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14. ABSTRACT
An International Symposium was held bringing together the world's leaders in the theory of scientific computing and practitioners in science and engineering to discuss and identify future challenges and opportunities in Computational Science and Engineering. The symposium was held on the campus of Princeton University, hosted by the Department of Mechanical and Aerospace Engineering.

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International Symposium on 21st Century Challenges

In Computational Engineering and Science

Final Report submitted to AFOSR

February 26, 2010

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Princeton, NJ 08544

On behalf of the Organizing Committee of the Symposium

Summary

Computational Science and Engineering in general, and Computational Fluid Dynamics in particular, plays an important role in scientific discovery and practical engineering design. To extend the development of this important field into the 21st century, a Symposium was held bringing together the world's leaders in the theory of scientific computing and practitioners in science and engineering to discuss and identify future challenges and opportunities in Computational Science and Engineering. The symposium was held on the campus of Princeton University, hosted by the Department of Mechanical and Aerospace Engineering.

1. Coordination of the Symposium

An organizing committee consisting of

- Luigi Martinelli - Princeton University
- Richard Miles - Princeton University
- Feng Liu - *UC Irvine*
- John Vassberg - The Boeing Company
- Dimitri Mavriplis - University of Wyoming
- Venkat Venkatakrishnan - *The Boeing Company*
- David Caughey - Cornell University
- Fred Habashi - McGill University
- Kasidit Leoviriyakit - *Airbus UK, Lmt*
- Marsha Berger - *NYU*
- Charbel Farhat - Stanford University
- Chongham Kim - Seul National University
- Kun Xu - *HKUST*
- Kozo Fujii - Japan Aerospace Exploration Agency
- Rainald Lohner - George Mason University
- Mohamed Hafez - *UC Davis*
- Elaine Oran - *NRL*

- Seokkwan Yoon - *NASA Ames*
- Norbert Kroll - *DLR*
- Jacques Periaux -CIMNE/ UPC Barcelona

coordinated the event.

2. Format of Symposium

The symposium was held on the campus of Princeton University from Nov. 19 to 21, 2009, consisting of two and half days of plenary sessions. Each session was lead by a a keynote lecture in a particular theory or application field, followed by individual presentations, and end by a panel discussion.

The following topical areas were addressed in the symposium:

Numerical analysis, Foundations of computational fluid dynamics and its application to scientific discovery and aerodynamic design, Control theory and flow control.

Keynote Speakers :

The following invited speakers, among the world's leaders in the field, presented their current perspective and vision for the future:

- Jay P. Boris - NRL
- Rupert Biswas – NASA AmesRc
- Phil Roe - University of Michigan
- Steven Orszag - Yale University
- Chi-Wang Shu - Brown University
- Olivier Pironneau - University of Paris VI (Pierre et Marie Curie)
- Mike Giles - Oxford University
- Bruno Stoufflet - Dassault Aviation
- Torbjörn Larsson - BMW Sauber AG
- Thomas Bewley - UC San Diego
- Roger Blandford - Stanford University

Leading researchers in several topical areas participated and presented papers at the symposium. Approximately 125 people attended all or part of the Symposium. The final scientific program is attached at the end of this document.

A collection of contributed papers and presentations has been compiled and is available for download in electronic form at http://u2.princeton.edu/~aj75th .

Conclusion:

Through close interactions of these leaders and researchers in academia, industry, and government, the symposium germinated new ideas and impetus that will guide the field well into the 21 century.

Scientific Program

19-Nov-09		**Session I - CFD in Aeronautics**
9:00 - 9:15 AM		**WELCOME**
9:15 - 9:45 AM	***Vassberg, J*** *The Boeing Co.*	**A Brief History of FLO22**
9:45 - 10:15 AM	***Stoufflet, B*** *Dassault Aviation*	**An Overview of more than 20 years of Aerodynamic Simulation in Dassault Aviation**
		BREAK
10:30 - 11:00 AM	***Kroll, N et al*** *DLR*	**TAU-Code Development**
11:00 - 11:30 AM	***Rossow, C et al*** *DRL*	**Application of TAU for Aerodynamic Analysis, Design and Optimization**
11:30 - 12:00 PM	***Habashi, W*** *McGill Un.*	**Towards Real-time 3D In flight Icing Simulation**
12:00 - 12:30 PM	***Steinhoff, J*** *Un. Tennessee Space Institute*	**Computing Flow over Complex Aircraft and Vortex Wakes for Long Distances Using a New Technique – "Vorticity Confinement".**
		LUNCH BREAK

