

# **FUN3D v12.7 Training**

## **Session 2:**

# **Welcome and Overview**

Eric Nielsen



# FUN3D Training Workshop

June 20-21, 2015

Saturday, June 20

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



# FUN3D Training Workshop

June 20-21, 2015

Sunday, June 21

Session 11: Time-Dependent Simulations	Bob Biedron	8:00-8:30
Session 12: Dynamic Grid Simulations	Bob Biedron	8:30-9:00
Session 13: Sugar ++	Ralph Noack	9:00-10:00
BREAK		10:00-10:15
Session 14: Overset Grid Simulations	Bob Biedron	10:15-10:45
Session 15: Adjoint-Based Design for Unsteady Flows	Eric Nielsen	10:45-12:00
LUNCH ON YOUR OWN		12:00-1:00
Session 16: Aeroelastic Simulations	Bob Biedron	1:00-1:45
Session 17: Rotorcraft Simulations	Bob Biedron	1:45-2:45
BREAK		2:45-3:00
Session 18: High-Energy / Generic Gas Simulations	Peter Gnoffo	3:00-3:30
Session 19: Current Development Activities, Summary of User Feedback and Requests	All	3:30-5:00



# Administrative Details

- Need to stay on schedule, but please do not hesitate to ask questions
  - WebEx participants: please use the WebEx “chat” feature to raise questions – a FUN3D team member will be monitoring the chat continuously during the workshop and can interact with you and the local group as needed
- 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!



# 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](mailto: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](mailto: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 Gnoffo, 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

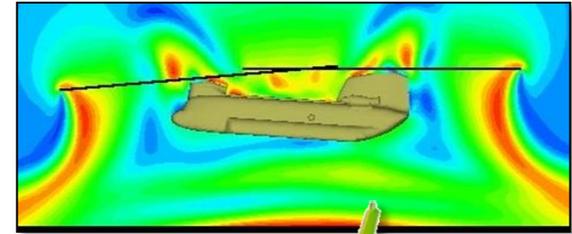
[fun3d-users@lists.nasa.gov](mailto:fun3d-users@lists.nasa.gov)

- 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

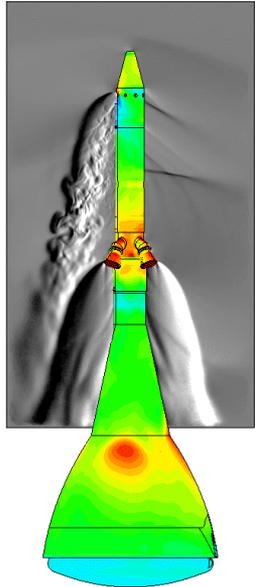


# FUN3D Core Capabilities

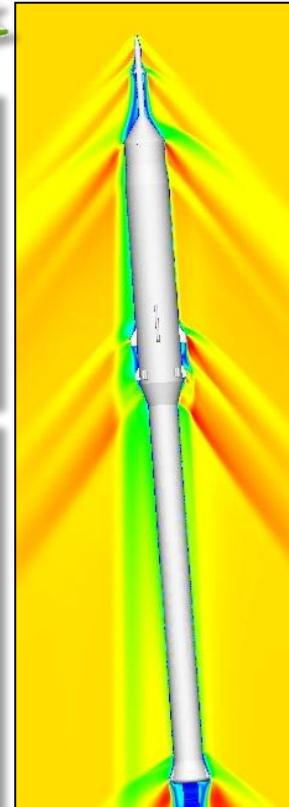
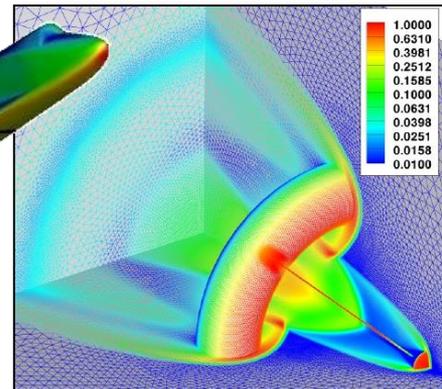
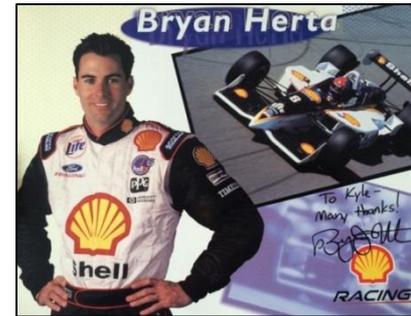
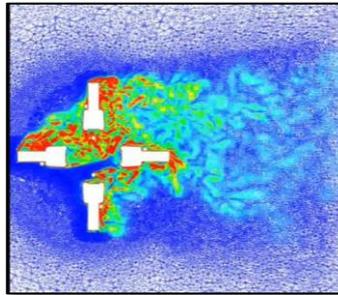
- Established as a research code in late 1980s; now supports numerous internal and external efforts across the speed range
- Solves 2D/3D steady and unsteady Euler and RANS equations on node-based mixed element grids for compressible and incompressible flows
- General dynamic mesh capability: any combination 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



