

UNIVERSITY OF ILLINOIS @ URBANA-CHAMPAIGN (UIUC)
NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS (NCSA)
EXTERNAL PROGRAMS DIVISION

THE NCSA CSM GROUP OVERVIEW

The NCSA Computational Structural/Solid Mechanics (CSM) Group within the **External Programs Division** consists of five PhD and one MS professional, and one graduate student, including two UIUC College of Engineering professors, with 150 years of combined active advanced level R&D experience and more than 360 publications in archival journals and conference proceedings.

The Group's mission is to carry out cutting edge multidisciplinary¹ fundamental, advanced analytical and computational R&D in CSM and in fluid/ solid interaction projects to satisfy the customer's and the profession's present and future short and long range needs.

The NCSA CSM Group is vigorously pursuing marketing initiatives with the NCSA Private Sector Partners (PSP) as well as other industry, government laboratories, NSF, NASA and DoD programs in order to expand its efforts further with additional sponsors. Its technical staff has demonstrated experience and is actively engaged in research in such diverse linear and nonlinear CSM areas as:

aeroelasticity
analytical and computational solid mechanics
composites
damping (structural and material)
"designer materials"
dynamics
elasticity
electronic packaging
fluid/solid interactions
fracture mechanics
high polymers
macro- and micro-mechanics
material science/engineering
room and high temperature metals
penetration problems in thin and thick walled structures
plasticity
probabilistic failure analysis
stochastic minimum structural weight analysis
probabilistic structural control, stability and survivability
virtual experiments
viscoelasticity

¹ CSM with computational fluid mechanics (CFD), computational chemistry and materials science (CCM), and computational electronics and nanoelectronics (CEN)

Currently, *The NCSA CSM Group* has an active on-going \$645,000 per year DoD grant from the High Performance Computational Modernization Program (HPCMP-PET) carried out in cooperation with personnel from the Army Research Laboratory (ARL) at Aberdeen, MD and at the Aeronautical Systems Center (ASC) at Dayton, OH. This program has been in place for four years and is progressing well and on schedule. Additionally, the group has new \$100,000 yearly support of outside non-PET research funds.

Examples of current projects of *The NCSA CSM Group* are (For more details see

http://www.ncsa.uiuc.edu/EP/CSM/presentations/EP-CSM-Briefing_Feb01

- Development of new software and modifications to legacy codes for remote portable parallel computing and integrated visualization
- Advancement of unique analytical research and computational protocols in fundamental areas with applications to material characterizations of composite and metal structures under static, dynamic, impact, aeroelastic and aero-viscoelastic loads, including structural control, health monitoring and probabilistic structural survivability
- Promotion of interaction between diverse DoD groups and centers through multidisciplinary analytical modeling, analyses and high performance computational simulations including scientific visualization
- Training, short courses and workshops tailored to specific CSM interests of DoD, ASC, ARL, HBUC and MI researchers, scientists and engineers
- Publication of a monthly CSM Digest with over 700 current subscribers, which reports on activities at NCSA and through out the profession of interest to the CSM community
- Publishing research results in archival journals and conference proceedings, and organizing CSM sessions and conferences, such as MAPINT 2000, the yearly AIAA Structures, Structural Dynamics and Materials Conferences, High Performance Computing 2003, International Nonlinear Problems in Aeronautics and Astronautics 2002, to mention a few.

Some of the projects currently under development by *The NCSA CSM Group* include:

- To formulate multidisciplinary investigations, simulations and massively parallel computational protocols for the analysis and design of this century's lightweight materials and structures for flight, surface

and naval vehicles based on probabilistic and deterministic reliabilities, including aeroelastic, aeroviscoelastic, aero-viscoelastic and structural control capabilities

- To make analytical and computational results available to government, industry and academic institutions through grids (metacomputing)

The NCSA CSM Group is headed by CSM senior academic leads **Harry Hilton**, professor emeritus of Aeronautical and Astronautical Engineering (AAE), and **Jimmy Hsia**, associate professor of Theoretical and Applied Mechanics, both from the UIUC College of Engineering (COE). **Dr. Cristina Beldica**, research scientist (NCSA and AAE), **Dr. Ron Hinrichsen**, senior research scientist, **David O'Neal**, senior research programmer, and **Dr. Ganesh Thiagarajan**, research associate, are all valued NCSA members of *The Group*. (See web page listings below for details of *The NCSA CSM Group* activities and personnel descriptions.) They work closely together as an integrated unit on a number of R&D projects and have demonstrated the feasibility and efficacy of a successful working partnership between COE academics and NCSA technical staff.

Another goal of this *Group* is to further enhance and expand the current CSM working partnership between NCSA's technical staff and UIUC COE faculty and to carry out extensive additional research activities through cooperative partnerships with other academic institutions, government laboratories (DoD, DoE, NIST) and funding agencies such as AFOSR, ARO, NASA, NSF, ONR, etc. *The NCSA CSM Group* has currently established working relationships with university faculties at Clark Atlanta, Delaware, Florida Atlantic, New Mexico, Ohio State, Rice, Rutgers, Tennessee, UIUC, Greenwich (UK) and Singapore.

