Challenges Facing Computational Fluid Dynamics

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Challenge 1: Unsteady Turbulent Flow Including Transition and Separation

- Maturation Hybrid RANS-LES turbulence simulation capability
- Practical convergence of complex turbulence models
- Grid resolution impact on turbulence models
- Experimental datasets lacking
- Robust transition prediction

Are the answers believable?
Challenge 2: Autonomous and Reliable CFD Simulations

• Mesh generation and adaptivity
  • Inadequate linkage with CAD systems
  • Mesh generation performance and robustness

• Discretization, solvers and numerics
  • Incomplete or inconsistent convergence behavior
  • Algorithm efficiency / compatibility with emerging H/W

• Error control and uncertainty quantification
  • Limited use of uncertainty quantification
  • Current error estimation techniques inadequate

Are the answers believable?
Challenge 3: Knowledge Extraction and Visualization

- Effective use of a single CFD simulation
  - By 2030 typical unsteady solution 10-100 billion grid points
  - Visualization and interrogation of solution

- Effective use of multiple CFD solutions
  - Same as above but for database generation
  - Detect trends / variations across multiple solutions

- Rapid interfacing with wind tunnel and flight test
  - Rely on simulation – test only when required
  - Certification by analysis

Turning data into knowledge
Challenge 4: Multidisciplinary / Multiphysics Simulations and Frameworks

• Robustness and automation of CFD solutions
• Coupling of high fidelity multidisciplinary analyses
• Uncertainty quantification
• Standardization and coupling frameworks
  • CGNS
  • Level of coupling

Highly integrated designs
Challenge 5: Effective Utilization of Emerging HPC Systems

- Scalability and compatibility of applications
  - Solvers
  - Pre- and post-processor applications

- Move to Exa-scale platforms
  - Increased complexity of compute environment
  - Hide from the user as much as possible

- Power, cost, footprint
  - It must be affordable

Bringing it all together
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