2014

CTR SUMMER PROGRAM

Parviz Moin

27th anniversary of CTR
Participants

- Fifteenth biennial Program
- 76 participants from 10 countries
- 46 Projects
- Participants selected based on their research proposals and scientific interests of CTR
- Sponsors: AFOSR, NASA, NSF, DOE
Technical Groups

Emphasis on Multi-physics Effects in Turbulence

Numerical methods and modeling (RANS and SGS Modeling, optimization, algorithms for high fidelity numerical simulations)

Stability and Control (compliant wall, cross-flow instability, acoustic liners, reduced order models)

Combustion (combustion and thermo-acoustic instabilities and UQ, emissions control, soot, combustion noise, backscatter, )

Two-phase Flow (Liquid layer and jet break-up and atomization, methods for interfacial flows, SGS modeling of primary atomization and phase transition, )

Particle laden flows (Modeling interaction of turbulence, radiative heating and particle transport,)

Aero-acoustics (supersonic and subsonic jets, fans, trailing edge noise, origin of strong pressure peaks, noise of transonic turbine stage)

Application of LES and Wall Modeling (wall-roughness, prediction of unsteady loads on turbines, wall resolved and wall modeled LES in complex and moving geometry, separated flows, turbomachinery, shocks/BL interactions )
Predictive Science at CTR

Advanced Simulation and Computing Legacy at CTR

DOE National Nuclear Security Administration Oversees Today’s Stockpile Stewardship Program.
DOE NNSA Mission: Develop Science-Based Capability to Assess & Certify w/ Nuclear Testing.
To Maintain Technical Merit and Confidence in Stockpile Simulations, NNSA Supports University & DOE Lab Partnerships ($M USD/year)

A Long-Term Federal Investment (~17 Years of Stable Support at Stanford)

1943 Stanford
Simulation Supports Design & Test-Based Certification (Triad)

1992 Nuclear Test Monitirn (Uncertainty)

1997-2007 Nuclear Stockpile Safe, Reliable, Viable without Nuclear Testing?

2008-2013 Over-Arching Engineering Simulations Focus Research in Computational Math/Science

2014-2019 Broad Expertise in Large Scale, Interdisciplinary Predictive Simulations

2020-2030 Exascale Computing Transforms Aerospace Design & Certification

CTR PSAAP-I Center (2008-2013)

Overarching simulations of an air-breathing hypersonic vehicle to predict off-design, transient failure modes including sudden engine stall due to thermal choking in scramjet engines.

CTR PSAAP-II Center (2014-Exascale)

The center is developing the computational science infrastructure for predictive simulation of particle-laden turbulence in a radiation environment on exascale compute systems.

CTR Center for Integrated Turbulence Simulations (1997-2007)

A complete jet engine (fan, compressor, combustor, turbine and nozzle) were modeled together in a seamless high-fidelity, 3D, unsteady, end-to-end simulation of a Pratt & Whitney commercial engine advancing the state-of-the-art in engine design.

Technology Transfer and Impact of Unstructured Grids

CTR simulation technology & culture are varied and widespread. Some highlights include:

- Compositional jet noise prediction from complex geometries
- Aerodynamic design of high-lift multi-element airfoils

Aerodynamic optimization of Airborne Imaging Systems

Supercooling flow

Mesh-based combustion models

Complex geometry fuel injection

A critical mass of technology and people co-located at CTR through nearly two decades of DOE NNSA support have acquired the multi-disciplinary culture needed to build, run and validate complex computational models needed to address overarching problems, e.g. LES with realistic hydrocarbon chemistry and 2-phase flow in complex geometries for engineering high-speed delivery systems. With exascale computers, calculations of high-lift systems, jet noise, scramjets, etc. will further leverage the CTR technology and community to drive high-consequence business/engineering decisions at the labs and in the aerospace industry. This CTR culture has trained many generations of modern computational engineers that are transforming the role of modeling and simulation in science and engineering, turning exascale computing into a true science-based predictive discipline that strengthens industrial competitiveness, national security, energy and the environment.