The following are short biographical sketches of *The NCSA CSM Group* members. For more complete details please consult the web pages listed below.

Cristina E. Beldica holds an MS in Aeronautical Engineering from the Polytechnic Institute of Bucharest, Romania and a Ph.D. in Engineering Mechanics from the University of Illinois at Chicago. She has been at UIUC since 1996. Prior to this she has served as Research Assistant at University of Illinois at Chicago, Assistant Professor at the Polytechnic Institute of Bucharest and R&D Engineer at ICA Aircraft Manufacturing, Romania. Currently, she is a Research Scientist for Computational Structural Mechanics at NCSA at the University of Illinois at Urbana-Champaign. She also holds a joint appointment in the Aeronautical and Astronautical Engineering (AAE) Department at UIUC. Nationally, she is a member of the American Institute of Aeronautics and Astronautics Technical Committee on Structures.

Dr. Beldica's research interests include characterization of viscoelastic materials, linear and nonlinear stress analysis, fracture properties of reinforced composites. Currently she is working on aero-thermo-viscoelastic studies on divergence, flutter and aerodynamic noise response and control, on optimum anisot-

ropic viscoelastic damping properties of composites and on intelligent and piezoelectric viscoelastic materials. She has developed and used computer code for stress analysis based on finite and boundary element algorithms. She has performed 2D and 3D numerical simulations of curing processes in thermosetting composite materials. Her work also includes numerical and experimental analysis of fracture, crack growth characteristics and scale effects in composites with long fibers.

Harry H. Hilton received a BS and an MS in Aeronautical Engineering from New York University and a PhD in Theoretical and Applied Mechanics with a minor in mathematics from UIUC. At UIUC he has been AAE department head from 1974 to 1985 and an assistant dean of engineering during the summers of 1989 and 1990. Currently, he is Professor Emeritus of AAE and Senior Academic Lead for Computational Structural Mechanics at NCSA. Since 1997, he also holds an appointment as Charles E. Schmidt Distinguished Visiting Professor at Florida Atlantic University. He is a member of several international and national scientific committees, which organize technical conferences and set policies, standards and future planing in aerospace, high performance computing and mechanics.

He continues to be actively engaged in research, graduate teaching, MS and PhD thesis advising and in public and professional service. His recent analytical and computational research and extensive publication areas are deterministic and stochastic linear and nonlinear viscoelasticity, composites, aero-visco-elasticity, computational solid mechanics and probabilistic failure criteria and analysis. Some specific subsets include: viscoelastic failure analysis with random properties and loads, aeroelasticity, damping, nonlinear dynamics, linear and nonlinear anisotropic viscoelastic finite element analysis, piezoelectric viscoelastic materials, electronic packaging, nonlinear creep and delamination column and plate buckling, analytical determination of damping properties, stochastic minimum structural weight analysis, probabilistic delamination of composites during service and manufacturing processes (cure).

Ronald L. Hinrichsen received the following degrees in aeronautical engineering: a BS from the University of Arizona and an MS and PhD from the Air Force Institute of Technology. He has had a multi-disciplinary career in aerospace structures with over 25 years of experience in the teaching, development and applications of composite materials, solid mechanics, structural dynamics, aeroacoustics, and computer aided design. While at the Air Force Institute of Technology, he was an assistant professor in aerospace engineering. He taught basic and advanced courses in finite elements, advanced courses in structural vibrations, design philosophy, solid mechanics, space system design and conventional weapons' effects, and was selected as outstanding instructor of the year. At the Flight Dynamics Directorate, as technical manager and branch chief, he directed all aspects of the Structural Design Group that included supervision, design, optimization, and analysis of aerospace vehicles using several finite element based codes. He is a retired Air Force officer. He worked as a Senior Scientist for Science Applications International Corporation and a Senior Program Manager for Anteon Corporation prior to coming to UIUC.

Currently, he is a Senior Research Scientist for Computational Structural Mechanics at NCSA at the University of Illinois at Urbana-Champaign and is the on-site lead for Computational Structural Mechanics at the Air Forces' Major Shared Resource Center at Wright-Patterson Air Force Base, Ohio.

Dr. Hinrichsen's research interests include aeroacoustic spectra prediction, thermal-structural analysis and fluid-structure interaction with emphasis on hydrodynamic ram and aircraft survivability issues. Currently he is working on time domain aeroelastic predictions of flutter in damaged high performance fighter aircraft. He has developed and used computer codes for fluid-structure interaction analysis based on finite and boundary elements algorithms. He has also performed 3D numerical simulations of hydrodynamic ram damage of wings designed from all-composite materials. His work also includes numerical and experimental analysis of damage initiation and propagation in isotropic and anisotropic materials.

