FUN3D v13.1 Training
Session 2:
Welcome and Overview

Eric Nielsen
Administrative Details

- Need to stay on schedule, but please do not hesitate to ask questions
- In-room wireless access:
  - Network:  Password:
- Please submit your evaluation form at the end of the workshop
  - Very interested in your feedback, good or bad!

All Material Available Online

- For the v13.1 material presented here:
  - Slides online in PDF format
  - To obtain FUN3D, see website for link to NASA Software Catalog
- A FUN3D v13.1 manual is available as NASA/TM-2017-219580 on the website
  - You should also receive a copy of this with the source code distribution
  - Additional material will continue to be added with new releases
  - Your feedback/suggestions are extremely helpful
- Extensive material from prior training workshops is available on the website
  - Slides in PDF
  - Pro-shot streaming video
  - Demo content can be downloaded as a tarball
- We hope to eventually add an extensive tutorials document
The FUN3D Development Team
fun3d-developers@lists.nasa.gov

- Consists of ~15-20 researchers across several branches at Langley
  - Computational AeroSciences Branch
  - Aerothermodynamics Branch

- Some people are full-time FUN3D, others part-time
  - Spectrum runs from full-time development to full-time applications

- Also external groups such as Georgia Tech, National Institute of Aerospace (NIA)

- Open to other interested parties joining us
  - Remote, real-time, read/write access to FUN3D repository is available

The FUN3D Support Team
fun3d-support@lists.nasa.gov

“Who sees my questions to the support alias?”

- Consists of 16 members of the development team

- All are NASA civil servants
  - Proprietary/sensitive data can be shared/discussed: all are bound by Trade Secrets Act

- Members: Kyle Anderson, Bob Biedron, Jan-Renee Carlson, Cameron Druyor, Peter Gnoffo, Dana Hammond, Bill Jones, Bil Kleb, Beth Lee-Rausch, Steve Massey, Eric Nielsen, Matt O’Connell, Mike Park, Kyle Thompson, Aaron Walden, Jeff White

Myth: Our job is to develop a production-level tool and support users.

Reality: None of us are funded at any level to support users, maintain documentation, keep up a website, run training workshops, etc. The team is funded solely to perform their individual research efforts.
The FUN3D User Community
fun3d-users@lists.nasa.gov

- FUN3D widely used within NASA for projects across the speed range
  - Both engineering and research applications
  - Users routinely running on several thousand cores

- Distributed to hundreds of external organizations across academia, industry, DoD, and OGAs
  - Average about 150 distributions / year
  - Wide range of uses including aerospace, automotive, HPC, wind energy, etc.
  - Wide range of hardware being used
  - From RC enthusiasts on single workstation to groups generating matrices of hundreds of solutions on thousands of HPC nodes

FUN3D Core Capabilities

- Established as a research code in late 1980s; now supports numerous internal and external efforts across the speed range
- Solves 2D/3D steady and unsteady Euler and RANS equations on node-based mixed element grids for compressible and incompressible flows
- General dynamic mesh capability: any combination of rigid / overset / morphing grids, including 6-DOF effects
- Aeroelastic modeling using mode shapes, full FEM, CC, etc.
- Constrained / multipoint adjoint-based design and mesh adaptation
- Distributed development team using agile/extreme software practices including 24/7 regression, performance testing
- Capabilities fully integrated, online documentation, training videos, tutorials
Some Recent NASA Applications

Airframe Noise

Courtesy NASA/Gulfstream Partnership on Airframe Noise Research

Adjoint-Based Adaptation for High-Lift

Some Recent NASA Applications

Aeroelastic Analysis of the Boeing SUGAR Truss-Braced Wing Concept

Open-Rotor Concepts

Courtesy Bill Jones
Some Recent NASA Applications

Transonic Buffet Characterization for Space Launch System
Courtesy Greg Brauckmann, Steve Alter, Bil Kleb

Sonic Boom Mitigation
Courtesy Chris Heath

Mars InSight Lander
Some Recent NASA Applications

Mars Ascent Vehicle for Sample Return

Courtesy Ashley Korzun

Some Recent NASA Applications

Validation for Full Scale UH60A

- Structural loads
- Sectional airloads/pressures
- Balance loads
- Control settings
- Blade root motions
- Elastic blade deflections

Blade Pressures at High Advance Ratio

Courtesy Beth Lee-Rausch, Bob Biedron
Some Recent NASA Applications

Distributed Electric Propulsion

Courtesy
Mike Park, Sally Viken, Karen Deere, Mark Moore

Distributed Electric Propulsion

Courtesy
Bill Jones

Courtesy
Mike Park, Sally Viken, Karen Deere, Mark Moore
Some Recent NASA Applications

Aeroelastic Analysis of HIADs: Hypersonic Inflatable Aerodynamic Decelerators

Courtesy Beth Lee-Rausch, Bob Biedron, and Bil Kleb

At the Department of Defense

AMRDEC at Redstone Arsenal

- Troop safety: airworthiness qualification
- Dramatic cost savings: fewer tunnel & flight tests
- Intense demand for timely results on massive computing systems
- Decade of use in direct support of the US warfighter

- NAVAIR at Patuxent River
- Air Force Research Laboratory
- HPCMP CREATE-AV
Across the Aerospace Industry

First private company to achieve orbit and dock with the International Space Station

- FUN3D used for extensive analysis of Falcon 1 and Falcon 9 rockets, Dragon spacecraft
- Team consults frequently and provides new features and capabilities as requested

“THE FUN3D SOFTWARE SUITE AND DEVELOPMENT TEAM HAVE ENABLED SPACEX TO RAPIDLY DESIGN, BUILD, AND SUCCESSFULLY FLY A NEW GENERATION OF ROCKETS AND SPACECRAFT.”

- Justin Richeson
  Manager, SpaceX Aerodynamics

FUN3D and High-Performance Computing

FUN3D is used on a broad range of HPC installations around the country

Scaled to 80,000 cores on DoE’s Cray XK7 ‘Titan’ using grids containing billions of elements

Awarded the Gordon Bell Prize in a past collaboration with Argonne National Lab

http://fun3d.larc.nasa.gov

FUN3D Training Workshop
July 30, 2017
"Works out of the box" paradigm for KNL is encouraging but dangerous: tempting to declare success before achieving its full potential

- Vector intrinsics on Xeon Phi Knights Landing beat conventional Fortran on 28-core Xeon Broadwell by 2.5x
- Intrinsics attractive for performance (including Skylake and beyond), but effort/portability must be considered

Using the more common single-socket Haswell benchmark, Knights Landing is 5.4x faster and 3.6x more power-efficient
- Compares well with other early apps
FUN3D Solver on NVIDIA GPUs

- FUN3D implicit solver also implemented for GPUs using OpenACC, CUDA, and PTX
- Up to 7x improvement over existing CUDA libraries for range of block sizes
- NVIDIA Pascal P100 shows 3.9x speedup over 28-core Xeon Broadwell

Some Final Notes

- The material that will be shown here represents the current recommended best practices for the perfect gas option in FUN3D
- Many topics omitted from what is normally a two-day course:
  - Boundary conditions, turbulence models, high-speed simulations, geometry parameterization, error estimation and mesh adaptation, time-dependent flows, dynamic and overset grid simulations, adjoints for unsteady flows, aeroelastic simulations, rotorcraft simulations, general-gas simulations
  - There are always many research and development efforts taking place within the code that are not described here
  - If you do not see something, please ask about it