On the Road to Exascale Computing at CTR

+1 Million Core Jobs

In 10 years, engineering design, optimization, and control on a 1,000,000-core system will be just as routine as 1,000 cores today. Get ready now.
Advanced Simulation and Computing Legacy at CTR

DOE National Nuclear Security Administration Oversees Today’s Stockpile Stewardship Program.

DOE NNSA Mission: Develop Science-Based Capability to Assess & Certify w/o Nuclear Testing.

To Maintain Technical Merit and Confidence in Stockpile Simulations, NNSA Supports University & DOE Lab Partnerships (>4M USD/year)

A Long-Term Federal Investment (+17 Years of Stable Support at Stanford)

1943
Simulation Supports Design & Test-Based Certification (Triad)

1992
Nuclear Test Moratorium (Uncertainty)

1997-2007
Nuclear Stockpile: Safe, Reliable, Viable w/o Nuclear Testing?

2008-2013
Over-Arching Engineering Simulations Focus Research in Computational Math/Science

2014-2019
Broad Expertise in Large Scale, Interdisciplinary Predictive Simulations

2020-2030
Exascale Computers Transform Aerospace Design & Certification
A complete jet engine (fan, compressor, combustor, turbine and nozzle) were modeled together in a seamless high-fidelity, 3D, unsteady, end-to-end simulation of a Pratt & Whitney commercial engine advancing the state-of-the-art in engine design.

Investment in numerical methods, engineering physics and computational science at CTR revolutionized unstructured-grid, reacting flow simulations in jet engines and new technology.
Technology Transfer and Impact of Unstructured LES

CTR simulation technology & culture are varied and widespread. Some highlights include:

- Compressible jet noise prediction from complex geometries
- Aerodynamic design of high-lift multi-element airfoils
- Flow control and LES wall-modeling
- Aero-optics of Airborne Imaging Systems
- Supersonic reacting flow
- Complex geometry fuel injectors
- Flamelet-based combustion models
- Aeroacoustic Shape Optimization
CTR PSAAP-I Center (2008-2013)

Overarching simulations of an air-breathing hypersonic vehicle to predict off-design, transient failure modes including sudden engine stall due to thermal choking in scramjet engines.
CTR PSAAP-II Center (2014-Exascale)

The center is developing the computational science infrastructure for predictive simulation of particle-laden turbulence in a radiation environment on exascale compute systems.
On the Road to Exascale Computing at CTR

+1 Million Core Jobs

In 10 years, engineering design, optimization, and control on a 1,000,000 cores will be just as routine as 1,000 cores today. Get ready now.

A critical mass of technology and people co-located at CTR through nearly two decades of DOE NNSA support have acquired the multi-disciplinary culture needed to build, run and validate complex computational models needed to address overarching problems, e.g. LES with realistic hydrocarbon chemistry and 2-phase flow in complex geometries for engineering high-speed delivery systems. With exascale computers, calculations of high-lift systems, jet noise, scramjets, etc. will further leverage the CTR technology and community to drive high-consequence business/engineering decisions at the labs and in the aerospace industry. This CTR culture has trained many generations of modern computational engineers that are transforming the role of modeling and simulation in science and engineering, turning exascale computing into a true science-based predictive discipline that strengthens industrial competitiveness, national security, energy and the environment.
TUTORIALS

• Low Order Models and Jet Noise (Colonius)
• Radiation Modeling (Boyd)
• Particle Laden Turbulent Flows (Elghobashi)
• Combustion Instabilities (Jacobs)

All at Braun Lecture Hall followed by refreshments

• TODAY: Tips on computational facilities
Milestones

- Presentation of research plans (July 7)
- Midterm/Progress Reports (July 21)
- Final Presentations and Banquet (August 1)

All in Annenberg Auditorium

BBQ: July 20th, Terman Park (Gibbons Grove)
Reporting

• Proceedings of the 2014 CTR Summer Program
  Due September 22, 2014

• 2014 APS/DFD Meeting in San Francisco
  Abstracts due Friday August 1.