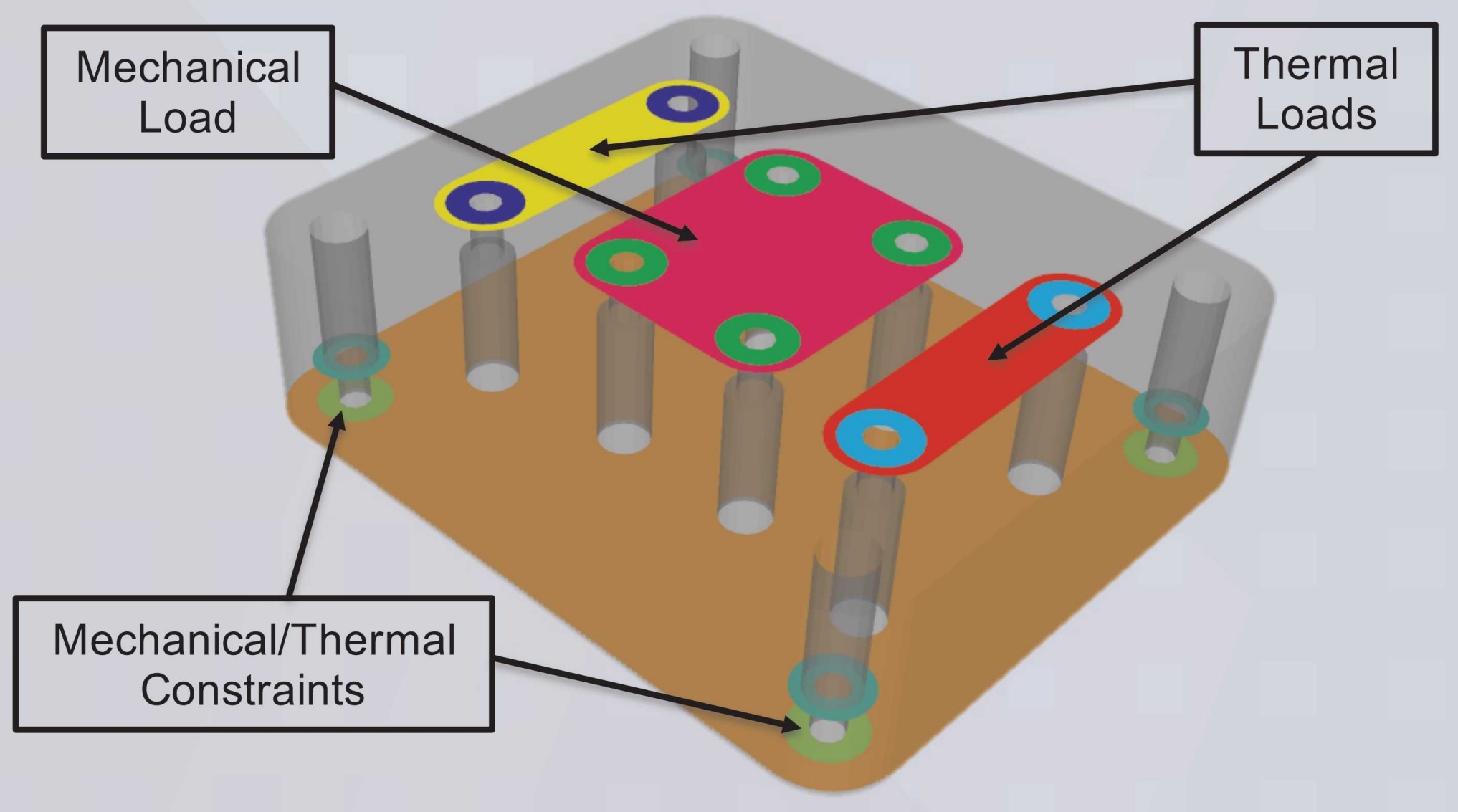
Random Vibe Objective
Physics code 2
40 procs

