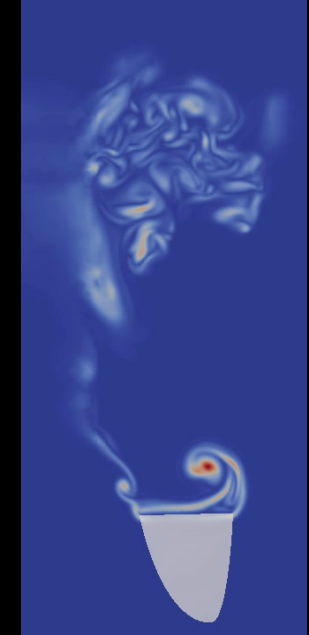
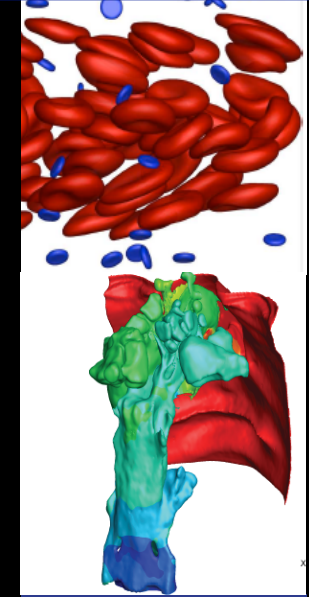
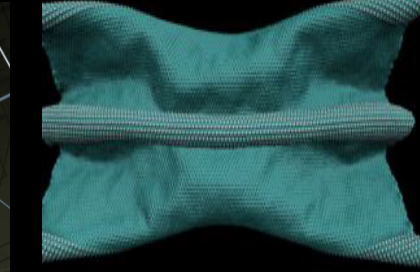
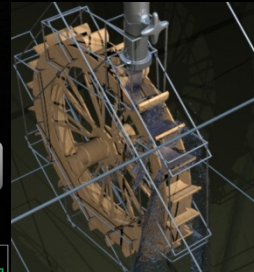
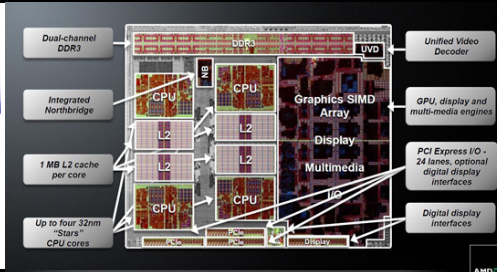
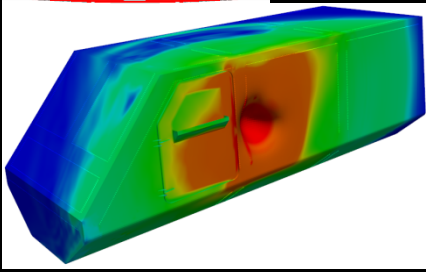
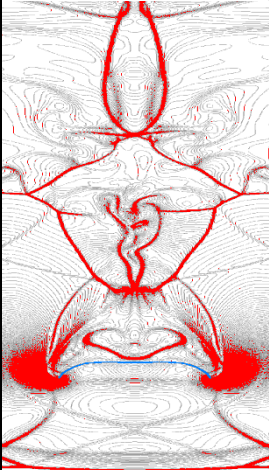




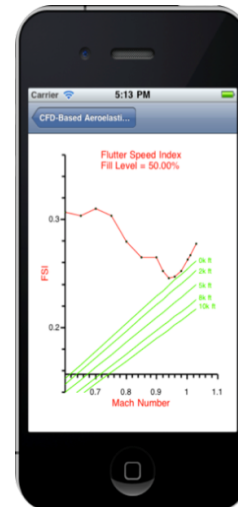
The Army High Performance Computing Research Center

