January 13, 2016

Final Report

Extreme Computing and U.S. Competitiveness
DOE Award: DE-FG02-11ER26087/DE-SC0008764

Recipient: Council on Competitiveness
Principal Investigator: Cynthia McIntyre (now Chris Mustain)
Report Prepared by: Chris Mustain
Report Period: March 15, 2013 – Nov 30, 2015

I. Progress / Accomplishments during Current Funding Period

The Council has acted on each of the grant deliverables during the funding period. The deliverables are: (1) convening the Council's High Performance Computing Advisory Committee (HPCAC) on a bi-annual basis; (2) broadening public awareness of high performance computing (HPC) and exascale developments; (3) assessing the industrial applications of extreme computing; and (4) establishing a policy and business case for an exascale economy.

HPCAC: The HPCAC met in Washington, DC, during the funding period on July 11, 2013, December 10, 2013, April 22, 2014, November 5, 2014, April 20, 2015, and October 26, 2015. The Council also conducted several working group calls 2014 and 2015 and hosted three regional software workshops:
- August 25, 2014, at the Council on Competitiveness
- September 12, 2014, at Argonne National Laboratory
- September 30, 2014, at Lawrence Berkeley National Laboratory

Finally, the HPCAC Software group hosted a session in Washington, DC, on August 26, 2014, on how HPC could be used to improve regulatory cost, compliance, and outcomes. The meeting included officials from the Department of Transportation, the Food and Drug Administration, and the Federal Energy Regulatory Commission.

Current members of the HPCAC include:

Dona Crawford; Co-Chair
Associate Director, Computation
Lawrence Livermore National Laboratory

Steven Koonin; Co-Chair
Director, Center for Urban Science and Progress
and Professor of Information, Operations &
Management Sciences
New York University

J. Michael McQuade; Co-Chair
Senior Vice President, Science and Technology
United Technologies Corporation

Vijay Agarwala
Senior Director, Research Computing and
Cyberinfrastructure

The Pennsylvania State University

Richard Arthur
Manager, Advanced Computing Lab, Computational Sciences & Architectures
GE Global Research

Steven Ashby
Director
Pacific Northwest National Laboratory

David Bader
Executive Director, High Performance Computing
Georgia Institute of Technology

Raymond Bair
Senior Computational Scientist for Applications
Argonne National Laboratory

Christopher Carothers
Director, Center for Computational Innovation
Rensselaer Polytechnic Institute

John Campbell
Associate Provost and Chief Information Officer
West Virginia University

Vicki Colvin
Vice Provost for Research; Kenneth S. Pitzer-Schlumberger Professor of Chemistry; and Professor of Chemical and Biomolecular Engineering
Rice University

Spiros Dimolitsas
Senior Vice President and Chief Technology Officer
Georgetown University

Merle Giles
Director, Private Sector & Economic Development
NCSA, University of Illinois at Urbana-Champaign

Brian Goldiez
Deputy Director, Institute for Simulation and Training
University of Central Florida

Robert Graybill
President & CEO
Nimbis Services, Inc.

Robert Hoekstra
Manager, Extreme Scale Computing, Scalable Algorithms Department, Computation, Computers, Information and Mathematics Center
Sandia National Laboratories

Subhash Mahajan
Distinguished Professor and Special Advisor to the Chancellor
University of California, Davis

Gary Mastin
Lockheed Martin Fellow and Chief Scientist, Mission Development, Corporate Engineering & Technology
Lockheed Martin

Michael Norman
Director, San Diego Supercomputer Center; Dean, College of Engineering; and Dowd University Professor
University of California, San Diego

Alice Popescu-Gatlan
Engineering Manager, Global Synergies
Deere & Company

Daniel Reed
Vice President for Research and Economic Development, and Computational Science and Bioinformatics Chair
University of Iowa

Addison Snell
Chief Executive Officer
Intersect360 Research

Suzanne Tichenor
Director, Industrial Partnerships Program,
Computing & Computational Sciences
Oak Ridge National Laboratory

David Turek
Vice President, Exascale Systems
IBM Corporation

HPCAC meetings also feature a variety of guests who are experts and leaders in HPC policy, markets, and technology. Recent guests include:

Barry Bolding
Vice President, Marketing and Business
Development
Cray Inc.

