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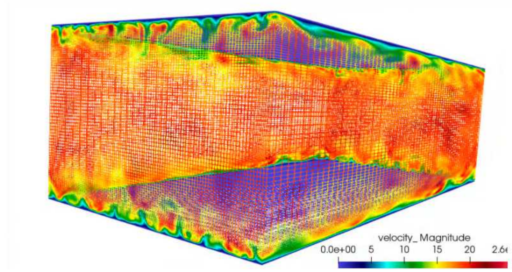
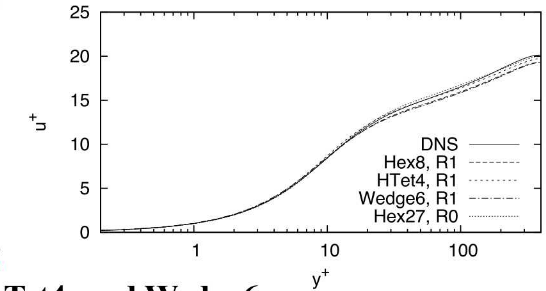
The suitability of hybrid meshes for low-Mach LES

Stefan Domino, Sandia National Labs, L. Jofre

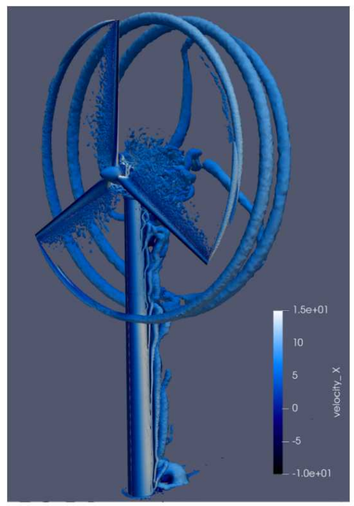
Typical VVUQ Approach

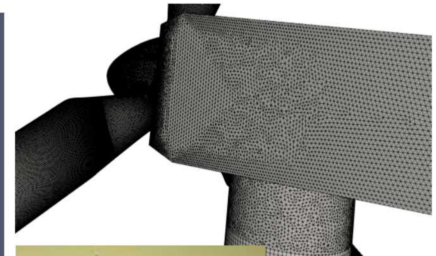
- Verify code
  - Using “friendly” Hex8, 27, ..
- Validate Models
  - Using ”friendly” Hex8, 27, …
- Deploy to user-based
  - Using “mean” Hex8, Hex27, Tet4, Pyr5, Wedge6, THex8, …
- NNSA Advanced Simulation and Computing (ASC) project, has initiated a *Next Generation Simulation* foundational research project that seeks to improve the throughout, effectiveness, and credibility of multi-physics simulation analysis
  - Development of *advanced discretization schemes*, error indicators, embedded VVUQ, and efficient parallel mesh generation
  - Paradigm shift from insisting on “friendly” meshes (using discretization schemes that excel) to a fast-meshing generation archetype whose time scale can support penetration of the design cycle
  - Algorithms that are Next Generation Platform (NGP) ready





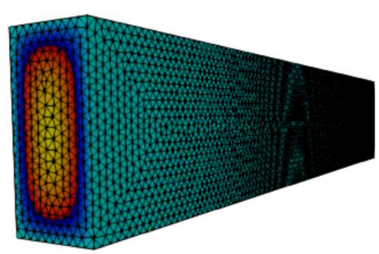
Re^{τ}=395 using Hex8, Hex27, Tet4, and Wedge6

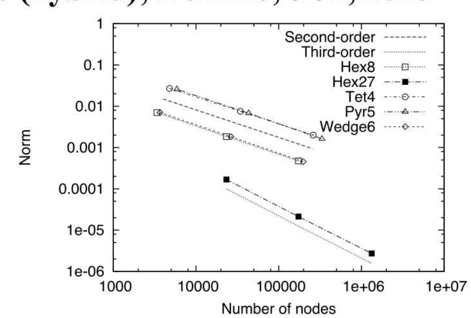




How do we drive high-fidelity fluids usage in currently prohibitively complex geometries?

Vestas V27 225 kw turbine (hybrid); Domino, JCP, 2018





1x2x10 verification on Hex8, Hex27, Tet4, Pyr5, Wedge6

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Foundational work already completed prior to the 2018 CTR summer program:

- MMS, Taylor-Green, plain channel LES, heated cylinder LES, and V27 LES - all on hybrid meshes
- Paper to be submitted to JCP; includes cost vs accuracy findings

Several FY18 ASC/NGS findings that will drive the 2018 CTRSP:

- Development of energy-stable weak boundary conditions (Build from Svard and Nordstrom, JCP, 2008) that managing non-orthogonality
- Exploration of suitable monotonic stabilization (cf Sharan et al., JCP 2018; build from Guermond entropy-viscosity and Shakib DCO)
- Resolution of certain stability nuances with particularly poor meshes (high aspect ratio, high volume ratio, etc.)

Expected Outcome:

- New set of implemented and verified, energy stable, design-order weak boundary conditions (open, inflow, wall, …)
- Implementation within open-source low-Mach code base, Nalu
  - Kokkos performance &portability interface

Wish List:

- Through PSAAP-2/SNL ASC VVUQ partnership, eigenvalue perturbation techniques developed for LES formalized (Jofre et al., Flow, Turb, Comb., 2018)
- Work towards Machine Learning to drive perturbations for:
  - WMLES
  - Core LES model