Charbel Farhat
Director
Stanford University



AHPCRC: OUR MISSION

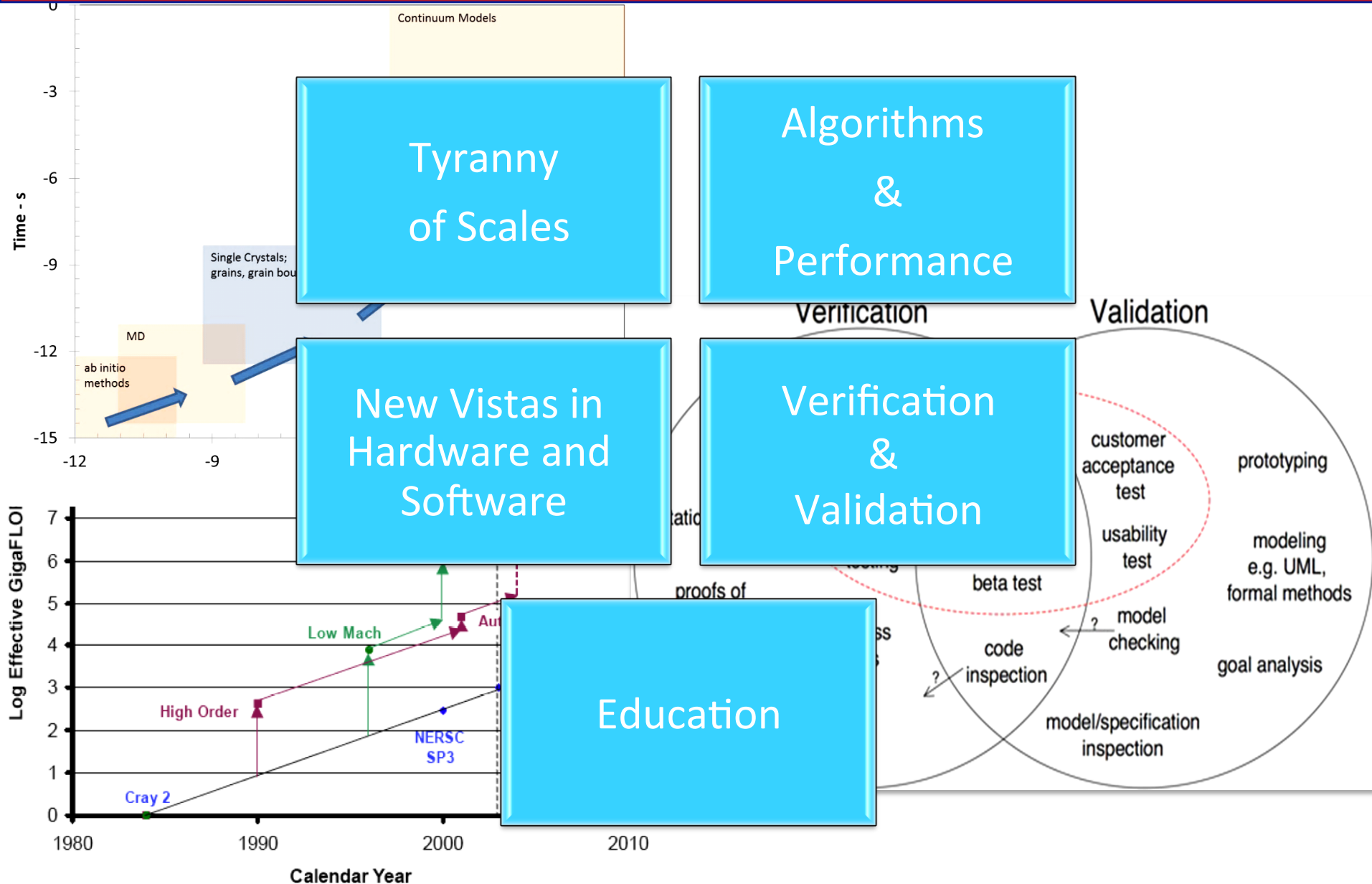
- Next-generation Computational-Based Engineering Sciences (CBES) and HPC
 - develop next-generation computational methods
 - harness the capabilities of next-generation HPC systems
 - foster better and faster scientific discovery, innovate technology reduce design-cycle time, support tests, and improve system performance, in the context of Army applications



- Army Communicator
Vol. 37, No. 2, Summer 2012



CBES: THE CHALLENGES





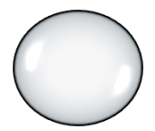
AHPARC: THE IMPLEMENTATION 2012-2017 (Phase II)