		Session II - Optimization
2:00 - 2:30 PM	***Pironneau, O*** *LJLL-UPMC (Paris VI)*	**Optimal Shape Design and the Control of Shocks**
2:30 - 3:00 PM	***Lohner, R et al*** *George Mason Un.*	**Adjoint-based Design of Passive and Active Shock Mitigation Devices.**
3:00 - 3:30 PM	***Kim, S and Park,SH*** *Konkuk Un. Seoul*	**Progress in Multi-fidelity Design Optimization for Natural Laminar Flow Wings**
3:30 - 4:00 PM	***Rumpfkeil, MP and Mavriplis D*** *Un. Wyoming*	**Optimization-based Multigrid Applied to Aerodynamic Shape Design**
4:00 - 4:30 PM	***Bewley, T*** *UC San Diego*	**Adjoint Analysis of Environmental Flow Systems for Coordinated Response to Homeland Security Threats**
4:30 - 5:00 PM	***Larsson, T*** *BMW-Sauber AG*	**Formula One : The Quest for Speed and Aerodynamic Flow Control**
		Session III - Flow Physics
5:00 - 5:30 PM	***Zhang, H*** *China Aerod. R&D Dev. Center (CARDC)*	**Computational Fluid Dynamics Based on Physical Analysis**
5:30 - 6:00 PM	***Yoon, S*** ***NASA***	**Hypersonic Transition**
		ADJOURN

20-Nov-09

Session IV - Algorithms and Methods

9:00 - 9:30 AM	***Roe, P and Fidkowski, K*** *Un. Of Michigan*	**Adjoint Mesh Adaptation with no Adjoint Calculation**
9:30 - 10:00 AM	***Venkat, V*** *The Boeing Co.*	**Algorithm Issues in Developing Robust CFD codes**
10:00 - 10:30 AM	***Kim, C.*** *Seoul National Un.*	**Efficient and Accurate Multi-Dimensional Limiting Strategy on Structured and Unstructured Grids**
		BREAK
10:45 - 11:15 AM	***Shu, CW*** *Brown Un.*	**Super-convergence and Time Evolution of Discontinuous Galerkin Finite Element Solutions**
11:15 - 11:45 AM	***Wang, ZJ*** *Iowa State Un.*	**Some Recent Progresses in Discontinuous High-order Methods**
11:45 - 12:15 PM	***Peraire, J*** *MIT*	**Hybridized Discontinuous Galerkin Methods**
12:15 - 12:45 PM	***Ou, Kui*** *Stanford Un.*	**On the Temporal and Spatial Accuracy of Spectral Difference Method on Moving Deformable Grids and the Effect of Geometry Conservation Law**
		LUNCH BREAK
2:00 - 2:30 PM	***Burgess, N, Nastase, CR and Mavriplis D*** *Un. Of Wyoming*	**Efficient Solution Techniques for Discontinuous Galerkin Discretizations of the Navier-Stokes Equations on Hybrid Anisotropic Meshes**
2:30 - 3:00 PM	***Biswas, R*** *NASA*	**NASA Supercomputing and its Impact on Agency Missions**

3:00 - 3:30 PM	***Guowei,He*** *Inst of Mecs, Chinese Acad. of Sci.*	**Space-time Correlation Model for Turbulence-generated Noise**
3:30 - 4:00 PM	***Fujii, K and Oyama A*** *Institute of Space and Astronautical Science, JAXA*	**Recent Effort on the Design and Data Explorations in Aerospace**
4:00 - 4:30 PM	***Orszag, S*** *Yale Un.*	**Progress on Rule-Based Computing of Fluid Dynamics**
4:30 - 5:00 PM	***Boris, J*** *NRL*	**Large Scale Urban Aerodynamics using monotone integrated LES**
		Session V - Other Applications
5:00 - 5:30 PM	***Blandford,R*** *Stanford Un.*	**Astrophysical Uses (and Abuses) of Magnetohydrodynamics**
5:30 - 6:00 PM	***Giles,M*** *Oxford Un.*	**From CFD to Computational Finance (and back again?)**
		ADJOURN
6:30 PM		**RECEPTION AND BANQUET**
	Hafez, M *UC Davis*	**40 Years of Jameson's Contributions**

21-Nov-09

		Session VI - Time Accuracy
9:00 - 9:30 AM	***Liu, F*** *UC Irvine*	**Accuracy and Efficiency Comparisons of the Time-spectral and Dual-time Stepping Methods for Unsteady Transonic Flows**
9:30 - 10:00 AM	***Mani, K and Mavriplis D*** *Un. of Wyoming*	**Spatially non-uniform time step adaptation in unsteady flow problems**
		Session VII - Student Session
10:10-10:30 AM	***Vassberg, D***	**Is Einstein Puzzle Over specified?**
10:30- 10:50 AM	***Liang, C*** *CTR Stanford Un.*	**Shock induced mixing of air and SF6**
10:50 - 11:10 AM	***Culbreth, M*** *Stanford Un.*	**Flapping Wings Optimization**
11:10 - 11:30 AM	***Chiu, E*** *Stanford Un.*	**An Edge-averaged Semi-meshless Framework for Numerical Solution of Conservation Laws**
		Session VIII - New Directions
11:30 - 12:00 PM	***Epstein, B and Peiguine, S*** *The Acad. College of Tel Aviv-Yaffo*	**Variable Accuracy Approach to CFD-aided Analysis and Design of Complex Aerodynamic Configurations**
12:00 - 12:30 PM	***Qiqi Wang*** *MIT*	**Solving adjoint equations for unsteady fluid flows**