Topology Optimizer
10 procs

…

Design

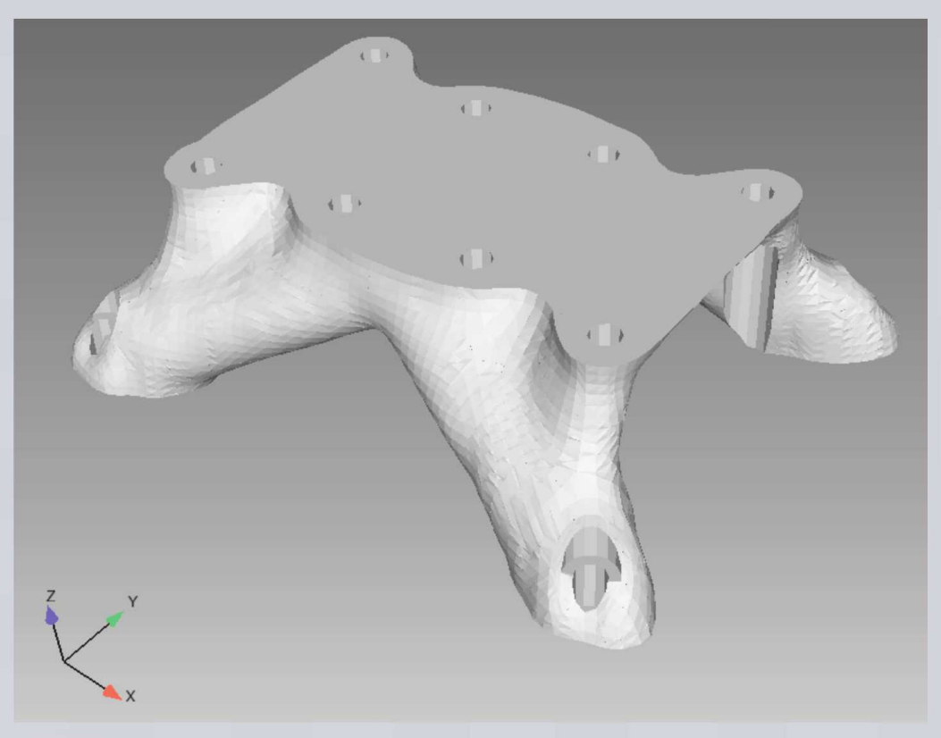
Below is an example problem with multiple load cases and multiple physics engines. Each load case will contribute to the final design. Each load case is run on its own set of processors and sends input to Plato Engine at each iteration of the optimization. The solution is shown in the bottom right.



1 Sierra/SD Engine (40 procs)

2 Albany Engines (30 and 35 procs)

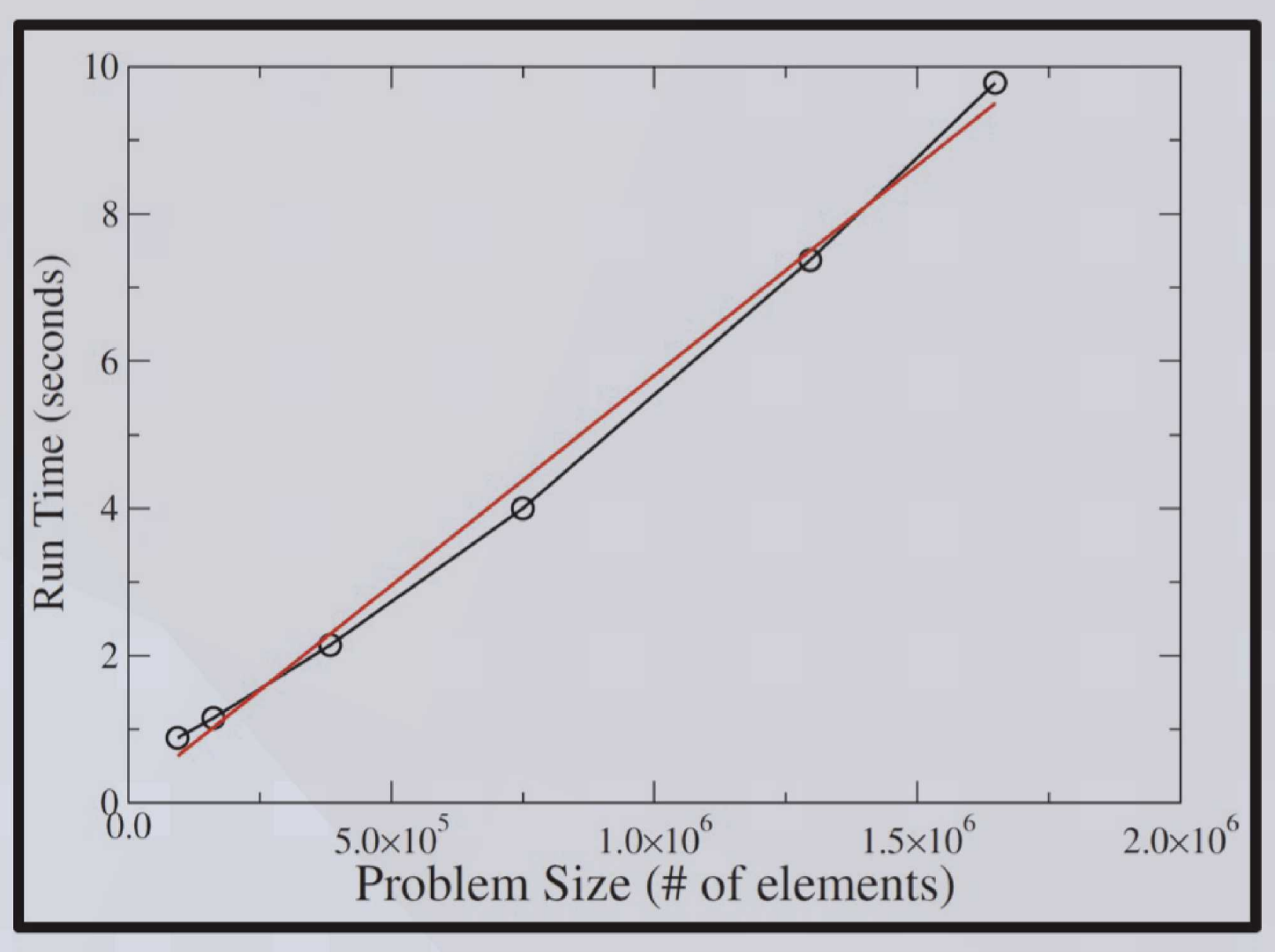
Plato optimizer (10 procs)