- Core research focused on CBES and HCP Enabling Technologies
 - **basic** research which addresses **grand challenges** associated with algorithms, software, hardware, and performance
 - **pertains to many different fields and applications**
- Thematic research focused on demonstrating potential and impact, maintaining relevance, and solving real problems of interest to the Army
 - a few themes which minimize overlap (redundancy) with other Army initiatives by focusing primarily on the **basic and computational aspects** of the research, but maximize synergy with them and promote **further collaborations** with Army

AHPCCRC: THE IMPLEMENTATION 2012-2017 (Phase II)

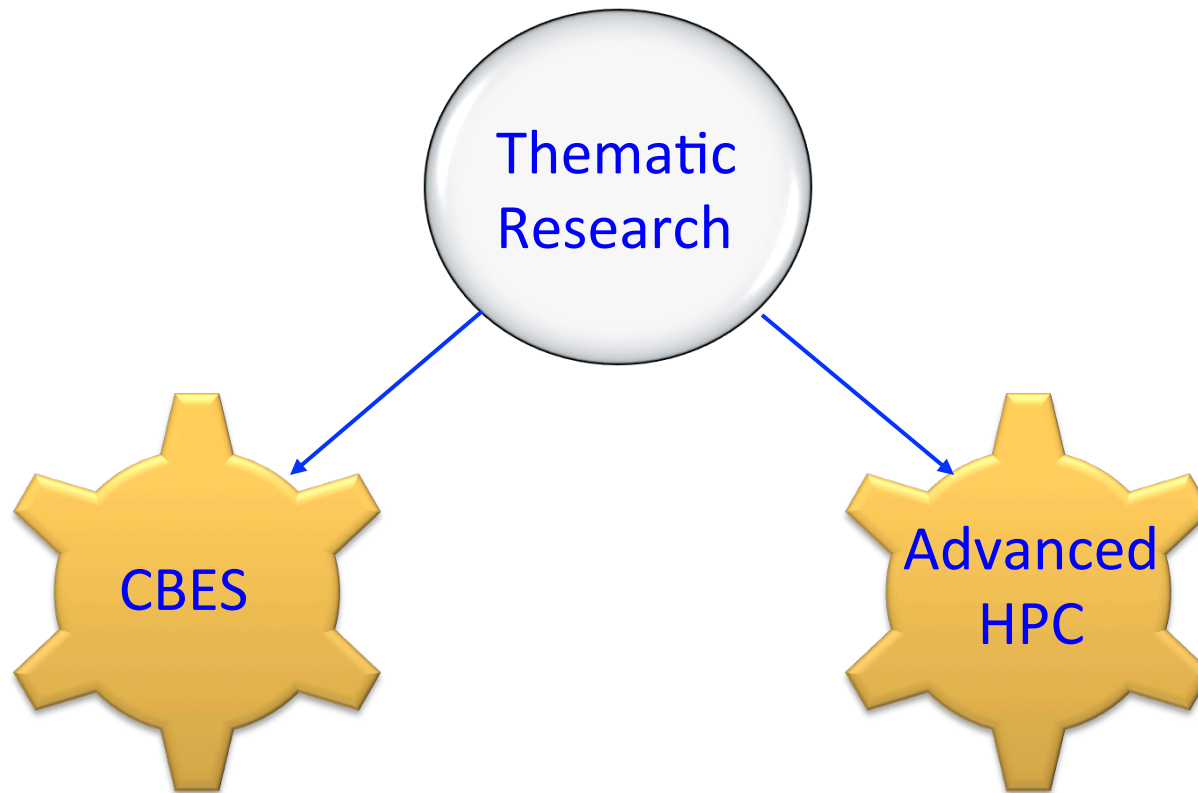


Core Research



Thematic Research





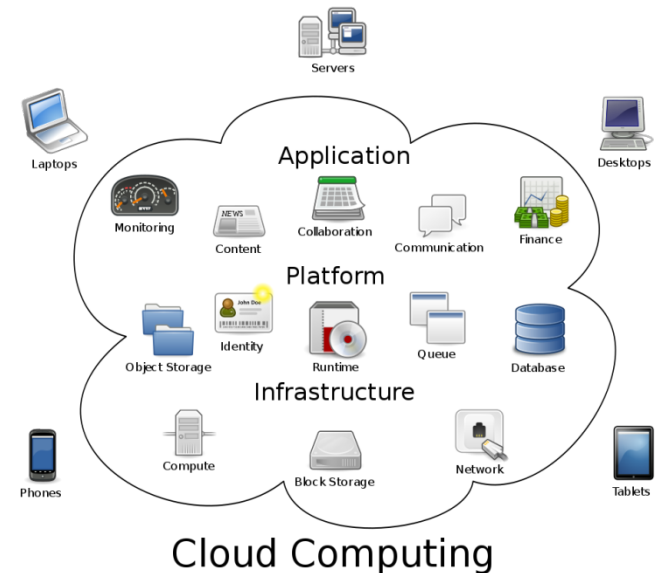
- Four main core efforts in CBES and supporting computational technology
 - next-generation CBES methodologies for:
 - o discretization and solution of multiscale problems
 - o formulation, discretization, and solution of highly nonlinear multiphysics problems
 - o advanced methods for the solution of problems with evolving domains and discontinuities
 - o nonlinear model reduction methods for online computing