Steve Binkley
Associate Director for Advanced Scientific
Computing Research, Office of Science
U.S. Department of Energy

Patricia Falcone
(then) Associate Director for National Security and
International Affairs
Office of Science and Technology Policy Executive
Office of the President

David Kahaner
Founding Director
Asian Technology Information Program

Thomas Kalil
Deputy Director for Policy
Office of Science and Technology Policy; and
Senior Advisor for Science, Technology and
Innovation, National Economic Council
Executive Office of the President

Robert Meisner
(then) Director for Advanced Simulation and
Computing
National Nuclear Security Administration
U.S. Department of Energy

Scott Misage
Vice President and General Manager for High
Performance Computing
Hewlett-Packard Company

Mark Seager
Intel Fellow & Chief Technology Officer for the HPC
Ecosystem
Intel Corporation

Robert Sorensen, Jr.
Research Vice President
HPC Research Group
IDC Corporation

The HPCAC aims to increase national competitiveness through the transformational use of advanced computing. The Committee defines advanced computing as "the systematic use and development of domestic high-end computer hardware, operating and applications software, data management and analytics, visualization tools, and necessary infrastructure, talent and knowledge to exploit these capabilities (the HPC ecosystem) to solve science, engineering, industrial and commercial, and energy and national security challenges."

HPCAC Members include representatives of industry, academia, and the national laboratories. The meetings and calls have served to identify top priorities on which participants believe they can drive action and to form working groups to execute on those priorities.

To sustain U.S. leadership in advanced computing, the HPCAC formed working groups around the following priorities:

- Define a skill set/"curriculum" for an undergraduate engineer or business student that prepares that person to "think computationally," addressing gaps and needs as identified by membership, and communicating recommendations to appropriate educational entities and professional organizations.

- Conduct a series of targeted forums with independent software vendors (ISVs), users, and laboratories to examine licensing/business models that (1) meet the needs of all parties in lowering barriers to entry and use and (2) incentivize ISVs to scale to evolving parallel hardware architectures.

- Develop policy recommendations that broaden access for industrial/commercial users to high-end computing capabilities largely resident in national laboratories and university supercomputer centers.

The Council convened the HPCAC working groups several times and reported to the entire Committee on their findings and recommendations. The working groups also developed two industrial surveys – one to assess the industrial applications of extreme computing, and another to understand industry priorities related to skills, software, and access.

Public Awareness: The Council carried out several activities to broaden awareness of the value of high performance computing and exascale development. The co-chairs of the HPCAC brief senior leaders each year in the Council's Technology Leadership and Strategy Initiative (TLSI). The TLSI brings together almost 50 corporate chief technology officers, heads of university research, and deputy directors at the national laboratories to advance American technology commercialization, leadership in strategic technologies, and the application of technology toward grand challenges.

In addition, the Council integrates insights about the value of HPC within the agendas of other initiatives. For example, on April 16, 2014, the Council organized a dialogue at the University of California, Berkeley, as part of its American Energy Manufacturing Competitiveness Partnership (AEMC) with the Assistant Secretary for Energy Efficiency and Renewable Energy (EERE) at the Department of Energy. The dialogue

included a session on how advanced computing can transform business, featuring Dawn Manley, Deputy Director of Chemical Sciences at the Sandia National Laboratories.

In September of 2015, this idea was carried further when David Danielson, Assistant Secretary of Energy for EERE, announced the HPC for Manufacturing Initiative at the Council's 3rd American Energy and Manufacturing Competitiveness Summit. The new initiative is administered by the Lawrence Livermore National Lab. The first solicitation resulted in 44 concept paper submissions. Of those, 18 have been invited to submit full proposals. The next solicitation is expected in early 2016.

At the 2013 and 2014 Supercomputing Conference, the Council presented on the work of the HPCAC and helped organizers at the Argonne National Laboratory put together a series of talks that showcase industrial users of HPC. The "HPC Impact Showcase" was a multi-day series of speakers from several industries describing how their companies utilize HPC for competitive advantage. Companies represented included Lockheed Martin, John Deere, Procter & Gamble, Astra Zeneca, Boeing, Dow Chemical, BP, Bank of America, Rolls-Royce, Robert Bosch, Westinghouse and others. The Council also organized a panel entitled "Extreme Computing and Industrial Competitiveness," featuring HPCAC co-chairs Crawford and Koonin.