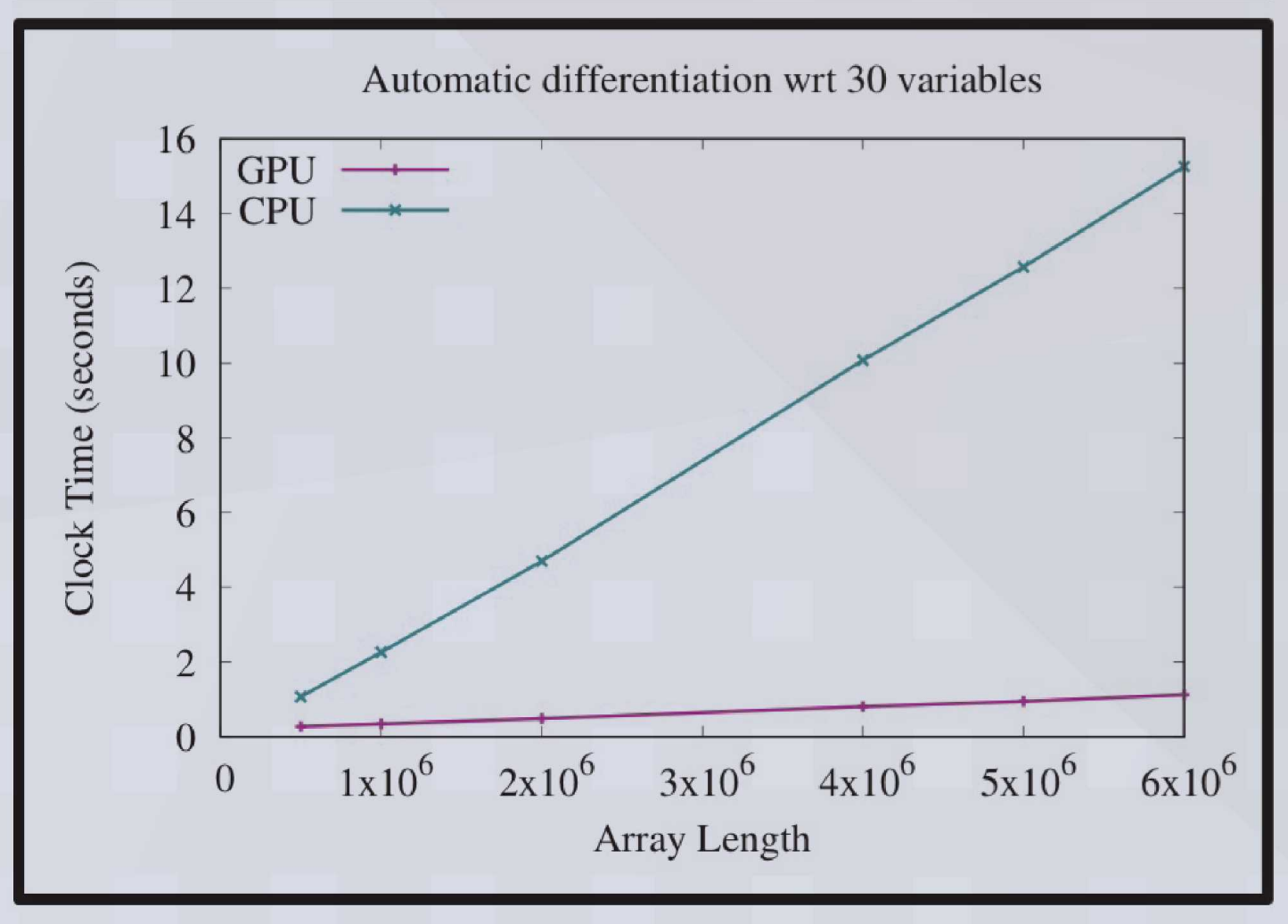


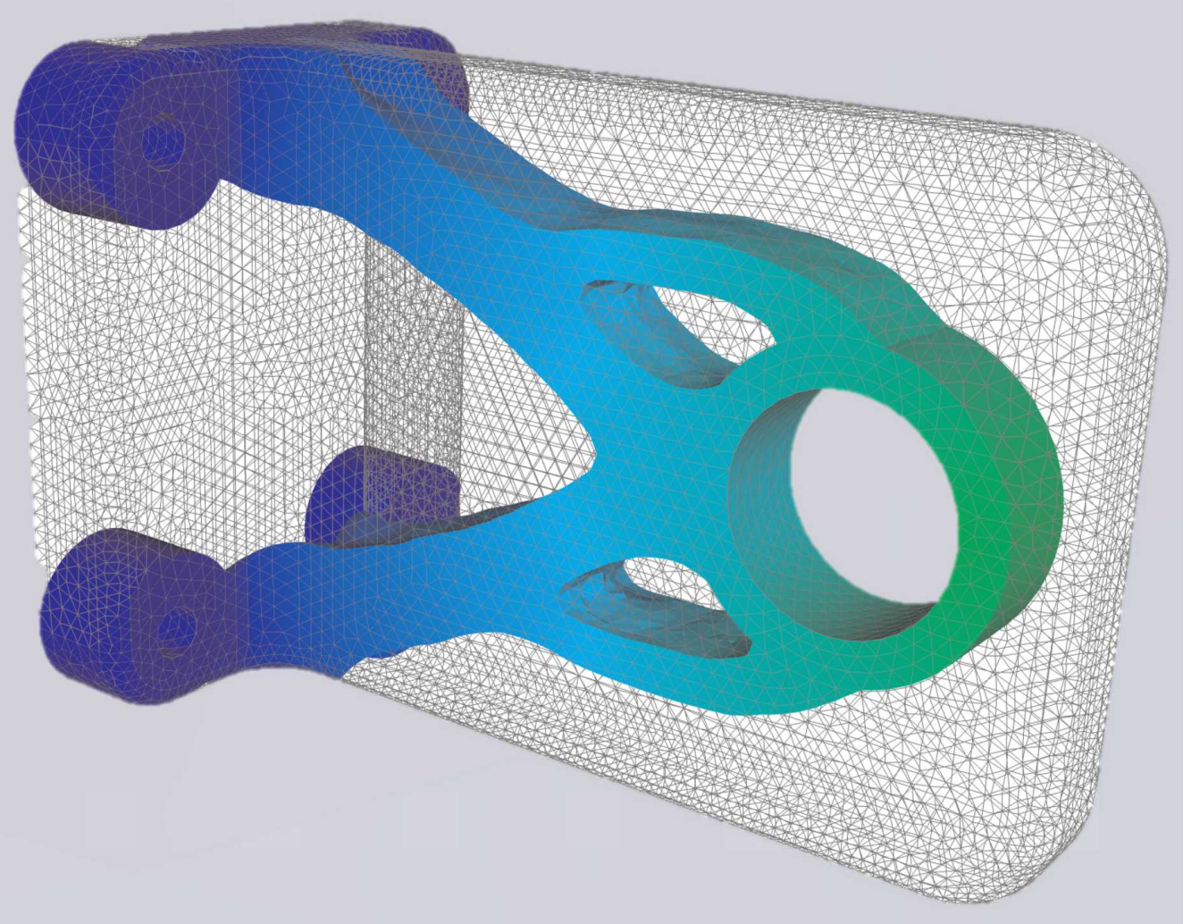
Integrated Physics codes
- *Sierra/SD*
- *Albany (open source)*
- *Plato Analyze*
- *Alexa GPU performer*
- *Aleph*