US Army



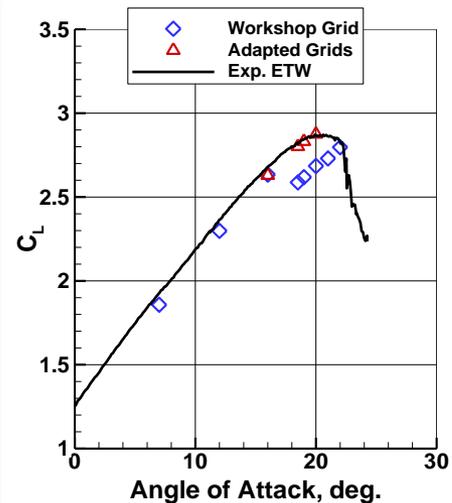
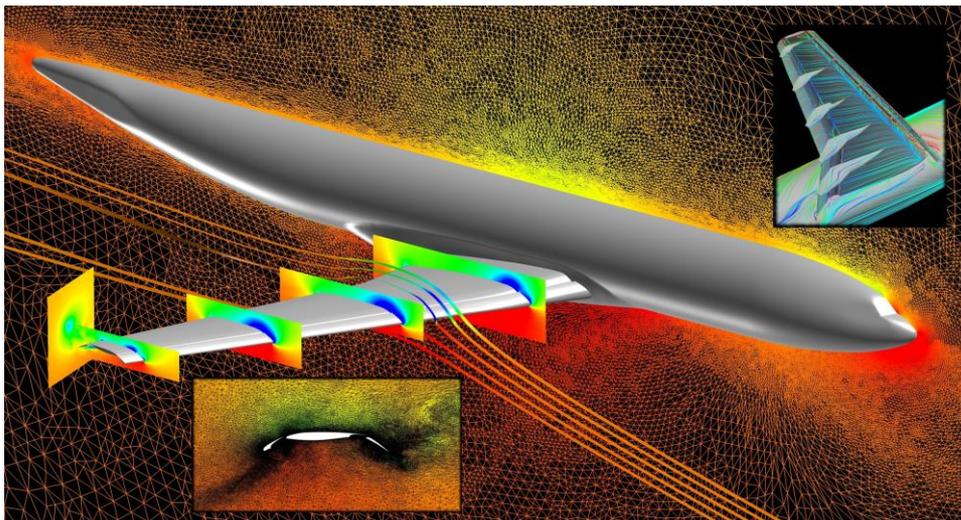
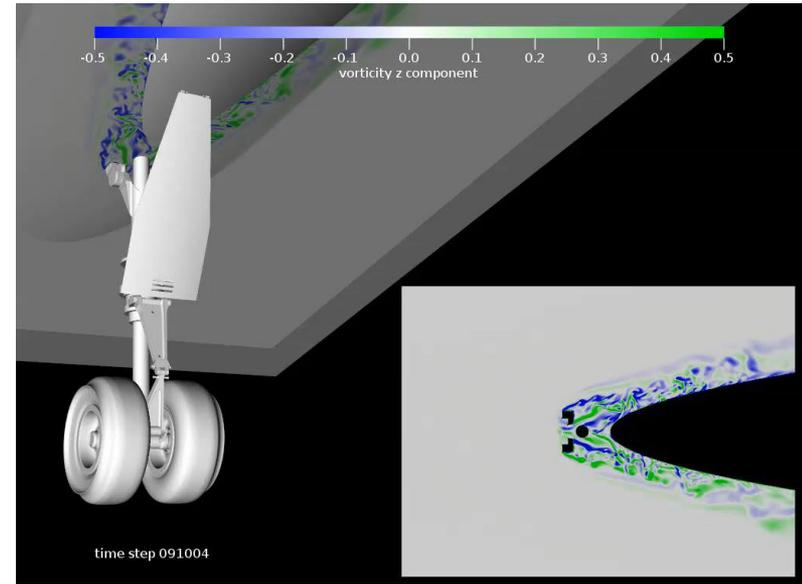
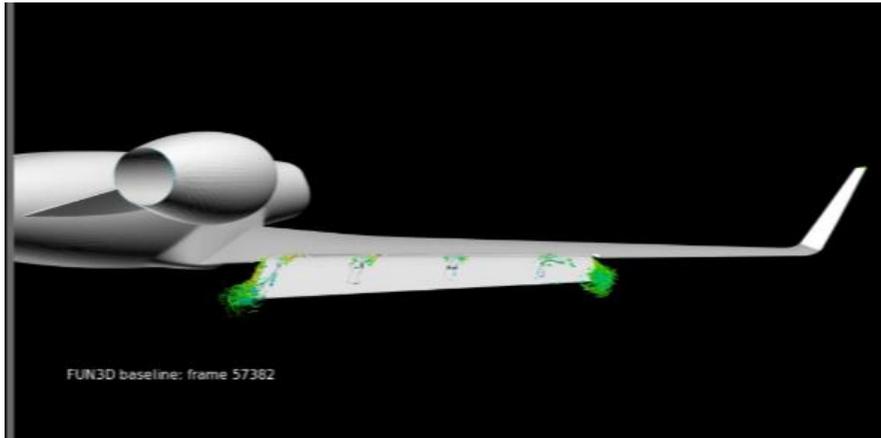
Georgia Tech



# Some Recent NASA Applications

## Airframe Noise

Courtesy  
NASA/Gulfstream  
Partnership on Airframe  
Noise Research

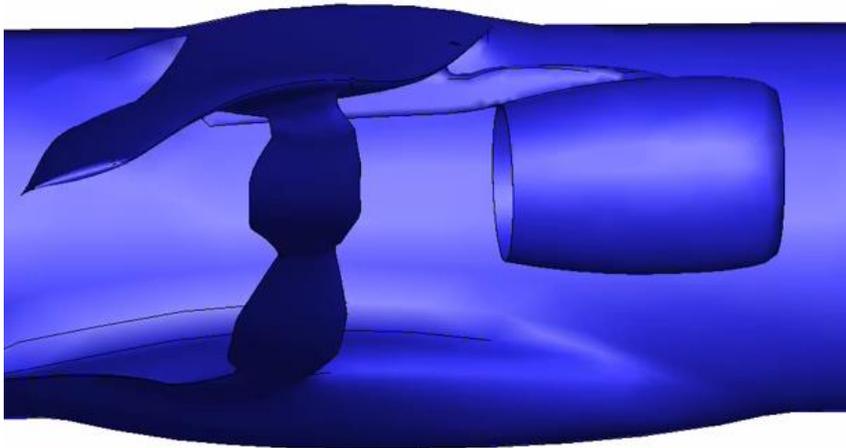
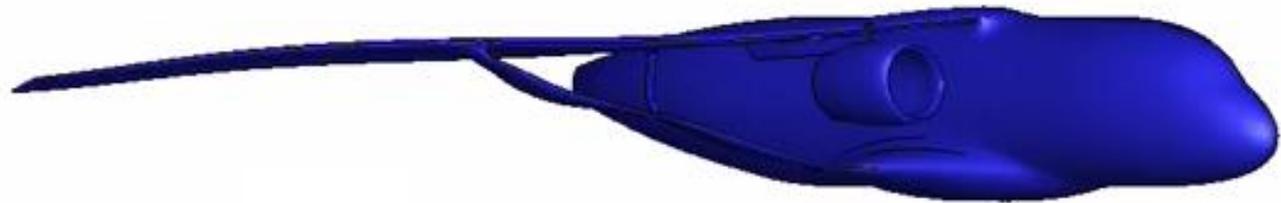


