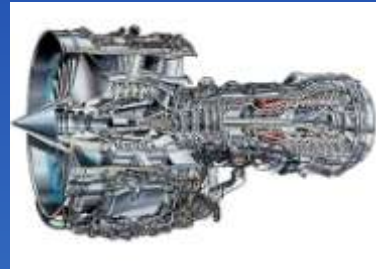


RIKEN HPC User Forum

Kobe, Japan

Challenges Facing Computational Fluid Dynamics



Doug Ball

Retired Chief Engineer, Aerodynamics

Boeing Commercial Airplanes

July 16, 2014



Challenge 1: Unsteady Turbulent Flow Including Transition and Separation

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- 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

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- 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

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- 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

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- 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

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- 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

Acknowledgements

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This presentation is based upon:

NASA/CR-2014-218178 “CFD Vision 2030 Study”

I would like to thank NASA for taking the leadership role in encouraging this study. I also thank the key leaders who led the writing of this report: Jeffrey Slotnick and Abdollah Khodadoust of Boeing, Juan Alonso of Stanford University, David Darmofal of MIT, William Gropp of NCSA University of Illinois, Elizabeth Lurie of United Technologies, and Dimitri Mavriplis of the University of Wyoming