PLATO ANALYZE GPU SOLVER

Plato Analyze is a physics solver written from the ground up with GPUs in mind. It currently provides a limited set of thermal and mechanical physics capabilities and is being expanded to support more complex physics such as dynamics and fluids. Utilizing GPU architecture, Plato Analyze is able to do solves in a fraction of the time required by CPUs. Plato Analyze includes an Automatic Differentiation package (Sacado) which accelerates the implementation of new objectives and gradients for topology optimization. An example problem using Plato Analyze is shown below.



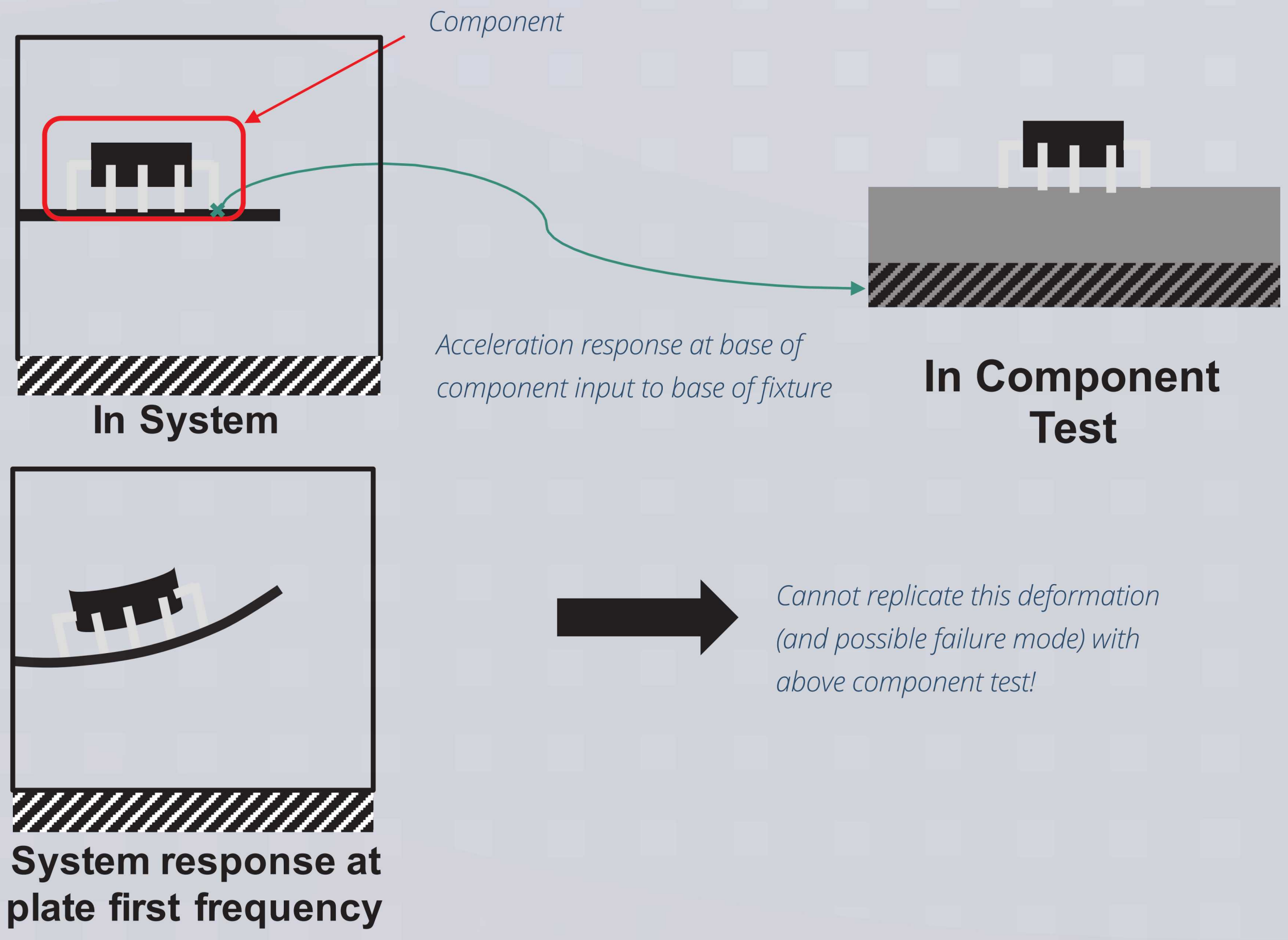

Automatic differentiation wrt 30 variables



Mechanical and thermal load cases. 2 GPUs.