 - o powerful linear algebra methods (low rank approximation schemes, scalable solvers, ...)
 - o advanced computational geometry
 - o innovative computational approaches for emerging HPC systems (space filling curves, multilevel methods)

- Related core efforts in CBES

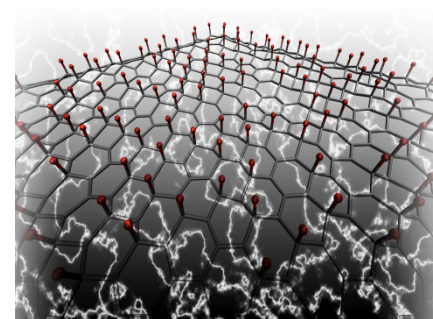
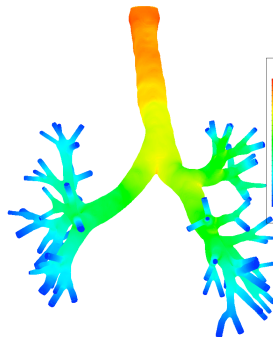
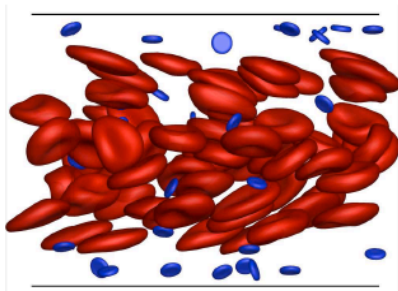
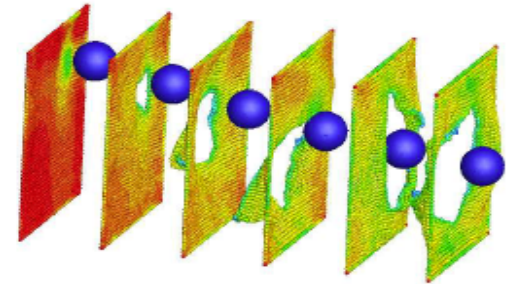
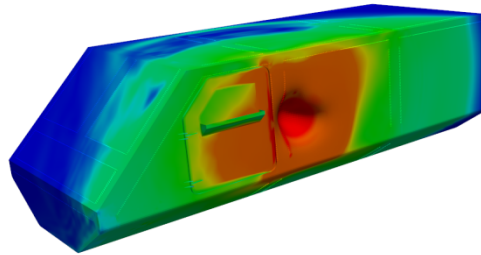
2011-2012: The Army launched several research efforts focused on model order reduction in particular at SLAD and TARDEC

2012: ARL announced the award of two Collaborative Research Alliances as part of the Enterprise for Multiscale Research of Materials (EMRM) (which is comprised of an In-house Initiative (I3M) and two CRAs — Materials in Extreme Dynamic Environments awarded to a consortium led by Johns Hopkins University, and Multiscale Multidisciplinary Modeling of Electronic Materials awarded to an Alliance led by University of Utah)

- Four main core efforts in Advanced HPC
 - o Domain Specific Languages (DSL) for finite element computations and fast scalable iterative solvers
 - o high-performance data analytics
 - o real-time computing
 - o cloud computing for the battlefield