**Adjoint-Based  
Adaptation for  
High-Lift**

# Some Recent NASA Applications

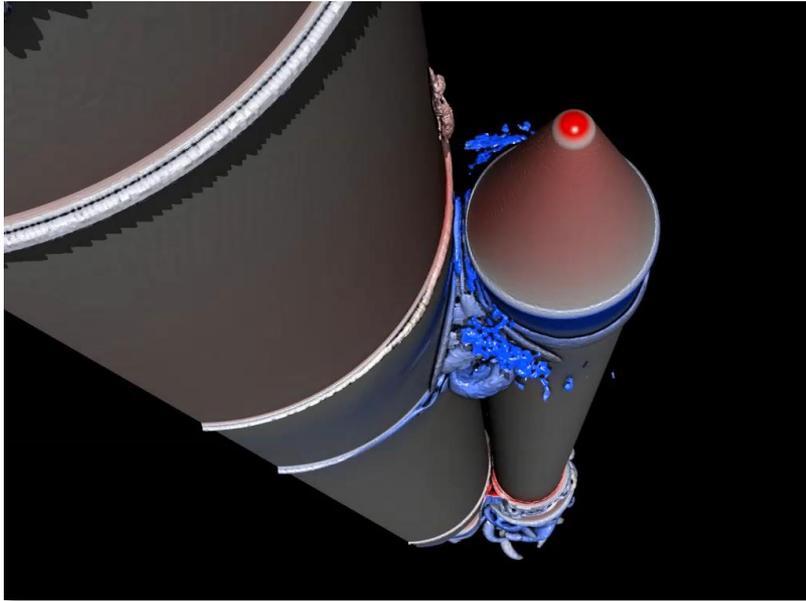


*Courtesy  
Bob Bartels*



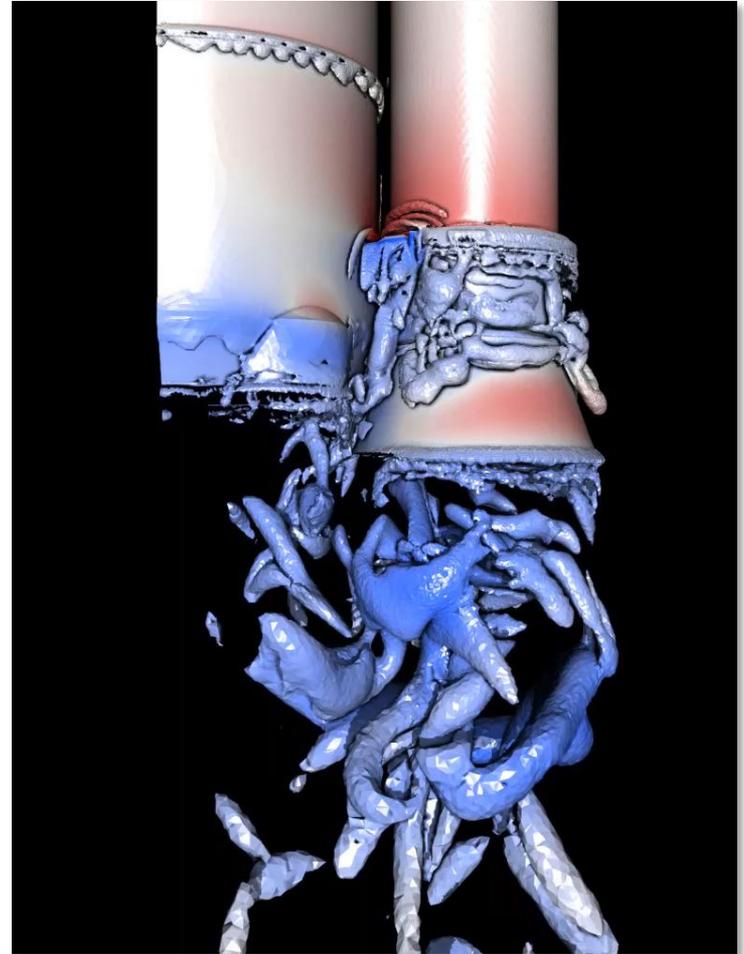
***Aeroelastic Analysis of  
the Boeing SUGAR  
Truss-Braced Wing  
Concept***