187K elements, 110K DOFs, 26 Iterations
Run time: 28s

FREQUENCY RESPONSE FUNCTION MATCHING

The Plato team is currently developing a capability for using topology optimization to generate designs that match a desired frequency response function (FRF). This effort is driven by the need to be able to better represent real life system environments in a test environment. The goal is to design test fixtures that will result in a component experiencing the same loading conditions it would see in actual use in a system.

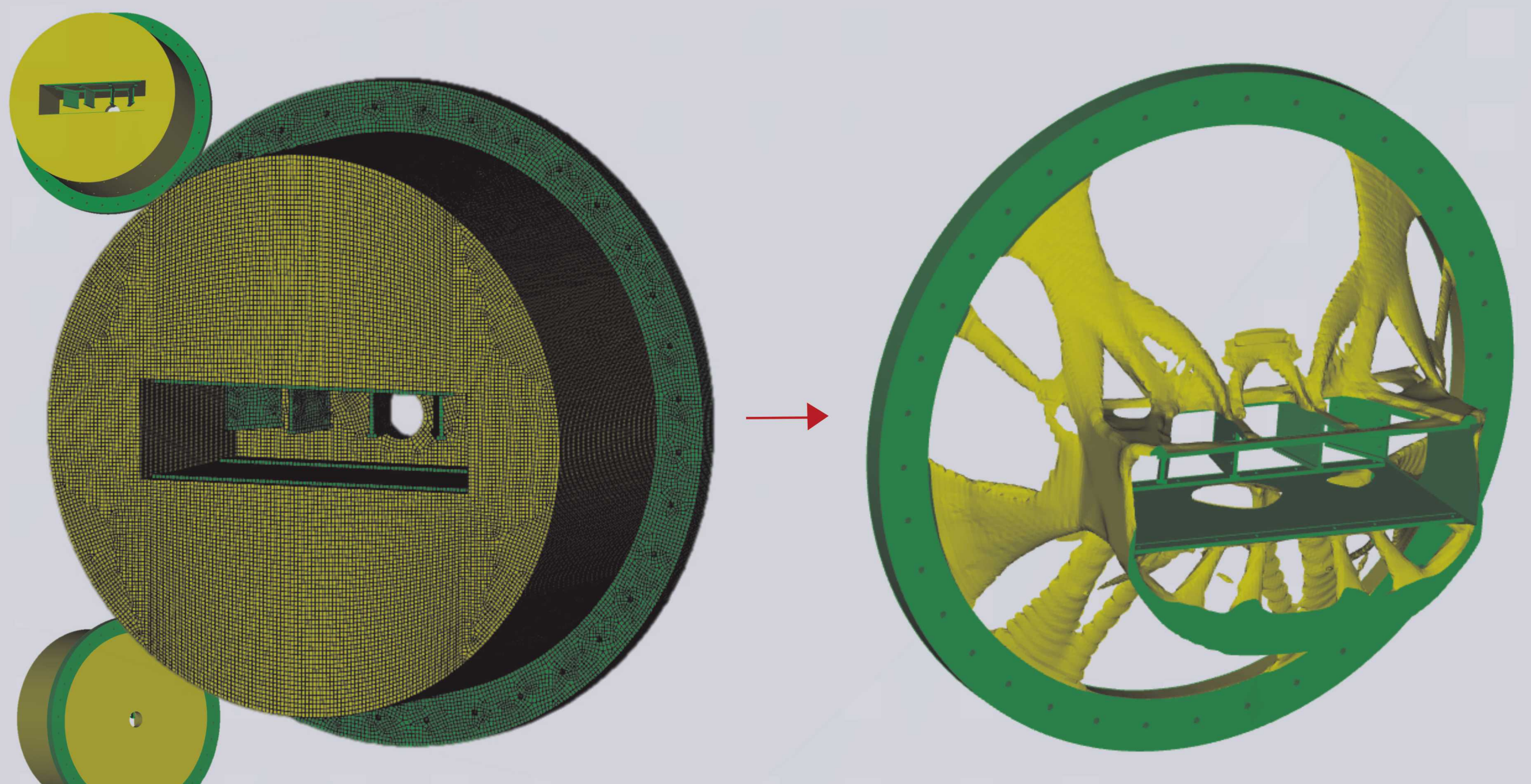


Acceleration response at base of component input to base of fixture

Cannot replicate this deformation (and possible failure mode) with above component test!

