Compete.
Council on Competitiveness

High Performance Computing and U.S. Manufacturing Roundtable

White Paper
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Problem: U.S. manufacturers must compete on innovation, not cost. High performance computing (HPC) modeling and simulation enables innovation by reducing design cycle time, development costs, certification costs, and re-engineering costs, and improving performance and efficiency while reducing waste.[1] Greater use of HPC modeling and simulation by U.S. manufacturers is therefore critical to creating and keeping good, high-paying jobs, strengthening and growing the U.S. manufacturing base and addressing the 21st century problems facing the U.S. and the world. Structural barriers and obstacles are preventing this from happening.

Proposed Solution: A public-private partnership between leading manufacturers and the federal government that would overcome/mitigate the structural barriers and obstacles to broader and deeper use of HPC modeling and simulation by U.S. manufacturers.

Why Now?

- Proactive measures by the public and private sectors are needed to ensure U.S. manufacturers remain globally competitive.
- The only way to create and keep good, high-paying jobs and keep/grow the U.S. manufacturing base is for U.S. manufacturers to compete on innovation.
- HPC modeling and simulation are crucial to competing on innovation.

1 "U.S. Manufacturing—Global leadership Through Modeling and Simulation," Council on Competitiveness draft white paper, 4 March 2009, p.3.

- DOE and DOD missions have put the United States ahead of most other countries in HPC modeling and simulation, but other countries realize its importance and are catching up.
- The United States must seize the advantage it has and exploit this advantage before the nation loses it.
- Yet the link between U.S. manufacturers and the HPC resources (hardware, software, and an educated and trained workforce) they need to exploit this advantage has stretched to the breaking point, if it has not actually snapped.

Why this workshop?

- HPC modeling and simulation are used extensively by Fortune 50 manufacturers.
- However, structural barriers and obstacles exist to the Fortune 50 manufacturers fully exploiting HPC modeling and simulation, and even more to broadening their use to Fortune 200 manufacturers and deepening their use down the supply chains.
- Both are essential if the Fortune 200 manufacturers and their supply chains are to compete on innovation rather than cost—which is vital to growing/keeping good, high-paying jobs in the United States and strengthening the U.S. manufacturing base.
- The Fortune 50 manufacturers here today are stepping forward in the spirit of a "call to service," and volunteering to form a partnership with the federal government to overcome/mitigate the barriers and obstacles to broadening and deepening the use of HPC modeling and simulation in U.S. manufacturing.
- The Council on Competitiveness' HPC and Manufacturing working group will present the greatest barriers and obstacles, in its experience, to U.S. manufacturer's innovation.
- The working group will put forth ideas and suggestions of how these barriers and obstacles could be overcome/mitigated, as a starting point for discussion.
- Finally, the working group will put before invitees some ideas/suggestions about what agencies and existing/future programs might contribute to overcoming/mitigating them, again as a starting point for discussion.

Topic A: Access to Hardware and Intellectual Capital for U.S. Manufacturers

The federal government, through the national laboratory system, industry and academia, offer crucial computer hardware, scientific and engineering expertise, and research software in modeling and simulation to be deployed toward the goal. All of the nation's advanced computing resources (public and private) must be called upon, coordinated and leveraged for U.S. manufacturing competitiveness.[2]

Problem: U.S. manufacturing research centers lack high-speed Internet access to DOE and NSF leadership class computing facilities.

Possible Solution: A public-private partnership in which the federal government would extend the high-speed Internet backbone to underserved areas and leading manufacturers would underwrite the cost of high-speed Internet connections from their research centers to the backbone. Fortune 200 manufacturers would gain access to HPC resources through the establishment of advanced HPC service centers that would serve each of the 50 states for economic development (see below).

Problem: U.S. manufacturers need leadership-class computational resources, not only for high-fidelity capstone simulations, but also for sets of verification and validation simulations.

Possible Solution: Leadership-class computational resources and a new INCITE-like program that would allow U.S. manufacturers to compete for time to do both high-fidelity capstone simulations and sets of verification and validation simulations. This public-private partnership would combine initial access to HPC resources supported by the federal government that would enable leading U.S. manufacturers to begin to exploit HPC resources and pay per use, once they are engaged.

Problem: U.S. manufacturers' intellectual property needs to be protected.

Possible Solution: New models should be developed that assure the protection of corporate intellectual property while still allowing companies to use leadership-class computational resources and engage in meaningful, innovation-focused, pre-competitive collaborations.[3] These models should allow for the use of proprietary software, collaborative improvements to proprietary software, protection of proprietary results, no publication requirement for proprietary results, etc., while requiring publication of results sufficient to demonstrate the value of the simulations and enable resources to be awarded competitively.