# Some Recent NASA Applications



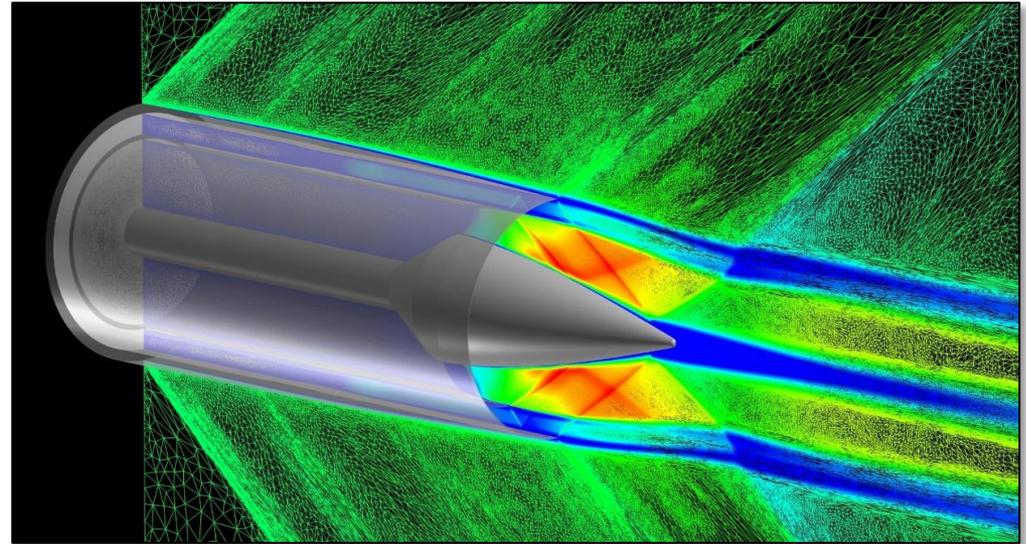
## ***Transonic Buffet Characterization for Space Launch System***

*Courtesy  
Greg Brauckmann,  
Steve Alter, Bil Kleb*

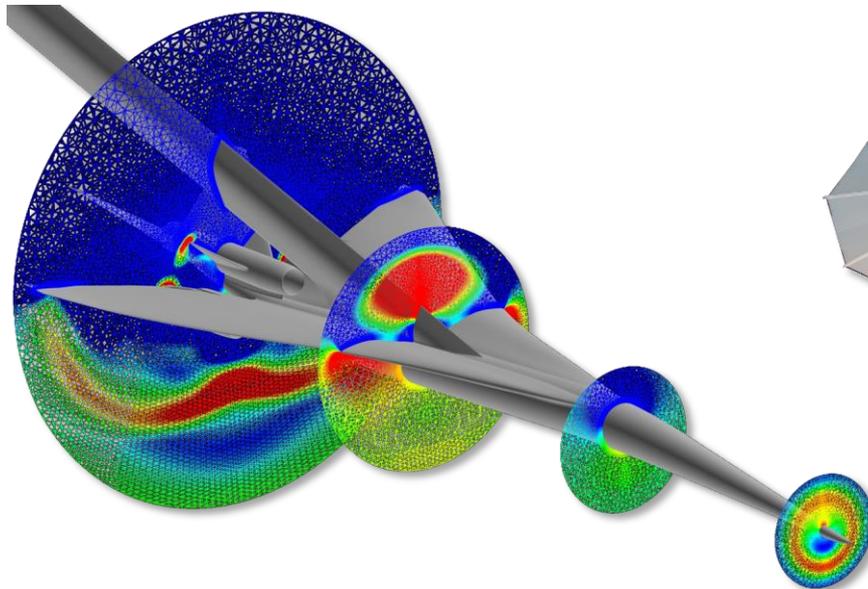


# Some Recent NASA Applications

Courtesy  
Chris Heath



## Sonic Boom Mitigation



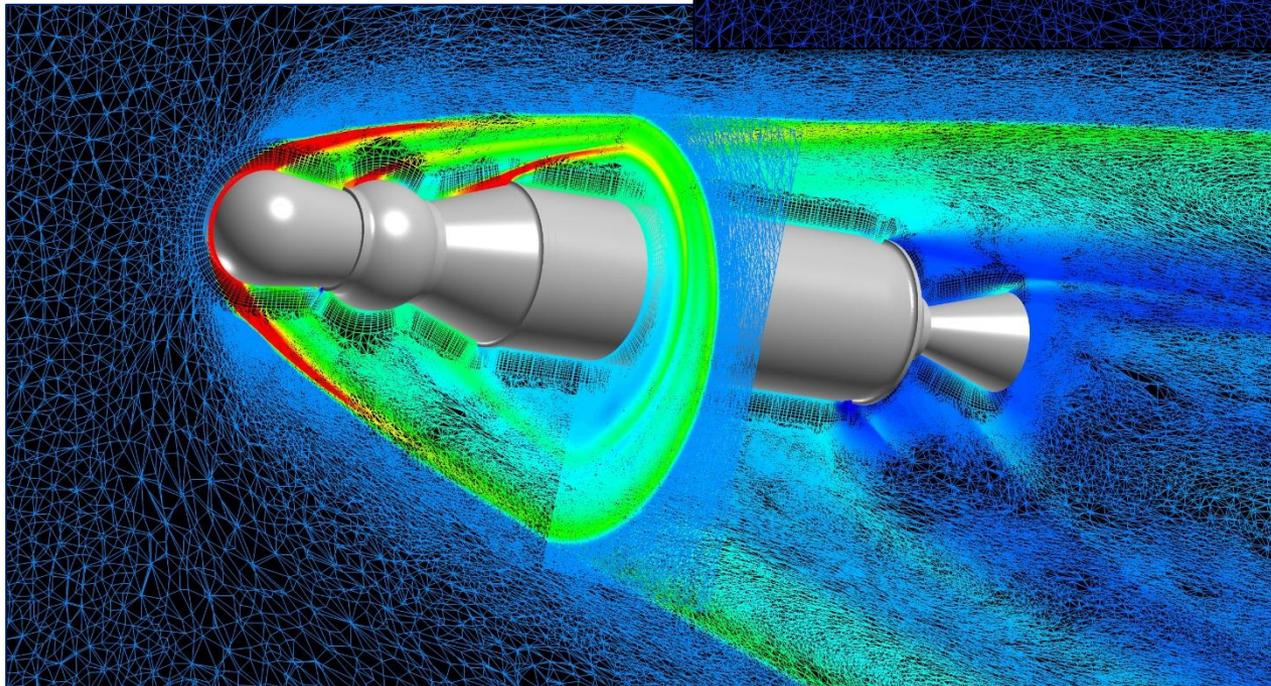
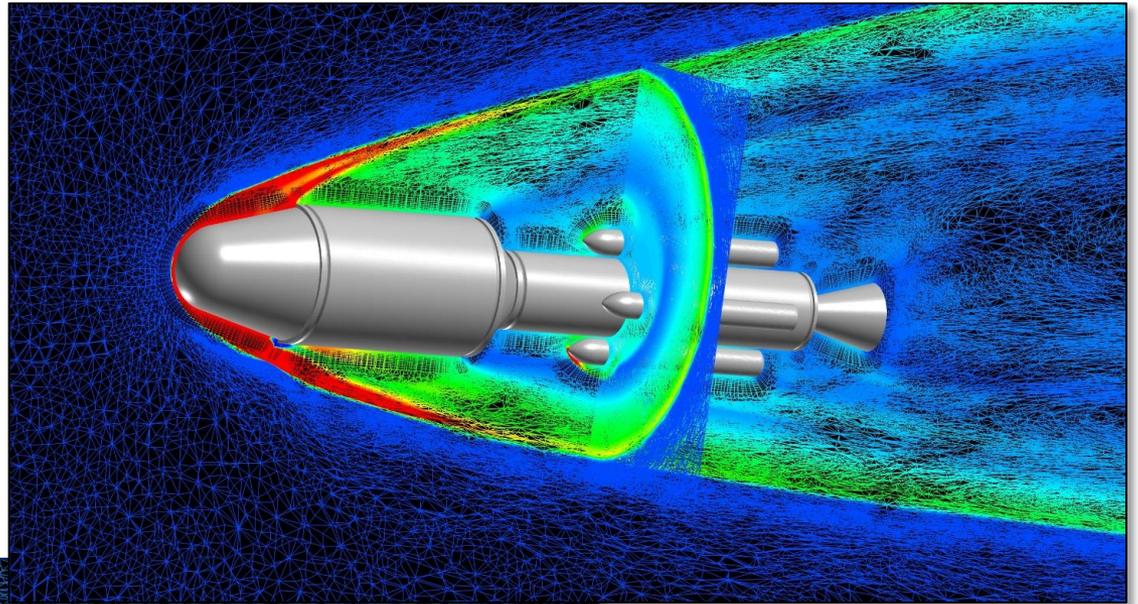
## Mars InSight Lander