- Three main research (and **validation**) themes
 - computational blast and ballistic for systems
 - computational medical theme
 - computational materials (exploratory)





AHPCCRC: THE IMPLEMENTATION 2012-2017 (Phase II)

- 8 research projects (instead of 18-20)
 - better management and focus on transition
 - better integration with the other components of the program
 - performance metrics
 - higher visibility and stronger impact
- Formulated and designed based on **validated** Army interests
 - include identified “Army partners”
 - Thematic Research incorporates high-impact Core CBES and/or Core Advanced HPC sub-theme(s)
 - include identified CPU resources, deliverables and transition
 - provides Summer Institute Research project(s)
 - 2 month summer internship at ARL “incentive” per 5-year
 - 2 workshops requirement per 5-year



RESEARCH PROJECTS

<u>Title</u>	<u>Performers</u>	<u>Core</u>	<u>Thematic</u>
HPC-enabled parametric studies of under body blasts: From high-fidelity to reduced-order models	Stanford Berkeley UTEP and NMSU	70%	30%
Computational fluid dynamics for blood transfusion on the battlefield and inhalation of toxic agents in the lungs	Stanford	50%	50%
2D nano-electromechanical devices	Stanford	40%	60%
High-performance data analytics	Stanford	100%	0%

<u>Title</u>	<u>Performers</u>	<u>Core</u>	<u>Thematic</u>
LisztFE: Finite element codes for exascale computers	Stanford	100%	0%
Scalable, shared and distributed memory algorithms for computational solids, fluids and geometry	Stanford	100%	0%
Towards enabling battlefield decision-making and planning through information processing in the DoD cloud	UTEP	100%	0%
Toward real-time computing for applications in the field	NMSU	100%	0%

- Project identification
 - title
 - research team and Army collaborators
- Project overview
 - scientific problem
 - Army relevance
 - technical challenges
 - objectives
 - technical approach
 - related work
 - collaborations with Army
- Project components
 - core components
 - thematic components

- Project deliverables
- Project roadmap
- Technical content
- APP 2013-2014
- Project publications (FY 2013)

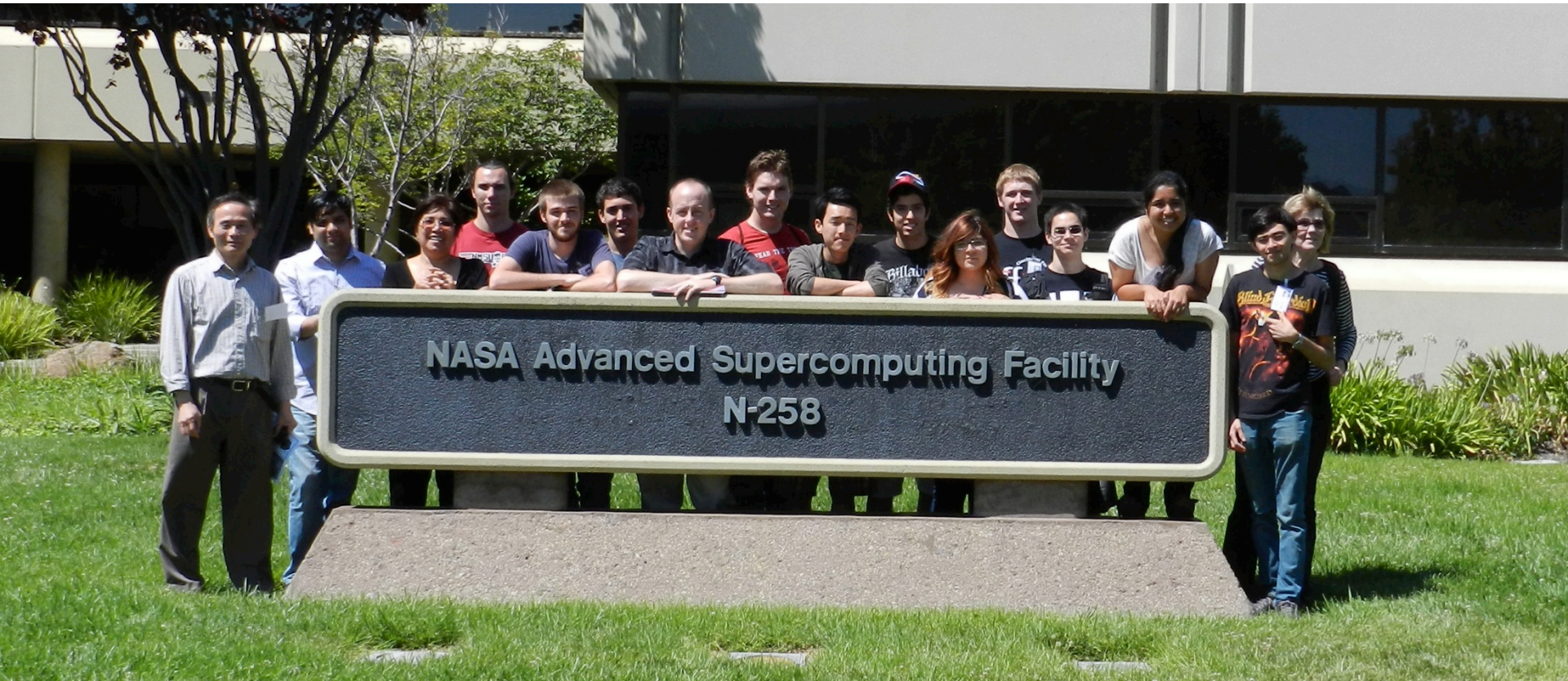
- NSF blue ribbon panel on CBES – major findings (2006)
 - CBES is a discipline indispensable to the nation's continued leadership in science and engineering: biomedicine, nano-manufacturing, homeland security, microelectronics, energy, environmental sciences, materials, and product development
 - formidable challenges stand in the way of progress in CBES research: ***multiscale*** and ***multiphysics*** modeling, ***real-time integration of simulation methods with measurement systems***, model validation & verification, handling large data, visualization, ***education*** of the next generation of engineers and scientists in the theory and practices of CBES
 - our nation's leadership in CBES is eroding

