FUN3D v12.7 Training

Session 2:
Welcome and Overview

Eric Nielsen

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FUN3D Training Workshop
June 20-21, 2015

Saturday, June 20

<table>
<thead>
<tr>
<th>Session 1: Meet and Greet</th>
<th>All</th>
<th>8:00-8:30</th>
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</thead>
<tbody>
<tr>
<td>Session 2 Welcome and Overview</td>
<td>Eric Nielsen</td>
<td>8:30-9:00</td>
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<tr>
<td>Session 3: Compilation and Installation</td>
<td>Bill Jones</td>
<td>9:00-9:15</td>
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<tr>
<td>Session 4: Gridding, Solution, and Visualization Basics</td>
<td>Eric Nielsen</td>
<td>9:15-10:15</td>
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<tr>
<td>BREAK</td>
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<td>10:15-10:30</td>
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<tr>
<td>Session 5: Boundary Conditions</td>
<td>Jan-Renee Carlson</td>
<td>10:30-11:00</td>
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<tr>
<td>Session 6: Turbulence Models</td>
<td>Jan-Renee Carlson</td>
<td>11:00-11:30</td>
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<tr>
<td>Session 7: Supersonic / Hypersonic Perfect Gas Simulations</td>
<td>Mike Park</td>
<td>11:30-12:00</td>
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<tr>
<td>CATERED LUNCH: Lightning Talks</td>
<td>Various</td>
<td>12:00-1:15</td>
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<tr>
<td>Session 8: Parameterization Tools</td>
<td>Bill Jones</td>
<td>1:15-2:15</td>
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<tr>
<td>Session 9: Adjoint-Based Design for Steady Flows</td>
<td>Eric Nielsen</td>
<td>2:15-3:45</td>
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<tr>
<td>BREAK</td>
<td></td>
<td>3:45-4:00</td>
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<tr>
<td>Session 10: Feature and Adjoint-Based Error Estimation and Mesh Adaptation</td>
<td>Mike Park</td>
<td>4:00-5:00</td>
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6/10/2015

FUN3D Training Workshop
### FUN3D Training Workshop
**June 20-21, 2015**

#### Sunday, June 21

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Instructor</th>
<th>Time</th>
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<td>11</td>
<td>Time-Dependent Simulations</td>
<td>Bob Biedron</td>
<td>8:00-8:30</td>
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<tr>
<td>12</td>
<td>Dynamic Grid Simulations</td>
<td>Bob Biedron</td>
<td>8:30-9:00</td>
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<td>13</td>
<td>Suggar ++</td>
<td>Ralph Noack</td>
<td>9:00-10:00</td>
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<td><strong>BREAK</strong></td>
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<td>10:00-10:15</td>
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<tr>
<td>14</td>
<td>Overset Grid Simulations</td>
<td>Bob Biedron</td>
<td>10:15-10:45</td>
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<tr>
<td>15</td>
<td>Adjoint-Based Design for Unsteady Flows</td>
<td>Eric Nielsen</td>
<td>10:45-12:00</td>
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<td><strong>BREAK</strong></td>
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<td>12:00-1:00</td>
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<td>16</td>
<td>Aerelastic Simulations</td>
<td>Bob Biedron</td>
<td>1:00-1:45</td>
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<td>17</td>
<td>Rotorcraft Simulations</td>
<td>Bob Biedron</td>
<td>1:45-2:45</td>
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<td><strong>BREAK</strong></td>
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<td>2:45-3:00</td>
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<tr>
<td>18</td>
<td>Current Development Activities, Summary of User Feedback and Requests</td>
<td>All</td>
<td>3:00-4:00</td>
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<tr>
<td>19</td>
<td>High-Energy / Generic Gas Simulations</td>
<td>Peter Gnoffo</td>
<td>4:00-4:30</td>
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</table>

***Please see important note for this session below ***

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**Administrative Details**

- Need to stay on schedule, but please do not hesitate to ask questions.

- Please submit your two forms by lunchtime on Sunday to any team member.
  - **User Feedback/Requests Form**
    - User feedback and requests will be summarized and discussed in the final session on Sunday.
  - **Training Evaluation Form**
    - Very interested in your feedback, good or bad!

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*Due to security regulations, workshop participants who would like to attend this session will be required to present a valid US passport as proof of US citizenship. There will be no exceptions to this requirement. The FUN3D team apologizes for any inconvenience this may cause.*
All Material Available Online

• For the v12.7 material presented here:
  – Slides online in PDF format
  – Demo content can be downloaded as a tarball
  – Capture hopefully online soon

• A FUN3D v12.7 manual is available as NASA/TM-2015-218761 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

• 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 14 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, Peter Gnoallo, Dana Hammond, Bill Jones, Bil Kleb, Beth Lee-Rausch, Steve Massey, Eric Nielsen, Matt O’Connell, Mike Park, Kyle Thompson, 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 100 distributions / year
  - Wide range of uses including aerospace, automotive, HPC, 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

Courtesy Bob Bartels

Open-Rotor Concepts

Transonic Buffet Characterization for Space Launch System

Courtesy Greg Brauckmann, Steve Alter, Bill Kleb
Some Recent NASA Applications

Sonic Boom Mitigation

Courtesy Chris Heath

Mars InSight Lander

http://fun3d.larc.nasa.gov

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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

Distributed Electric Propulsion

Courtesy
Beth Lee-Rausch, Bob Biedron

http://fun3d.larc.nasa.gov

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Some Recent NASA Applications

Distributed Electric Propulsion

Courtesy Bill Jones

Mike Park, Sally Viken, Karen Deere, Mark Moore

Aeroelastic Analysis of HIADs: Hypersonic Inflatable Aerodynamic Decelerators

Courtesy Beth Lee-Rausch, Bob Biedron, and Bill Kleb
Some User Applications

Falcon 9 First Launch
June 4, 2010

US Army

SpaceX

BMI Corporation

Mike Long

Georgia Tech

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
Some Final Notes

• The material that will be shown here represents the current recommended best practices for the perfect gas option in FUN3D

• Simulations with real gas effects are covered Sunday afternoon for users who present a valid US passport

• 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