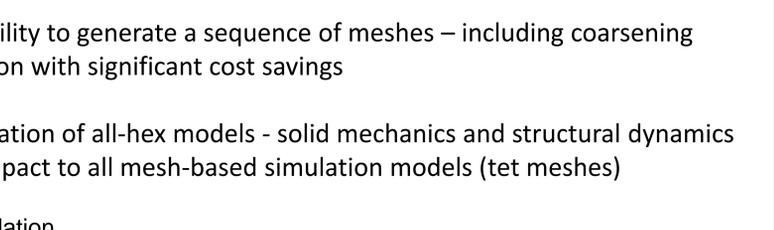
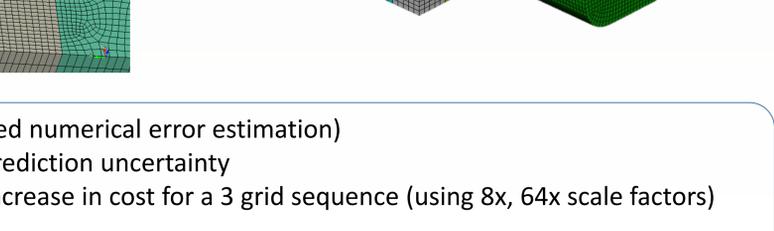
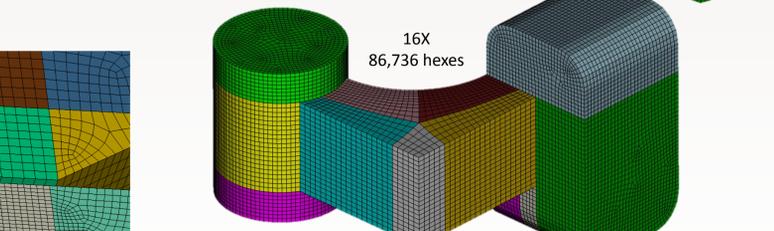
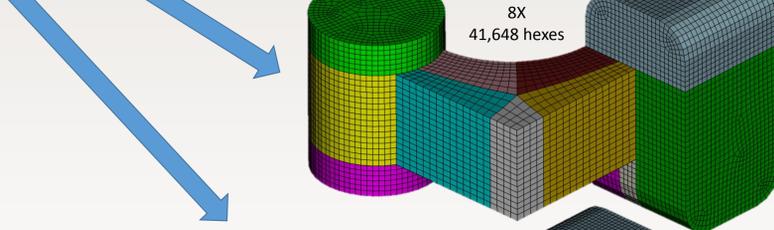
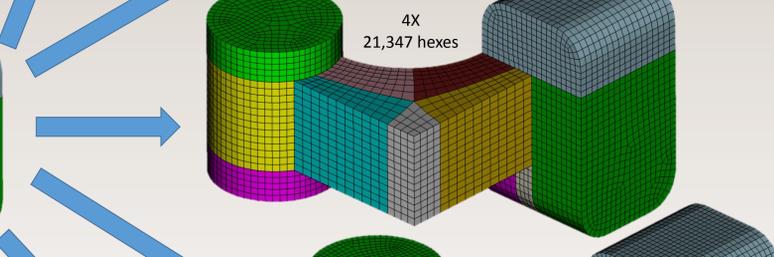
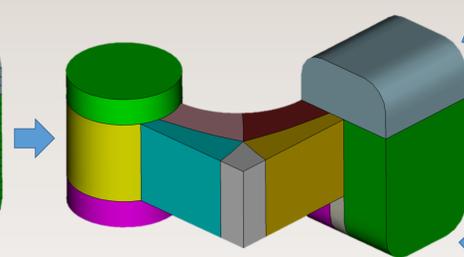
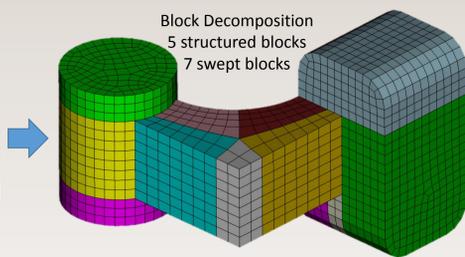
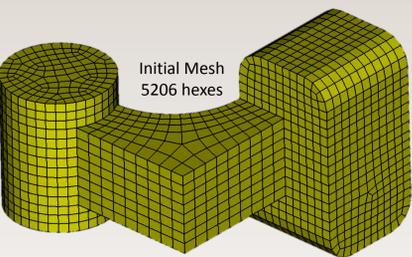


What is Mesh Scaling?

Mesh Scaling is a new mesh modification algorithm which, given an input all-hex mesh and a desired element count multiplier, N, will generate a new hex mesh with approximately N times more/less hex elements, while honoring element size grading and element orientations. Mesh Scaling offers an alternative to traditional uniform mesh refinement (UMR), without the 8X multiplier limitation.

We also introduce the next generation, "Hybrid" Mesh Scaling, which eliminates the paver from the remesh process, enabling algorithmic scaling to HPC platforms.

How Does Mesh Scaling Work?