THREATS (NSF, 2006)

- The chief global economic (and other) competitor of the US is China
 - in 2010: China graduated 10,000 PhDs
 - The US graduated 8,000 PhDs, 5,334 of whom are non US citizen
 - the cost of an engineer in China is $1/10^{\text{th}}$ to $1/6^{\text{th}}$ that of an engineer in the US
- Since 1988, Western Europe has produced more science and engineering journal articles than the US
 - the highest growth is in East Asia (492%), followed by Japan (67%), and Europe (57%), compared with 13% for the US
- The key for offsetting these disadvantages is CBES
 - throughout Europe and Asia, governments are making major investments in computational engineering and science

AHPCRC SUMMER INSTITUTE

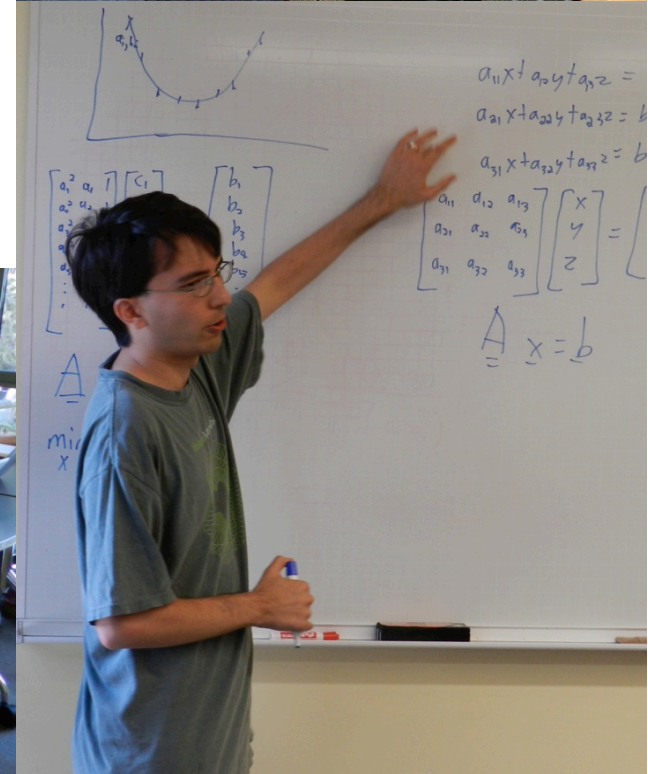
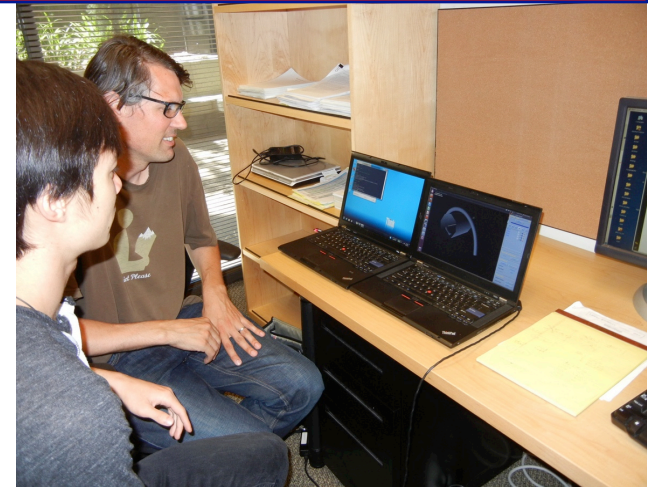
- 13 undergraduates: MSU(1), NMSU(3), Stanford (4), UTEP(2), and Columbia(1), Cal Poly(1) and University of Washington(1)
- Majors in aerospace, electrical, and mechanical engineering, and applied mathematics and computer science



