

U.S. Manufacturing— Global Leadership Through Modeling and Simulation

White Paper
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This is today's headline: *The Collapse of Manufacturing*, and many U.S. manufacturers and their supply chains are in crisis. In this time of crisis, the U.S. has the technological tools to maintain our competitive edge and global leadership in manufacturing, but we risk our manufacturing leadership position if we fail to utilize the game-changing tool of high performance computing (HPC) for modeling, simulation, and analysis.

U.S. companies are responsible for producing a majority of the HPC systems appearing on the most recent list of Top 500 Supercomputer Sites.¹ The use of HPC has provided a competitive advantage for many of the manufacturing Fortune 50. These companies employ in-house advanced computing and have access to high performance computing hardware, software, and technical resources through partnerships with national laboratories and universities. For U.S. leading manufacturers, to out-compete is to out-compute. The U.S. Bureau of Economic Analysis indicates that manufacturing gross output has increased through 2007.² We must engage the tools and new technologies that have been the keys to our success.³

This transformative technology is used by international competitors of U.S. manufacturers, often through public-private partnerships some of which are cross-border. For example, HLRS, the German national high performance computing facility in Stuttgart, has assisted the nation's coal-fired power plant industry in using modeling and simulation to optimize plant design and operation. These simulations have led to reduced emissions, higher efficiency, greater boiler availability, and increased safety.⁴ Meanwhile, the partnership between BMW and Japan's Earth Simulator supercomputer is benchmarking optimal automotive design, safety, and performance.⁵

U.S. national and economic security critically depend on our having innovative and agile manufacturing capabilities, and the current economic conditions have only heightened the need to accelerate competitive advantages for U.S. manufacturing companies.⁶ Manufacturers can maintain their global leadership position only through technological differentiation, not through labor cost savings or other "old-world"⁷ advantages. U.S. manufacturing is vital to the deployment of needed infrastructure, new energy sources, and transportation.

1 See <http://www.top500.org/>.

2 The U.S. Bureau of Economic Analysis (2008, December 15). *Gross Output by Industry*, at http://www.bea.gov/industry/gpotables/gpo_action.cfm.

3 Barrett, Amy. (2009, February 13). US: Manufacturing at home. *BusinessWeek*, at http://www.businessweek.com/smallbiz/content/feb2009/sb2009029_090545.htm.

4 Risio, B. PhD. (2008 October) *3-D Flame Modeling in Power Plant Applications* at <http://www.hpcuserforum.com/presentations/Germany/RECOM-3D-Flame-Modelling-HPC-User-Forum.pdf>.

5 Joseph, Earl (2005, January 27) *HPC User Forum, Earth Simulator Visit* [Meeting notes]. International Data Corporation.

6 Helper, Susan (2009). The High Road for U.S. Manufacturing. *Issues in Science and Technology* 25(2):39-45.

7 Palmisano, Sam (2009, February 19). Smart ways to prepare for a world beyond recession. *Financial Times*.

A substantial effort toward wider adoption of modeling and simulation requires the commitment of intellectual capital, computer hardware and software for complex problem solving, and other resources from among the diverse advanced computing assets spread across the nation's regions, states, and advanced computing centers. This truly successful national initiative will leverage these vital resources from a new public-private partnership to bolster⁸ the U.S. manufacturing sector.

New Manufacturing “Call to Service”

The U.S. federal government should issue a “call to service” to U.S. manufacturing sector leaders by creating a national manufacturing initiative enabled by advanced computing. Leaders in advanced computer-enabled design and manufacturing should participate by leveraging their expertise in modeling, simulation, and analysis and partnering with the federal government to improve U.S. manufacturing competitiveness. The outcome of this call to service will be to:

- Accelerate and broaden the use of modeling and simulation
- Increase penetration of these tools into smaller companies (pushing these tools further down into the supply chain)
- Solve the biggest complex problems with the latest techniques
- Compete through innovation

The federal government, through the national laboratory system, offers the greatest scientific and engineering resources, computer assets, and research software to be deployed for the initiative. The initiative must also call upon, bring together, and leverage all of the nation's advanced computing resources—state to state, region to region, center to center.

An overarching framework for the initiative might look something like the following:

1. Facilitate formation of a software consortium of advanced computing users from industry, government, and academia addressing the often daunting issues surrounding software for advanced modeling and simulation. Software development for solving complex problems will require competent and innovative work on a continuous basis. The consortium will address:

- Moving legacy codes to new architectures and new machines
- Writing new codes to accomplish new powerful capabilities
- Formulation of new approaches to solve known problems
- Algorithm development to convert the new formulations into viable, hardware architecture-aware codes
- Methods to assure efficiency and scalability across a broad horizon of applications and algorithms
- Embracing multiple cores and accelerators in massively parallel architectures
- Methods for verification and validation that lead to certification of codes
- Using design methods that incorporate the reality of stochastics from the start
- New approaches to licensing and encouragement of open source software
- Develop new models for assuring the protection of corporate intellectual property while still allowing companies to engage in meaningful, innovation focused collaboration

A U.S. software consortium will enable new understanding and innovation. The consortium would be recognized as a worldwide leader in software development for addressing complex problems and proving to be a tremendous national advantage.