K. Jimmy Hsia received a BS in engineering mechanics from Tsinghua University in Beijing, China and a PhD in mechanical engineering from MIT. He has been on the faculty of UIUC since 1991. He was a recipient of Max-Planck Society Fellowship and a visiting scientist at Max-Planck Institute für Metallforschung in Stuttgart, Germany in 1998. He was also awarded the Japan Society for Promotion of Science Fellowship and was a visiting professor at Nagoya University in 1999. Currently, he is Associate Professor of Theoretical and Applied Mechanics at UIUC and Senior Academic Lead for Computational Structural Mechanics at NCSA. He also has served as a Guest Editor for *Materials Science and Engineering A*.

Prof. Hsia's research interests include micromechanics, micromechanisms of deformation and failure, damage mechanics, brittle-to-ductile transition in fracture, high temperature failure of metallic and ceramic materials, computational fracture mechanics under high strain rates, and fracture of ferroelectric materials. He has developed a technique to study the fundamental mechanisms of brittle-to-ductile transition in silicon. He has also performed numerical simulations of plastic deformation using dislocation mechanics, and of fracture of glass under thermal gradient loading as well as impact loadings.

David C. O'Neal received a BA in mathematics and computer science from the University of Colorado and an MA in applied mathematics from the University of Pittsburgh. He has been an active member of the high performance community since his first encounter with a small Intel Hypercube in his final year of undergraduate studies. His interests in numerical methods, parallel algorithms and multiprocessor computers were developed at the University of Pittsburgh, where new NSF supercomputing center resources had been integrated with the University's mathematics and computer science department curricula. In 1990, he moved to Carnegie Mellon University as a member of the Pittsburgh Supercomputing Center's technical staff, where he served as Senior Consultant and Senior Research Programmer.

His interest in the DoD High Performance Computing Modernization Program was cultivated that year through collaborations with members of the DoD's Programming Environment and Training team. In 1997, he came to the PET Program as the University of Illinois' On-Site Lead for Computational Structural Mechanics at the Aeronautical Systems Center at Wright-Patterson AFB, Dayton, OH. He was instrumental in building the NCSA CSM program at ASC, essentially from the ground up. But his desire to remain closer to family and friends led him back to Pittsburgh after two years, where he has continued to contribute to the NCSA CSM program through his on-going work with research groups from the Air Force Research Laboratory and ASC. He is currently developing a new method for solving fracture mechanics problems with engineers and scientists from the AFRL Materials Directorate. Additionally, he is the editor of the **NCSA CSM Digest**, a widely distributed monthly electronic publication featuring items of interest to the national community of CSM professionals.

Ganesh Thiagarajan received his Bachelors and Masters degree in Civil and Structural Engineering from the Indian Institute of Technology, Madras, India and PhD in Constitutive Modeling of Cyclic Plasticity and Damage in Composite Materials from Louisiana State University. He has worked three years in the industry prior to joining the doctoral program and has served LSU in the capacities of Instructor and as a Professional-in-Residence. As an LSU faculty member for five years he has taught various mechanics and analysis courses at the undergraduate level and has received numerous awards for teaching both at the college and the university level. He is currently a Research Associate with NCSA-UIUC. He is a member of ASCE, ASME and USACM and serves as a member of the Inelastic Modeling Committee of ASCE.

Ganesh has been actively working in the areas of constitutive modeling of composite materials to include their behavior under cyclic loading, damage in metal matrix composites and has recently worked in modeling their viscoplastic behavior. He has also a very keen interest in the area of computational solid mechanics especially in the parallel implementation the conjugate gradient methods in a distributed computing environment of finite element methods using HPF and MPI. These methods have been tested to solve very large problems. Currently he is working in the area of numerical simulation of crack propagation behavior under static and dynamic loading situations.

The NCSA CSM Group's activities and personnel are described in detail on a number of web sites, such as

- NCSA CSM website:
<http://www.ncsa.uiuc.edu/EP/CSM/>
- NCSA CSM Digest archives:
<http://www.ncsa.uiuc.edu/EP/CSM/archives/digest/>
- Publications:

<http://www.ncsa.uiuc.edu/EP/CSM/publications/>

- Presentations:
<http://www.ncsa.uiuc.edu/EP/CSM/presentations/>
- Success Stories:
<http://www.ncsa.uiuc.edu/EP/CSM/projects/success-stories/>
- Conference Calendar
<http://www.ncsa.uiuc.edu/EP/CSM/conferences/>
- Cristina Beldica:
<http://jasmine.ncsa.uiuc.edu/~cbeldica/>
- Harry Hilton:
<http://www.uiuc.edu/ph/www/h-hilton>
- Ron Hinrichsen:
<http://www.ncsa.uiuc.edu/EP/CSM/people/Ron.html>
- Jimmy Hsia:
<http://www.tam.uiuc.edu/Faculty/Hsia.html>
- David O'Neal:
<http://www.psc.edu/~oneal/>
- Ganesh Thiagarajan:
<http://www.ncsa.uiuc.edu/EP/CSM/people/Ganesh.html>

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