PROGRAM OBJECTIVES

- Train the next generation of scientists and engineers in CBES
- Provide students with early research experience to encourage them to pursue advanced degrees
- Provide students with Army relevant experience to encourage them to pursue careers in defense-related science and engineering

- Programming in C, Python and MPI
- Parallel Computing
- Geometric Modeling and Mesh Generation
- Computational Discrete Mathematics
- Engineering Optimization
- Computational Engineering
- Subdivision surfaces



- Google
- Facebook
- NASA Ames Research Center
- Computer History Museum



- NMSU minority participant admitted at Stanford Graduate Engineering Program
- **Virtual Braille Keyword (VBK)**
 - concept quickly spread worldwide: in less than two weeks, it got featured by many media outlets in the US (including NPR), the UK, Brazil, Vietnam, Germany, the Netherlands, Mexico, and New Zealand, to mention only a few countries
 - its reception in the worldwide community of visually impaired people, and their educators and family members, has been overwhelmingly positive as demonstrated by the following quotes from some of the many emails we have received

"I think such a device could prove immeasurable productive with such learners,"

Jamie Bowring, Leader of ICT, Exeter Royal Academy for Deaf Education, UK

"I wanted to express my excitement on the phenomenal project you have accomplished in creating touch-screen Braille writer software for iPad and App. This is certainly a break-through in the field of Braille writing devices (such as the Braille Notes)."

Dora Rodriguez, M.A., DSPS Computer Adaptive Instructor,
Disabled Students Programs and Services, City College of San Francisco

"Needless to say we are all very excited about the thought that this application might be a real possibility for our children"

Camille Peterson-Steege, mother of a blind child

"I have just read the news article on the touchscreen Braille writer - wow! If you need a tester I have an 8 year old daughter who is blind & would love to try this technology"

Jane McCreadie, Scotland

"I am of the opinion that the solution you are developing would have a significant positive affect on the lives of many disabled users"

Paul Bepey, Access Technology Manager, BBC

SUCCESS STORIES

“She has been wanting a tablet, iPad since they have come out ... and something like this would open a whole new world for the blind. Danielle is 12yrs old. Keep up your good work. Thank you.”