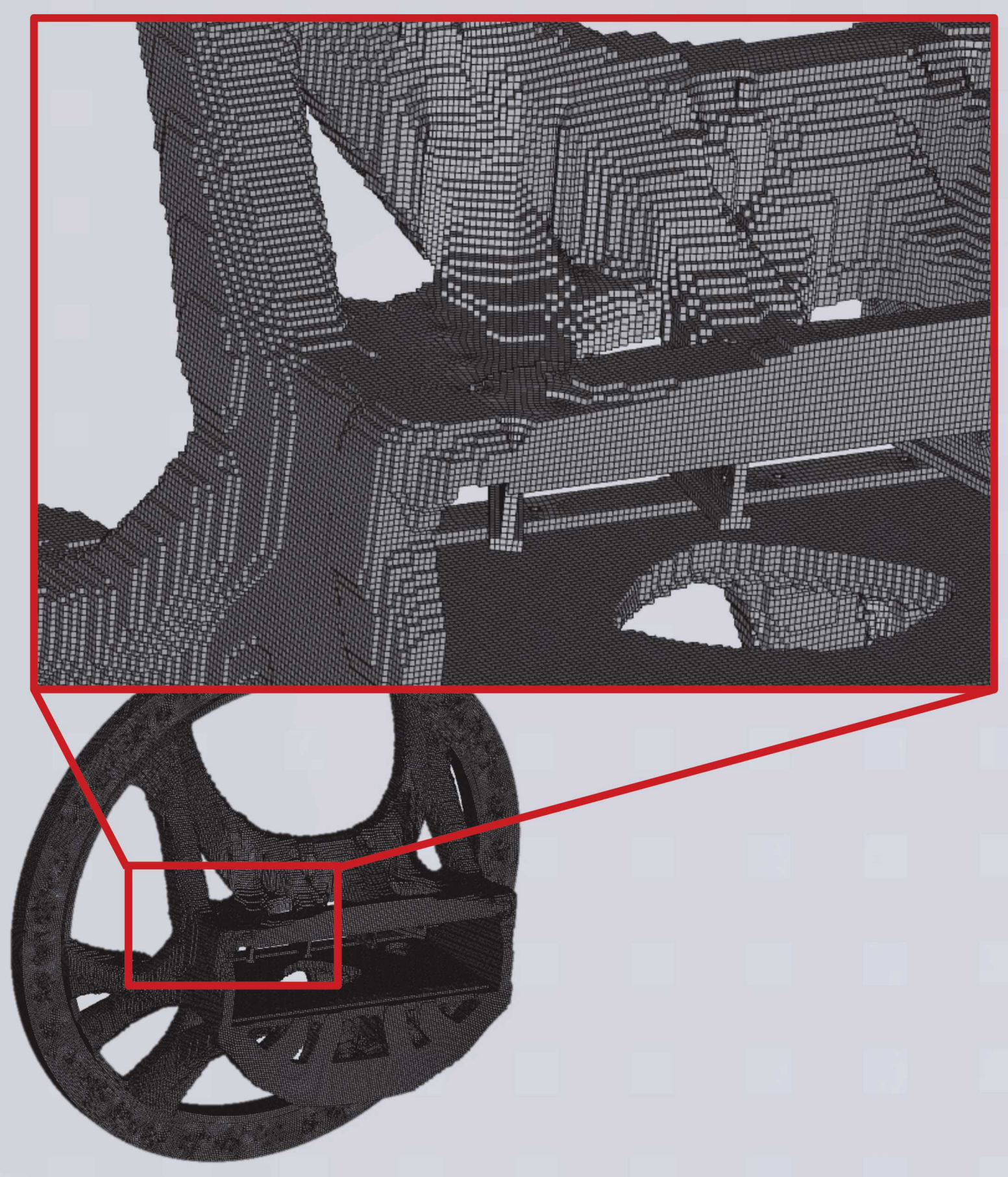
PRUNE AND REFINE

"Prune and Refine" is a method for greatly reducing the computational cost of an optimization run while also increasing the design resolution. An initial run is done at an initial mesh resolution to get the general location of design members. The initial mesh is then pruned using the initial design and then globally refined to give a new starting mesh for the next run. The result is a smoother, finer detailed design at roughly the same cost of running at the initial mesh resolution.

