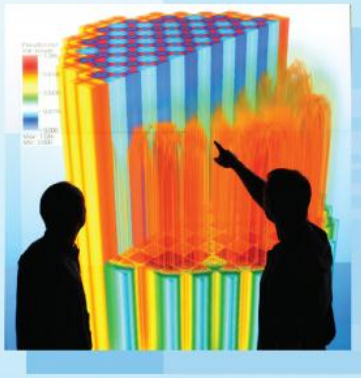
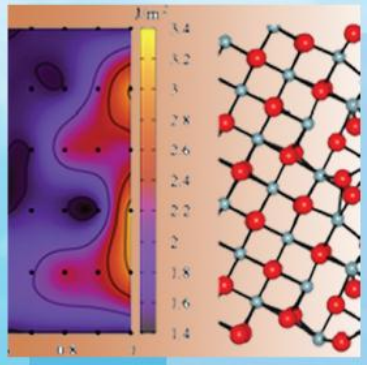
Power uprates
and plant life extension



Engineering design
and analysis

Science-enabling
high performance
computing



Fundamental science

Plant operational data

Consortium for Advanced Simulation of LWRs

L3:VUQ.VVDA.P3.01

Kevin Copps
SNL

Completed: 10/31/11

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

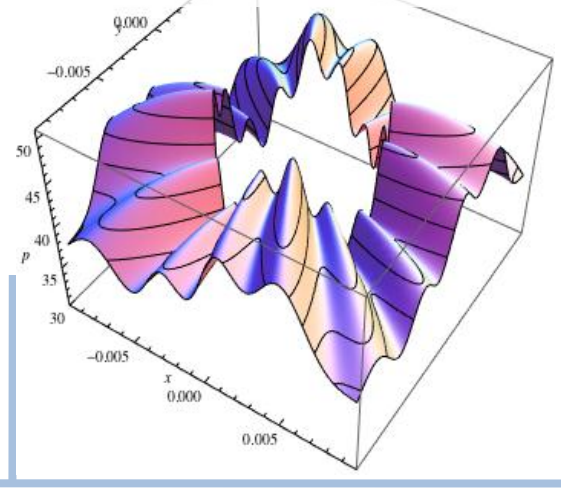
L3.VUQ.VVDA.P3.01 GTRF CFD-to-Mechanics Data Transfer Verification

Kevin Copps (SNL), VUQ

Description, Linkages, Completion Criteria

- Linked with simulation of GTRF
  - Forces computed in CFD transferred to structural analysis code
  - Pressure boundary condition
  - Goal is to predict vibrational response of a fuel rod
- Milestone Linkages
- Completion Criteria
  - Perform both code and calculation verification of the pressure transfer
  - Demonstrate use of the *Percept* code (verification tools)
  - Deliver technical brief

$p_{\text{exact}}(x, y, z_0, t_0)$



Technical Approach and Results

- Code verification
  - Use *Feature Coverage Tool to* gather evidence of relevant set of high quality code tests.
- Calculation verification
  - Perform a convergence study of transfer
  - Use an exact solution (nearby CFD solution) interpolated to sequence of CFD meshes and transferred to structural meshes for precise metrics
  - Use new analytic functions in *Percept*
  - Use new mesh refinement in *Percept*
- Transfer of boundary condition is satisfactory with some caveats

Personnel, Costs, Challenges/Issues

- Personnel and interactions:
  - THM (Shadid, Smith, Weber, Cyr, Pawlowski)
  - MPO (Sham, Nath) & VUQ (Copps, Rider, Witkowski)
  - VRI (Turner, Rodriquez, Garcia)
- Cost Estimate (3 person-months, $110K)
  - Development of new features in Percept
  - Large amount of time spent on meshing issues
- Challenges
  - Dependency of features in Percept on 3rd party libraries
  - Dependency of verification activities on analysis preparation