Beverly Houch, Shop Administrator, Direct Ph/Fx: 714.628.7542



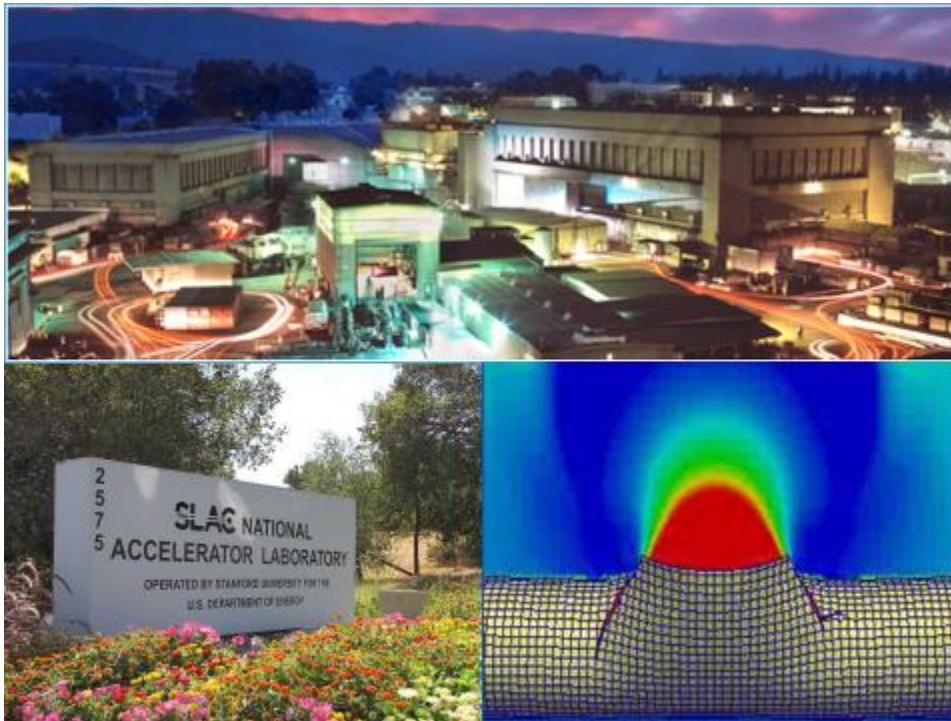
- VBK was nominated for the 2012 Chairman’s Awards in Advancement in Accessibility (FCC) ... **and won the Honor mention**

- AHPARC Poster Competition at USNCCM 2012
 - excellent opportunity for graduate and undergraduate students to meet with, learn from, and discuss their research work with world leaders from a variety of fields
 - presenting author must be a full-time graduate or undergraduate student who has made a substantial contribution to the presented work
 - in addition to the poster competition, students may submit an abstract to present a talk in an appropriate minisymposium, giving them further visibility at the congress
 - competition is judged by a panel of 3-5 expert scientists from academia, government, and/or industry with \$500 honorarium as well as commemorative plaques awarded to selected outstanding posters
 - most attended session of the USNCCM 2012 congress!

- Refereed publications (4//1/13—9/30/13)
 - 36 in archival journals
 - 30 in conference proceedings
- DARPA Young Faculty Award
- International Association of Computational Mechanics Award
- Katayanagi Prize in Computer Science
- Two new members of the National Academy of Engineering

OTHER FORMS OF OUTREACH

- Workshop on Computational Methods for Problems With Evolving Domains and Discontinuities (December 3—5, 2013, Stanford)



- 25 leaders in the field from 7 different countries

- AHPARC Summer Institute graduates regularly intern at ARL
 - 21 undergraduates since summer 2010
- AHPARC graduates hired at ARL
 - David Powell (Ph. D.) hired at WMRD
- AHPARC is currently promoting
 - long-term visits by graduate students
 - o Matthew Kury
 - o Alejandro Queiruga
 - post-doc hires
 - additional and longer faculty visits



- This year, each APP contains a detailed section on planned collaborations with Army — for example (extract from UBB APP)
 - one-day visit to the Blast Institute at ARL to initiate with Dr. Scott Kukuck and his research team a technical collaboration program based on both high-fidelity modeling and reduced-order modeling of blast problems
 - two-day visit to TARDEC to install the first deliverables
 - similar two-day visit to ARL/SLAD to install the same deliverables and provide an initial training for using them
 - one or more visit to ARL/CSD to establish collaboration with Pat Collins on nonlinear model order reduction for CFD problems
 - Pat Collins will also be visiting Stanford for strengthening this collaboration
 - longer-term visits to ARL by graduate students

PLANNED COLLABORATIONS

- Planned longer-term faculty visits to ARL during summer 2014
 - Michael McGarry (UTEP)
 - Mingjun Wei (NMSU)