# Some Recent NASA Applications

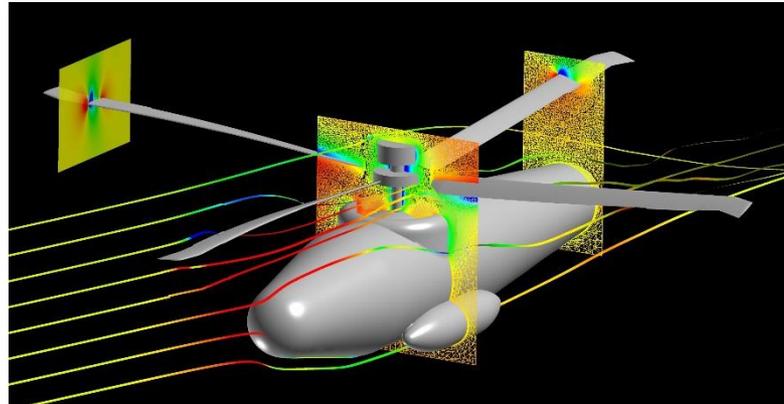
## *Mars Ascent Vehicle for Sample Return*

Courtesy  
Ashley Korzun



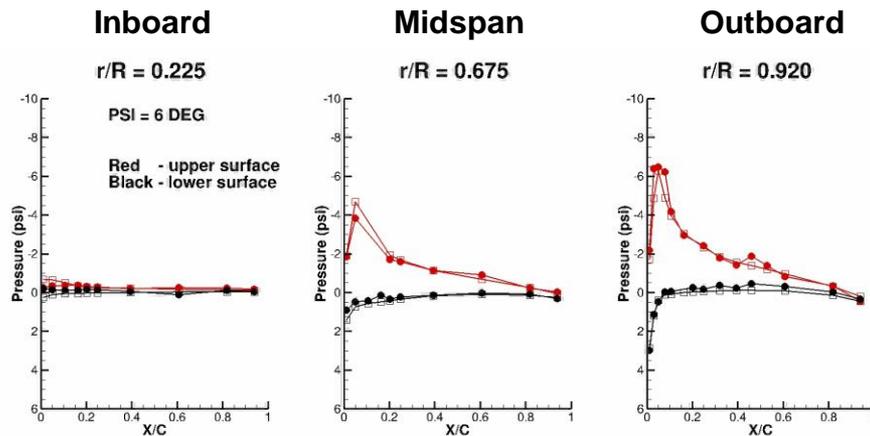
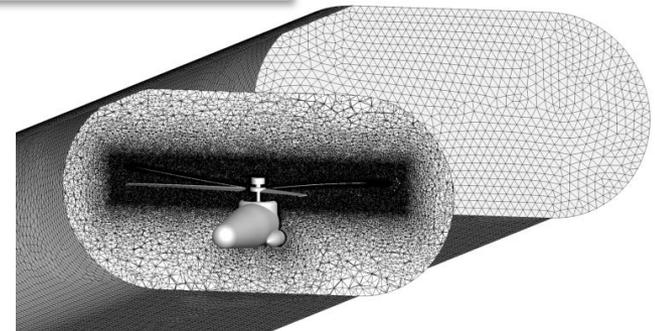
# Some Recent NASA Applications