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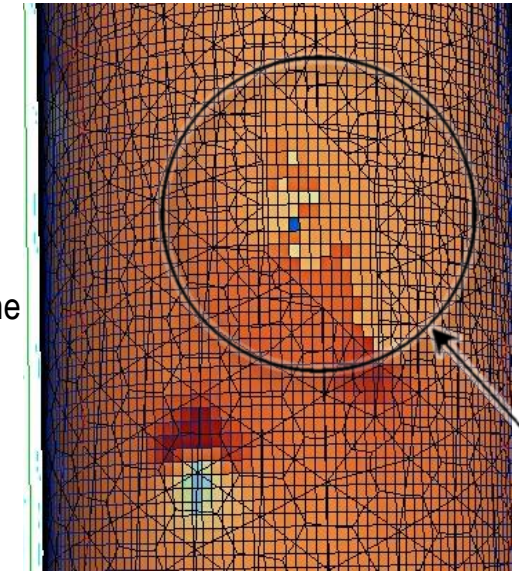
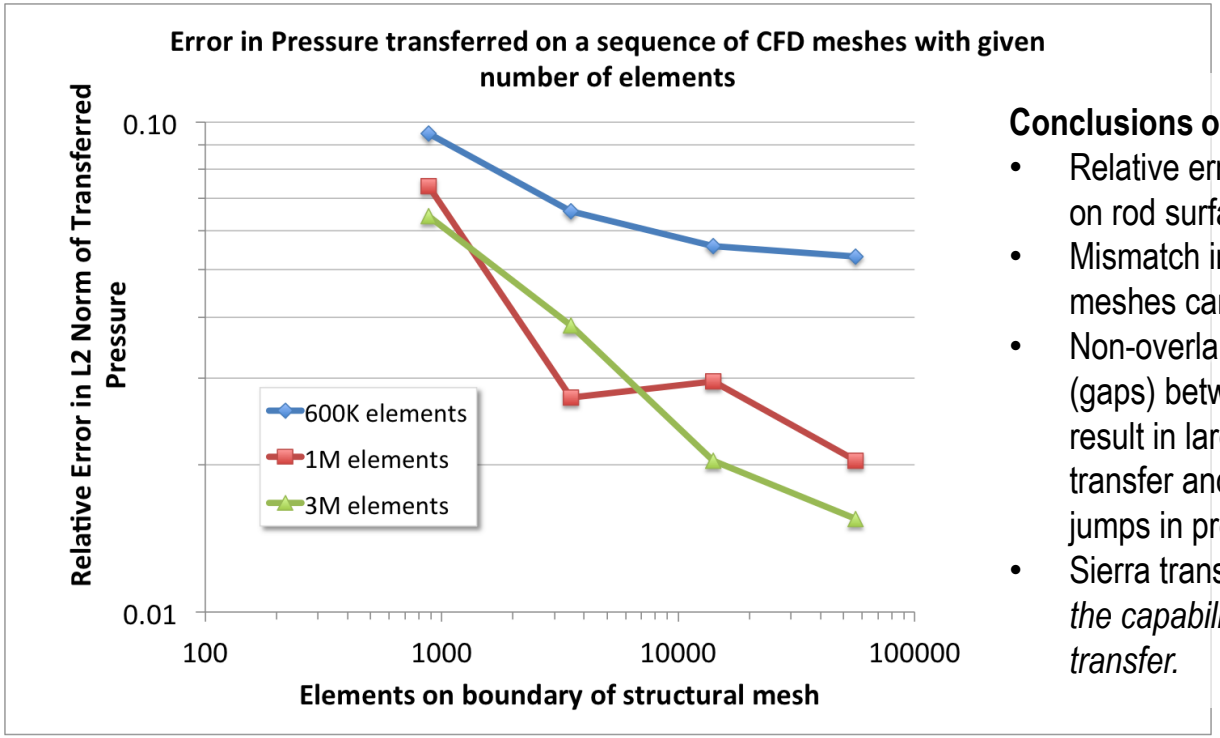
Milestone Results

Calculation Verification

- An analytic (nearby) solution for pressure was defined around the cylindrical fuel rod: p_{exact}
- The nearby solution was interpolated to grid points of the sequence of CFD meshes: 671K, 1M, 3M elements
- The transfer of pressure was performed, targeting a range of refined sequences of structural meshes.
- Production transfer capability from Sierra Mechanics (SNL)



Example of non-overlapping CFD boundary resulting in a non-smooth pressure on the fuel rod.



Conclusions of study:

- Relative error between 1%-10% in L^2 on rod surface
- Mismatch in element sizes between meshes can cause oscillatory trend.
- Non-overlapping domain surfaces (gaps) between CFD/solids meshes result in large extrapolation during transfer and consequently sharp local jumps in pressure field
- Sierra transfer is well tested but *lacks the capability for conservative transfer.*

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