2. Establish advanced computing service centers to serve each of the 50 states for economic development. These service centers will work with local industrial partners to increase the innovation capacity of regions and broaden the adoption of advanced modeling and simulation throughout our national supply chains. The centers will help in the following ways:

- Coordinate and increase industry access to the nation's advanced computing assets
- Provide local professional development opportunities
- Facilitate discovery of advanced modeling and simulation for innovation among companies with limited or no technical experience

Focus on “Simulation-Based Manufacturing”

As previous Council research has shown^{9,10} modeling and simulation are fundamental analytical tools underlying the new way product design is conducted—with virtual engineering and tests replacing costly/wasteful physical processes. Employing computational models will reduce development costs, certification costs, re-engineering costs, design cycle time, and improve performance and efficiency while reducing waste such as emissions, noise, and raw material use. Modeling and simulation also facilitates innovations not previously possible such as modeling complex systems in energy (e.g., the Smart Grid), transportation, and health care and can help lead the way toward the creation of new jobs, industries, and markets.

Participants in the new manufacturing initiative, as well as those in national laboratories and HPC centers, must work to demystify “supercomputing” and “high performance computing.” They must promote a broader understanding of the power of advanced computing, virtualized models, and simulation-based engineering for lowering costs, improving product performance, and shortening product design cycles. The new focus should be on “simulation-based manufacturing,” not on “computing.”

Conclusion: For U.S. Manufacturers to Out-compete, They Must Out-compute

The long-term national and economic security of the United States is increasingly dependant on innovative and agile manufacturing capabilities. Present economic conditions have amplified the need to strengthen the competitive advantages of U.S. manufacturing companies in the global marketplace. This can only be achieved through technological differentiation. The use of high performance computing has already provided a competitive advantage for many companies, and as a result a national public-private partnership supporting the adoption of modeling, simulation, and advanced computing is recommended for the success of the U.S. manufacturing sector.

- GE Aviation and Energy executive engineer Bob Zacharias: “HPC and accurate design tools enable a company like GE to advance the state-of-the-art of our product line in a cost effective way. We can design, build, and sell jet engines, power generation gas turbines, wind turbines, etc that are more efficient, quieter, with less emissions, and are competitively superior (name your commercial benefit)

9 (2008). *Reveal: Council on Competitiveness and USC-ISI Broad Study of Desktop Technical Computing End Users and HPC*. Washington, DC: Council on Competitiveness.

10 (2008). *Reflect: Council on Competitiveness and USC-ISI In-Depth Study of Technical Computing End Users and HPC*. Washington, DC: Council on Competitiveness.

and bring these products to market faster, by decreasing the design cycle time through less reliance of development testing.”

- Caterpillar, Inc., has used virtual reality technology to test and improve the efficiency of heavy earth moving equipment. Design changes that once took between six and nine months to test and implement with computer-aided design blueprints and full scale wooden models, can now be made, at great savings, in less than one month.
- DreamWorks Animation, SKG's Chief Technology Officer Ed Leonard: “It became very clear to us that it wasn't about making something you already knew how to do go faster. It was about creating entirely new ways of making film and what that would do to the creative process...It's not optional for us to stay on the leading edge—it's essential.”
- PepsiCo, Inc.'s former Chairman and CEO Mr. Roger Enrico: “Computing power, along with the talent of people who knew how to use it, gave us the confidence we needed to mobilize our entire company and put a large majority of our resources behind a focused strategy...[it] gave us incredible insight that ultimately transformed our business.”
- Procter & Gamble Company's director of modeling and simulation, corporate research and development Tom Lange: “We used to use HPC modeling and simulation for autopsies—to explain why things didn't work after they failed, but now we have the computing power to get things done correctly up front rather than wait for a catastrophic failure and then try and figure out what went wrong. In other words, high performance computing has allowed P&G to be more accurate and relevant about what's going to happen in the real world.”
- Boeing's chief engineer, Enabling Technology and Research, Doug Ball: “Here in the U.S., we no longer enjoy the advantage we had in the 1950s and 1960s relative to the rest of the globe. Today our competitors are just as capable of making innovative discoveries as we are...Our work with supercomputers allows us to get a better product out the door faster, which makes us more competitive.”
- Pioneer Hi-Bred International, Inc., a DuPont business, has been getting the company the answers it needs with HPC. It is essential for providing alternative sources of energy, faster improvement in new seed products, staying ahead of the competition, making a major jump in innovation and productivity, and being able to help meet some of the world's most pressing demands regarding world food problems.
- PING Golf's senior engineer Eric Morales: “At PING more than 85 percent of the company's revenues are generated by new products that have been developed in the last two years. The implication is clear—innovate or die...There's no question about it—high performance computing is a strategic asset that has made us one of the top contenders in this very competitive game.”

The Council has conducted industry studies as well as individual case studies within the private sector to document and benchmark the success of individual firms during and after their adoption of HPC. The findings^{11,12,13} indicate the success they experienced.

11 (2008). *Advance: Benchmarking Industrial Use of High Performance Computing for Innovation*. Washington, DC: Council on Competitiveness.

12 (2009). *Goodyear Puts the Rubber to the Road with High Performance Computing*. Washington, DC: Council on Competitiveness.

13 (2009). *Pioneer is Seeding the Future with High Performance Computing*. Washington, DC: Council on Competitiveness.