## Validation for Full Scale UH60A

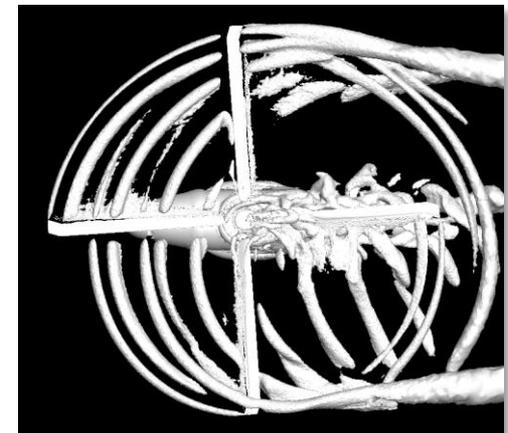


Courtesy  
Beth Lee-Rausch,  
Bob Biedron

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

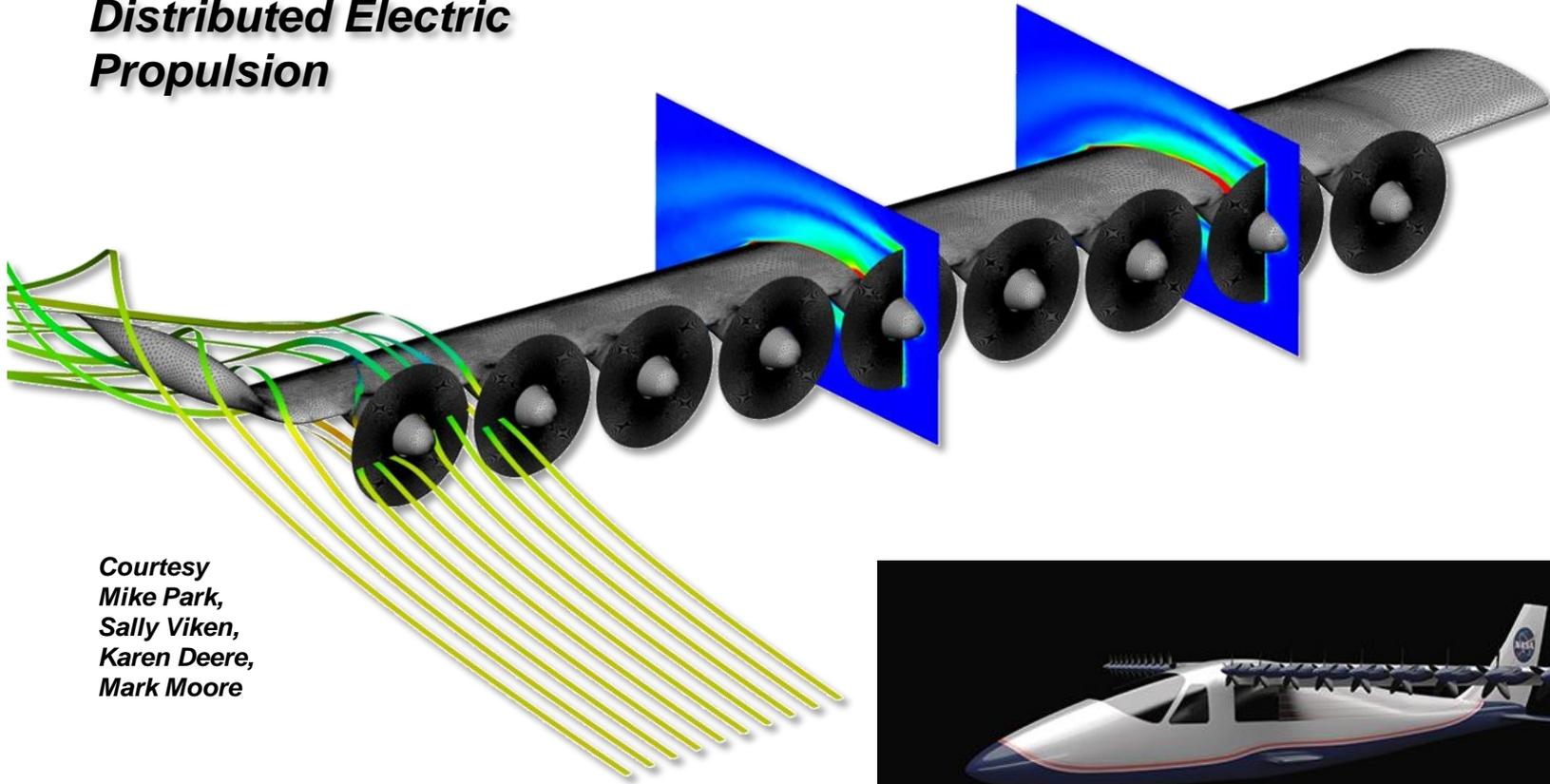


Blade Pressures at High Advance Ratio



# Some Recent NASA Applications

## *Distributed Electric Propulsion*

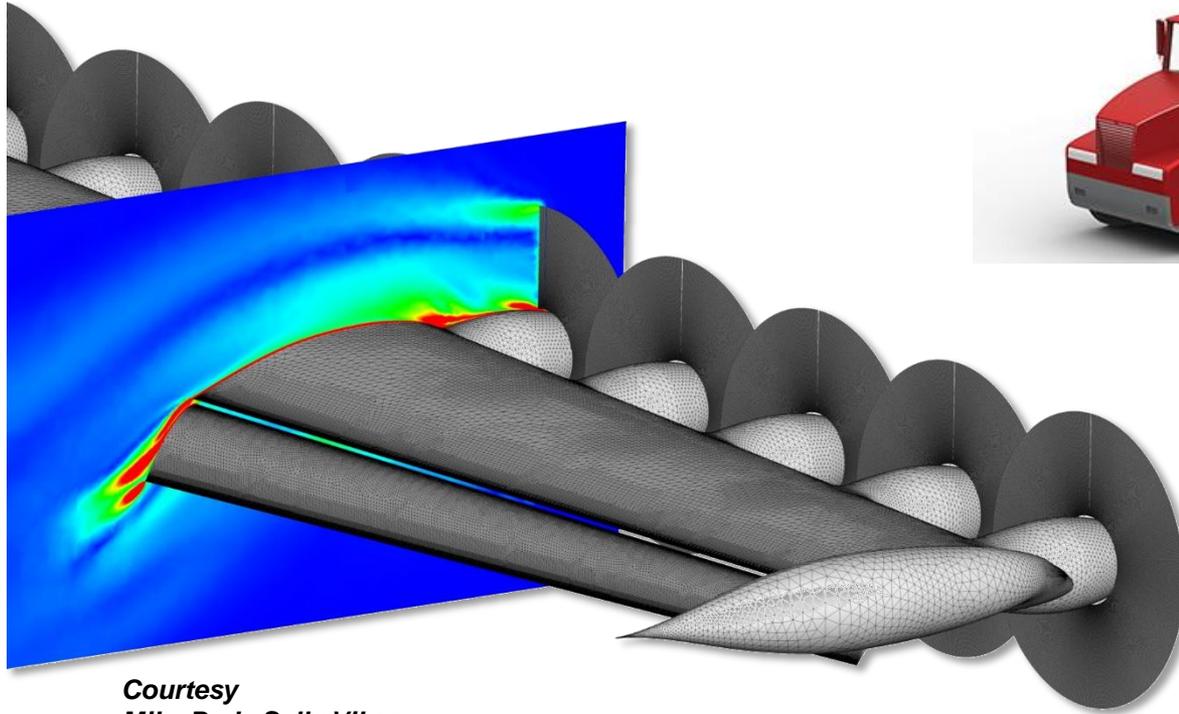


*Courtesy  
Mike Park,  
Sally Viken,  
Karen Deere,  
Mark Moore*



# Some Recent NASA Applications

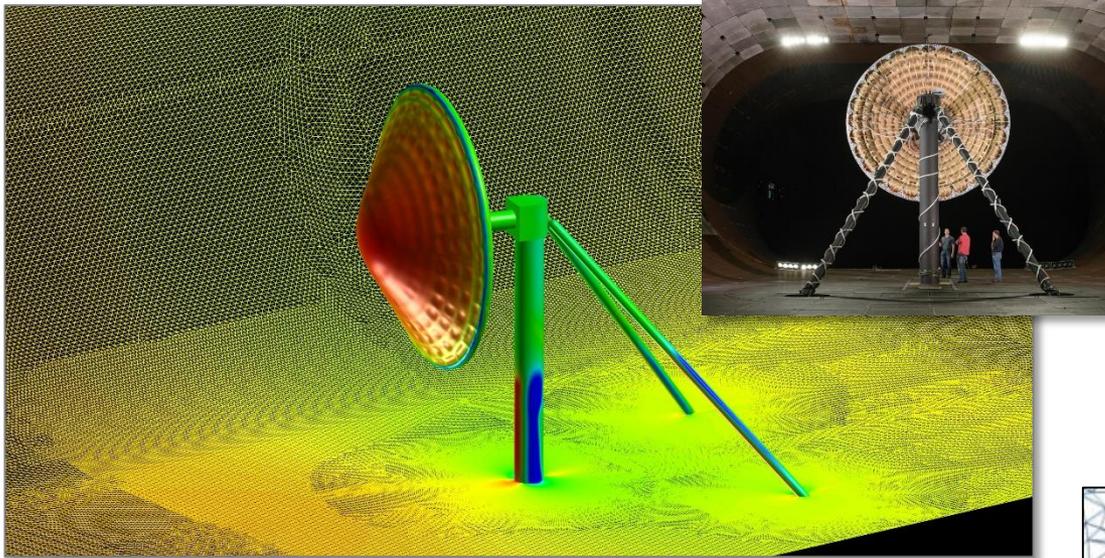