The Council also organized a well-attended briefing in the U.S. House of Representatives on July 10, 2013, on "why American industry, national labs and academia need advanced computing." Speakers included HPCAC co-chairs Crawford and McQuade, and representatives from the IBM Corporation, Argonne National Laboratory, and Boston University. The event also featured bipartisan engagement with Members of Congress Randy Hultgren (R-IL) and Chaka Fattah (D-PA).

The Council utilized social networks, trade publications, event demonstration booths, and the speaking engagements of its executives to promote the value of advanced computing to U.S. competitiveness.

Assessing the industrial applications of extreme computing: In November 2014 the Council released *Solve. The Exascale Effect: the Benefits of Supercomputing Investment for U.S. Industry* (Attachment 1). The report examines industrial use of HPC and suggests key actions that would enable companies to leverage the technology more effectively to compete. The report also examines how companies benefit directly and indirectly from government investment at the leading edge of HPC.

To develop *Solve*, the Council published a request for proposals and selected Intersect360 Research to survey companies and to draft the assessment under the guidance of the Council. Intersect360 collaborated with the Council to develop a qualitative discussion guide and a quantitative survey of companies (Attachments 2 and 3). The qualitative discussion guide gathered insights and information from a relatively small sample (14 HPC executives across industrial sectors) to inform the larger quantitative survey and the final assessment.

Over 100 senior industry HPC executives completed the quantitative survey. The survey gathered background information about the company and its HPC usage. It also collected data on: (1) the importance of HPC to the organization; (2) anticipated need to scale to higher levels of computing; (3)

limiting factors on scalability; and (4) the value derived from government-funded supercomputing centers and industrial engagements with these centers.

Some of the key findings from *Solve* are that:

- Many industrial HPC users are confident that their organizations could consume up to 1,000-fold increases in HPC capability and capacity in a relatively short amount of time. For example, over one-third of the companies surveyed believe that they could consume 1,000x increases in less than five years, including many entry-level HPC users.

- Software scalability is the most significant barrier to companies achieving a 10x improvement in HPC performance; and it remains one of the top barriers to achieving 1,000x improvement.

- U.S. industry benefits from government leadership in HPC technologies, but collaboration between government and industry should be strengthened.

Consistent with the deliverable to build public awareness, *Solve* was circulated to key leaders, released to the press, discussed on a podcast, promoted through social media, and presented at the 2014 Supercomputing Conference.

Establishing a policy and business case for an exascale economy: Drawing on over a decade of work on HPC issues and the working groups of the HPCAC, the Council drafted *Perceive – Finding the Future through an Exascale Economy*. The report explains for a general audience (public and policymakers) how the United States is moving toward an "exascale economy," why that move is important for economic competitiveness, and what steps should be taken to maximize the benefits of this transition.

Perceive includes several elements. It explains exascale computing and why it's important for national security, leadership in science, and economic competitiveness. It offers an overview of how members of the HPC community (e.g. industry HPC users, vendors, national laboratories, government agencies, universities) shape the marketplace now and possibly in the future. The report also notes challenges to establishing workable exascale systems, like energy efficiency and software development, and offers a brief overview of efforts in Europe, China, and Japan to lead in exascale.

To help the reader understand how widely HPC impacts the U.S. economy, *Perceive* includes snapshots of how companies in key sectors – those that account for a large share of U.S. jobs and gross domestic product – use HPC to compete. Building on the insights of the *Solve* report, the *Perceive* report makes the case that the impact and use of HPC is poised to grow significantly. The report also notes how HPC can impact small and medium sized enterprises.

Finally, the report includes findings and recommendations from the HPCAC working groups on skills, software, and talent. Although not a deliverable under this grant, the working groups also developed a second industry survey (Attachment 4) to quantify industry views on these

topics and lend deeper insights into which issues are most important to address. Those survey results are expected in January 2016 and will be included in the release of the *Perceive* report.

II. Unexpended Funds

As of December 22, 2015, the Council shows a remaining balance of $834.64. The Council intends to submit an amended Form F270 to draw on this total due to late receipt of conference call bills, copier charges, and reallocation of personnel time through the end of the award.

Council Contact for this Report

Mr. Chris Mustain
Vice President
Council on Competitiveness
cmustain@compete.org
(202) 969-3398