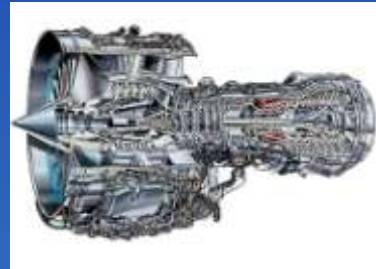


# RIKEN HPC User Forum

## 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**

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