## *Distributed Electric Propulsion*



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

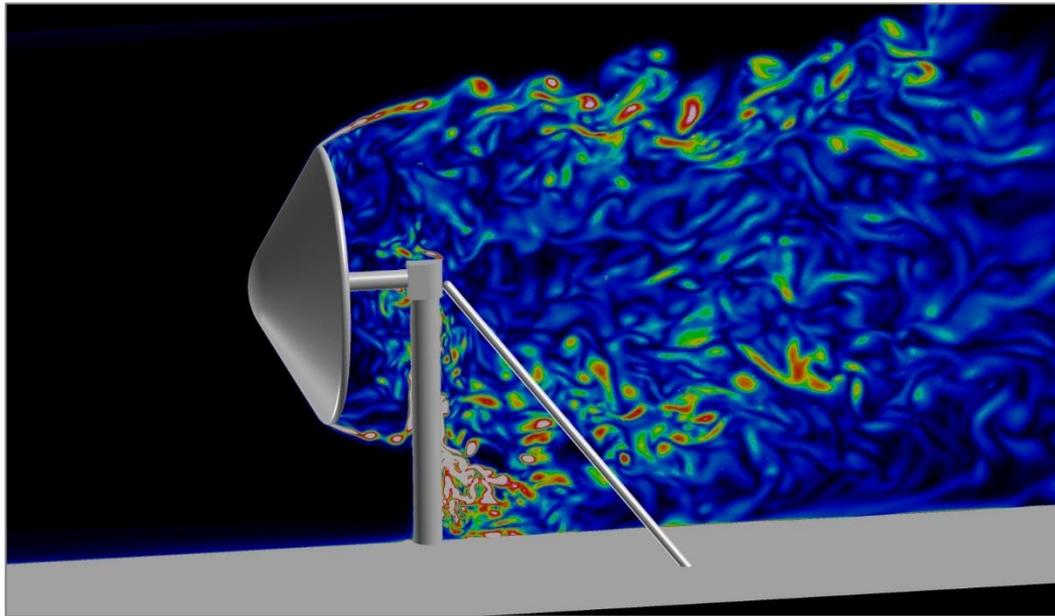


# Some Recent NASA Applications

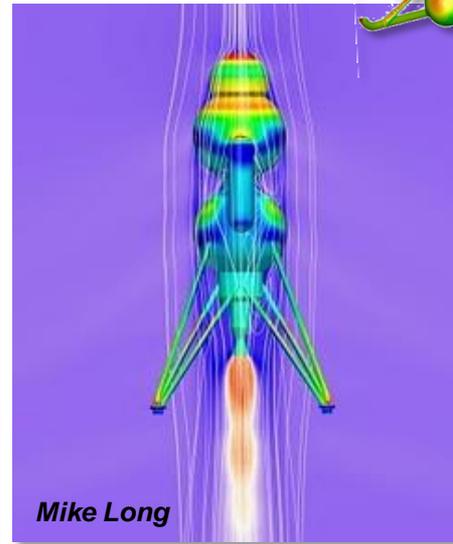
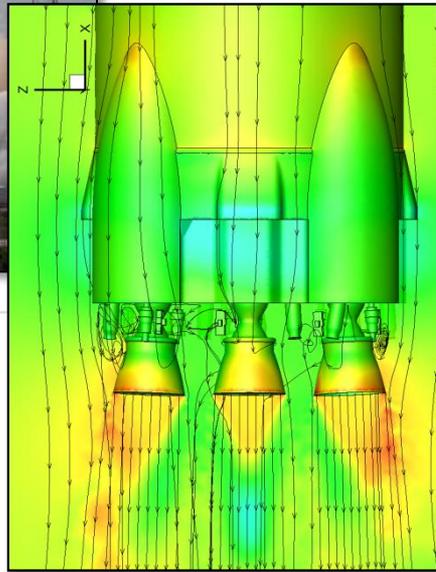
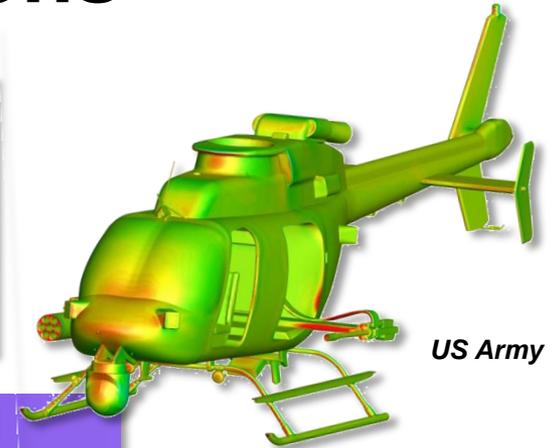
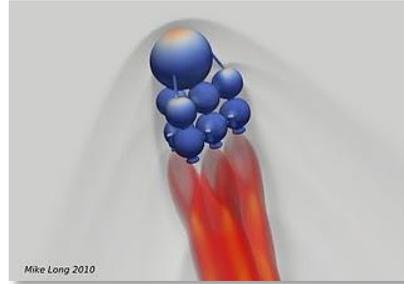


***Aeroelastic Analysis of  
HIADs: Hypersonic  
Inflatable Aerodynamic  
Decelerators***

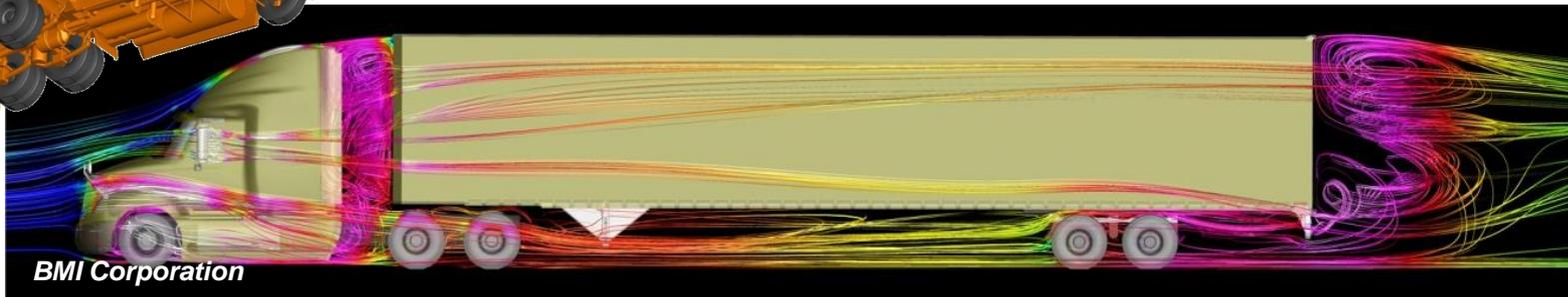
*Courtesy Beth Lee-Rausch,  
Bob Biedron, and Bil Kleb*