2 "U.S. Manufacturing—Global leadership Through Modeling and Simulation," Council on Competitiveness draft white paper, 4 March 2009, p.2.
3 "U.S. Manufacturing—Global leadership Through Modeling and Simulation," Council on Competitiveness draft white paper, 4 March 2009.

Three Overseas Examples:

- HLRS, the German national HPC facility in Stuttgart, has assisted the nation's coal-fired power plant industry in using modeling and simulation to optimize plan design and operation.[4]
- Partnership for Advanced Computing in Europe (PRACE) allows industry to compete for access to leadership-class computing facilities while enabling them to protect their intellectual property.
- A partnership between BMW and Japan's Earth Simulator supercomputer is benchmarking optimal automotive design, safety and performance.[5]

Topic B: Access to Software and Intellectual Capital for U.S. Manufacturers

The Fortune 50 HPC-intensive manufacturers are global industrial leaders. Their use of modeling and simulation enables them to compete on innovation. The federal government national laboratory system has research and production software that could be leveraged to enhance the use of HPC by the Fortune 50 manufacturers, broaden its use to the Fortune 200 manufacturers, and deepen its use down the supply chain for the competitive advantage of U.S. manufacturers.

Problem: Much of the modeling and simulation software currently available, either through open source or ISV software licenses, originated in codes brought out of the national labs and commercialized in the late 1960s and early 1970s. Much of it neither incorporates state-of-the-art methods nor runs efficiently at scale on current massively parallel computer architectures. Creating new software of this kind involves high risk and modest initial reward. Consequently, the market alone has not been able to address the commercial software problem for HPC modeling and simulation, as it was not able to address the hardware problem.

Possible Solution: New public-private models should be developed to bring into being state-of-the-art, multi-physics, multi-scale codes that run efficiently at scale on current massively parallel computer architectures, and that are robust and reliable enough, and sufficiently documented and supported, to be used commercially.

A federal program combining incentive "push" and demand "pull" might be a possible model. The program would incentivize the creation of new commercial software for HPC modeling and simulation through a competitive program that would provide funding for it. It will be important for the incentives to be equally available to commercial software vendors—partially proprietary, and partially open vendors and open source vendors—so that there is a level playing field.

4 "U.S. Manufacturing—Global leadership Through Modeling and Simulation," Council on Competitiveness draft white paper, 4 March 2009, p. 1.

5 "U.S. Manufacturing—Global leadership Through Modeling and Simulation," Council on competitiveness draft white paper, 4 March 2009, p. 1.

At the same time, the program would increase the market for such software to the Fortune 200 manufacturers and the supply chain for major manufacturers by establishing advanced computing service centers in each of the 50 states to provide education, training and support for smaller companies to learn how to use HPC modeling and simulation, combined with a targeted tax credit to encourage them to do it. The advanced computing service centers would help in the following ways:[6]

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

Proposition: National Software Alliance

Corporate industrial leaders in advanced computer-enabled design and manufacturing should be "called to service" to leverage their expertise in modeling, simulation, analysis and partnering with the federal government to improve U.S. manufacturing competitiveness. The Alliance will be a public-private partnership that includes advanced computing users from industry, government and academia, and will address 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. Issues the Alliance will address include the following:[7]

- 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 hierarchical processor structures in massively parallel architectures;
- Methods for verification and validation that lead to certification of codes;
- Using design methods that incorporate the reality of stochastic processes from the start; and
- New approaches to licensing and encouragement of open source software.

6 "U.S. Manufacturing—Global leadership Through Modeling and Simulation," Council on Competitiveness draft white paper, 4 March 2009, p. 3.
7 "U.S. Manufacturing—Global leadership Through Modeling and Simulation," Council on Competitiveness draft white paper, 4 March 2009. p. 2.

Topic C: Workforce Development for HPC Modeling and Simulation

Problem: The U.S. is failing to educate and train young scientists and engineers to design, develop, and implement algorithms and codes for the massively parallel computer architectures of the present, let alone the radically new architectures of the future, and to exploit HPC modeling and simulation for verification and validation.

Possible Solution: A public-private partnership to educate and train young scientists and engineers to use HPC modeling and simulation on current and future architectures should be explored. DOE, NSF and other agencies should consider creating fellowship programs to train graduate students and postdocs in HPC modeling and simulation, and expanding the Presidential Early Career Awards in Science and Engineering (PECASE) program in this area. These programs could be linked to internships and summer programs at manufacturers who use or want to start using HPC modeling and simulation.