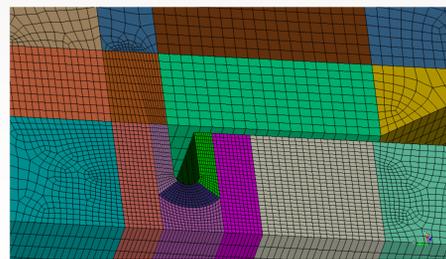
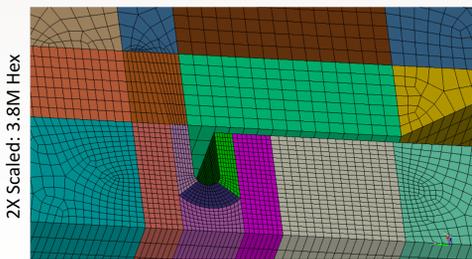
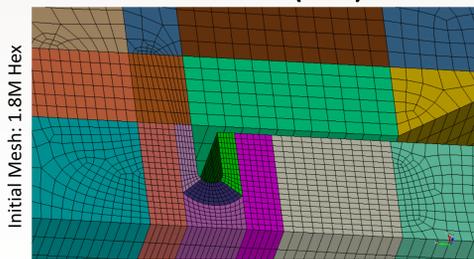
Step 1: Extract the Block Decomposition:
Hex mesh topology is traversed looking for:
1. Swept mesh connectivity, AND
2. Structured zones separated by mesh singularities

The mesh is then decomposed into both structured and swept blocks

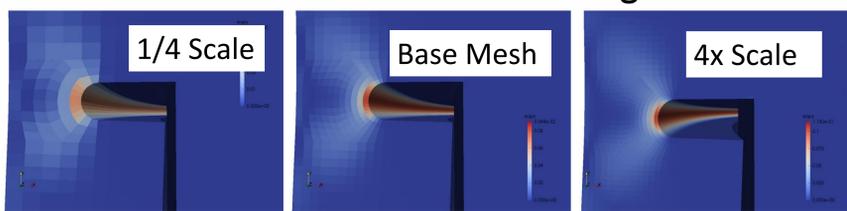
Step 2: Delete Initial Mesh:
Mesh sizing, grading, orientation, and BC loading are extracted from the mesh and stored in the block decomposition. The original mesh is then deleted.

Step 3: Remesh at any size:
An optimization is performed to compute mesh intervals on all of the curves in the block decomposition, followed by remeshing of each block with either structured mapping or Pave-and-sweep.

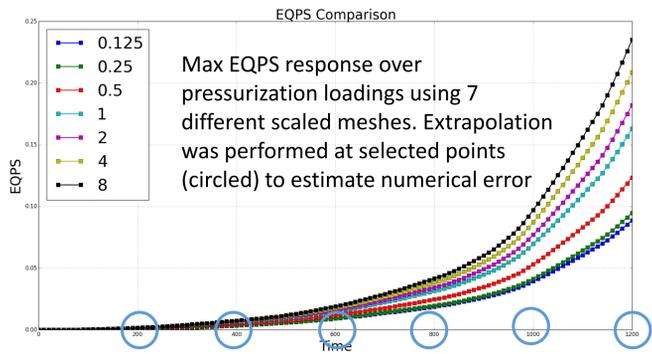
Solid Mechanics (SM) Model



Solution Verification and Mesh Scaling



The model simulates weld failure from thermal/mechanical loading. The main output is the maximum equivalent plastic strain (EQPS), an indicator of weld failure.



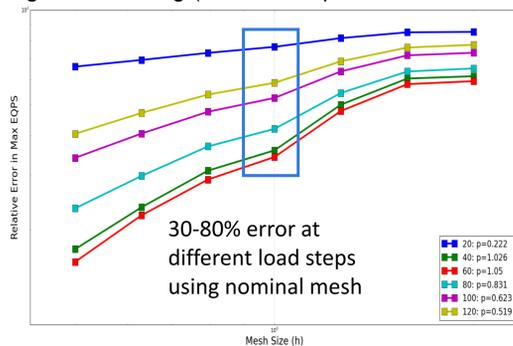
Solution verification (quantified numerical error estimation)

- is required for simulation prediction uncertainty
 - typically requires a >100x increase in cost for a 3 grid sequence (using 8x, 64x scale factors)
- The Mesh Scaling alternative:
- provides fine grained capability to generate a sequence of meshes – including coarsening
 - is used in solution verification with significant cost savings

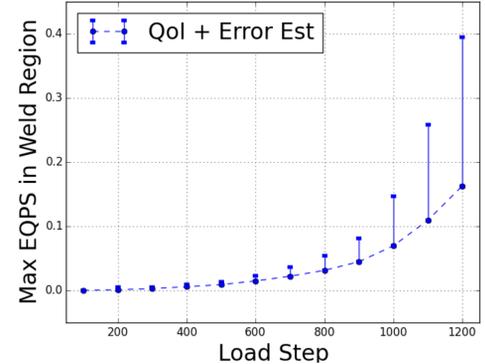
Impact of Mesh Scaling:

- has enabled solution verification of all-hex models - solid mechanics and structural dynamics
- future work will increase impact to all mesh-based simulation models (tet meshes)

Error estimates as a function of mesh size from extrapolation using mesh scaling (at selected points on the load history).



Nominal Mesh with Numerical Error Bars



Future Research:

Calling the Paver to remesh swept blocks is the weak link in the current mesh scaling algorithm. Paving:

- Results in unpredictable structure and quad count
- Inherently serial, can not scale to HPC
- No guarantee of certain number of layers through thin sections

We have prototyped a new "Hybrid" method to mesh scaling:

- Modifies original mesh with strategic dicing and smoothing
- No Paver
- Maintains number and type of singularities → structure
- Parallelizable
- Can guarantee certain number of layers through thin sections

Example Model Scaled With Hybrid Mesh Scaling