# Some User Applications



SPACEX

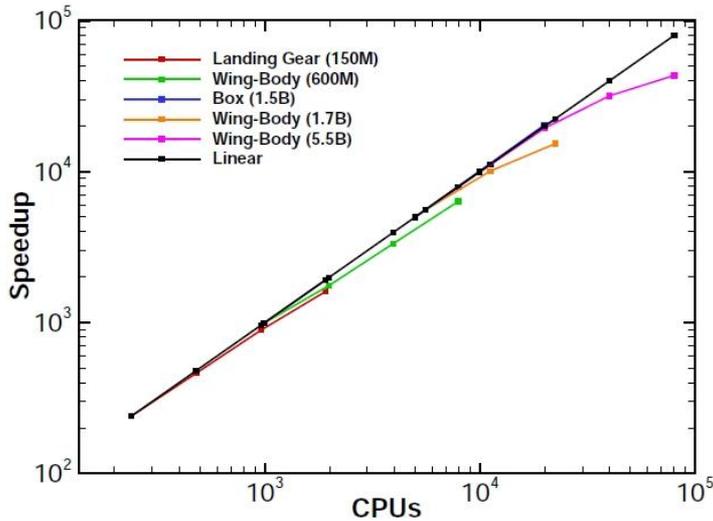


# FUN3D and High-Performance Computing

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



OLCF  
OAK RIDGE LEADERSHIP COMPUTING FACILITY



**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**



# 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, but material will be limited due to export control restrictions (full docs available to approved users)
- 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