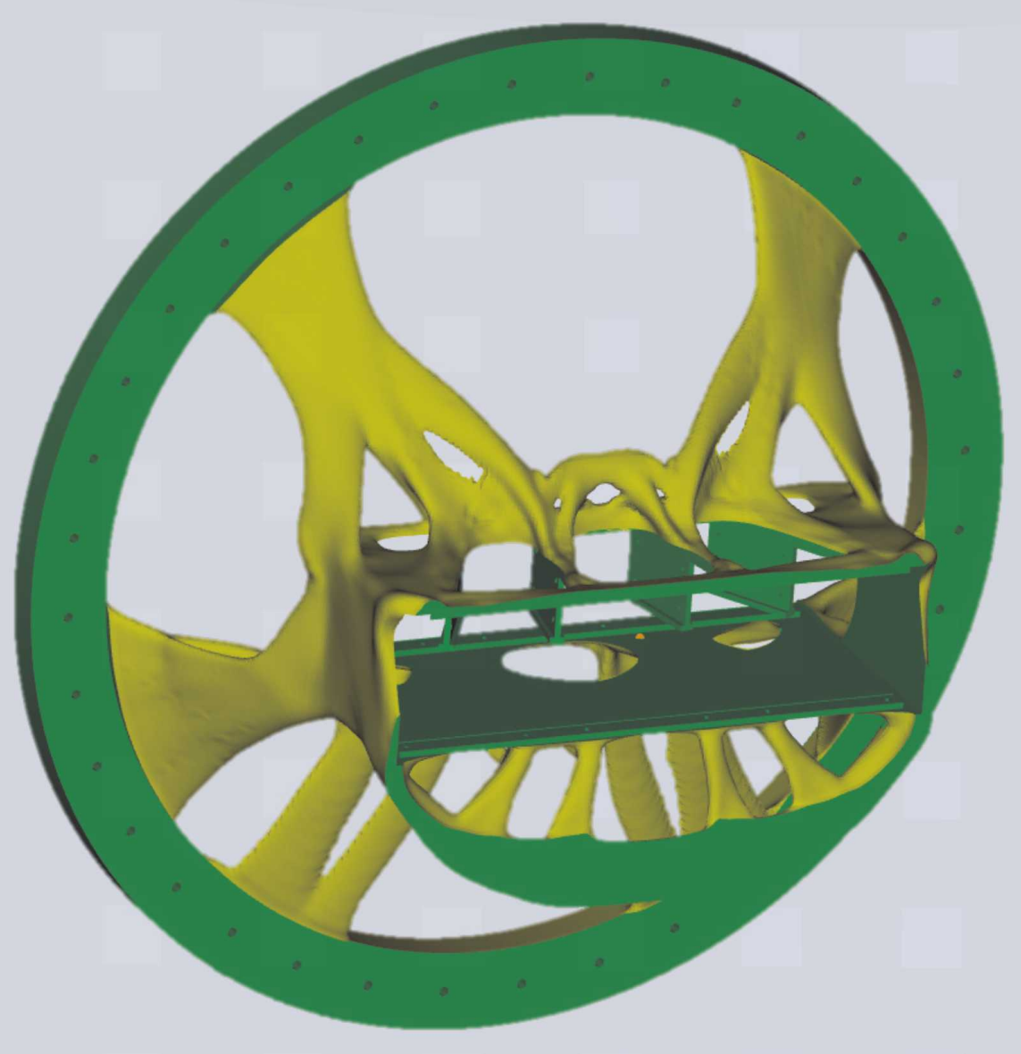


~1M nodes, ~986K hexes
8% Volume constraint

Rough design generated from initial mesh resolution



- *Pruned and Refined Mesh ~1.5M nodes, ~1.3M hexes*
- *Non-pruned, refined mesh would be ~8M nodes, ~8M hexes requiring ~1400 processors*



- *Final Design*

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NNSA National Nuclear Security Administration