High Performance Computing

Collaborate.

Moving Beyond Islands of Innovation

Third Annual High Performance Computing
Users Conference
September 7, 2006
Washington, D.C.

Compete.

Council on
Competitiveness

Third Annual High Performance Computing Users Conference Report

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Introduction

Moving Beyond Islands of Innovation

The Council's third annual High Performance Computing Users Conference, held during our twentieth anniversary year, marked an important turning point for the Council's—and America's—efforts to make the proven innovation, productivity and competitiveness benefits of high performance computing more pervasive within U.S. industry.

The federal government stepped up its support for High Performance Computing (HPC) through the American Competitiveness Initiative. This initiative, announced in 2006, seeks to double the federal commitment over the next decade to basic research in the physical sciences—including "promising areas such as…supercomputing." In 2006, federal programs aimed at accelerating innovation by giving companies access to some of the nation's most powerful computers also stepped up their investments and activities, including the Department of Energy's INCITE and SciDAC programs and others involving the National Science Foundation (NSF) and the National Nuclear Security Administration (NNSA). Council studies during the year found that the NSF and NNSA public-private partnership programs have been overwhelmingly successful, and the DOE once again chose to announce the INCITE award winners in conjunction with the Council.

Three years of pioneering Council research under the guidance of our HPC Advisory Committee laid the groundwork for announcing the National Innovation Collaboration Ecosystem (NICE), an exciting new partnership program we are leading with the University of Southern California's Information Sciences Institute (ISI). NICE will boost America's national productivity and competitiveness

From left: David E. Shaw, chairman, The D. E. Shaw Group, and co-chair, Council on Competitiveness HPC Advisory Committee; Dr. Karen A. Holbrook, president, The Ohio State University, and co-chair of the Council's HPC Advisory Committee; and Deborah L. Wince-Smith, president, Council on Competitiveness.

by making HPC systems and expertise more broadly available to companies, entrepreneurs and even solo inventors. The Council-sponsored research identified the benefits of HPC for industry, the barriers preventing wider usage, and successful models of public/private sector collaborations involving HPC. NICE will serve as a catalyst to spread public-private partnerships and help turn today's islands of HPC-based innovation into a national infrastructure for world-leading productivity and competitiveness.

The Council's HPC activity supports our larger National Innovation Initiative (NII), whose groundbreaking "Innovate America" report clearly established that innovation is the surest path to sustained economic growth and global competitiveness. Other governments are pursuing aggressive strategies to strengthen their innovation capacity and link innova-

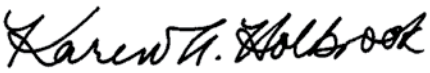
tion with economic development. America's business, university, and labor leaders agree that simply doing business the way it has always been done will not be enough to sustain leadership—either for the country or for U.S. companies.

At the same time, the nature of innovation is rapidly changing. Historically, innovation occurred mainly through the efforts of individual investigators working in single, sharply demarcated disciplines. Today, the biggest advances increasingly come from multidisciplinary collaborations. For studying disease pathways through the body, knowledge is needed about physics, chemistry, biology and in some cases also nanotechnology. Building superior cars requires the ability to look concurrently at interdependent factors, including crashworthiness, aerodynamics, fuel-efficiency, cabin noise and vibration, and ride harshness. No technology has shown greater ability to energize multidisciplinary, collaborative innovation and propel competitiveness than HPC. HPC can shrink time to insight, time to market and time to competitive advantage.

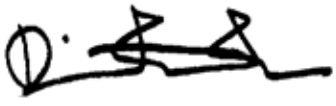
HPC is essential for addressing some of the nation's grand challenges: energy independence, protection of critical infrastructure (e.g., power, telecommunications, financial and transportation systems), and scientific leadership. But the real impetus for innovation occurs at the crossroads between businesses, national labs and other research centers, universities and skilled workers throughout the country. Regions have become the critical nodes for innovation-based economic growth, and some U.S. regions are already exploiting HPC in their economic development plans. Much more of this is needed.

The Council's HPC Advisory Committee will work closely with the Council and ISI in 2007 to prepare NICE for implementation. We want to ensure that NICE responds well to the major needs identified in the Council's research: recognizing the collaborative, multidisciplinary nature of innovation today; learning from successful public-private sector partnerships; supporting experienced and novice HPC users in the private sector; and helping regions to leverage their innovation assets.

The Council's fundamental belief is that U.S. competitiveness and the nation's ability to add high-value economic activity increasingly depend on 21st-century, HPC-based modeling and simulation. We look forward to helping make HPC usage more pervasive, so that U.S. businesses can stay in front of the competition and Americans can enjoy greater prosperity.



Karen A. Holbrook
President
The Ohio State University



David E. Shaw
Chairman
The D. E. Shaw Group

Executive Summary

Needed: A National HPC Ecosystem for Turbocharging Innovation

Council on Competitiveness President Deborah L. Wince-Smith welcomed attendees to the Third Annual HPC Users Conference on behalf of the Council and its conference partners: the Defense Advanced Research Projects Agency, the National Nuclear Security Administration, the Department of Energy Office of Science, and the National Science Foundation.

Three years ago, under the guidance of its HPC Advisory Committee, the Council launched a coordinated program of original research, conferences and workshops to learn how businesses were using high performance computing in practice, how HPC was contributing to innovation and productivity, and what barriers were preventing wider use of HPC in the commercial sector. The primary finding: HPC is indispensable for the survival of nearly all businesses that have adopted it, including some of America's largest companies. HPC is driving much of the innovation that fuels U.S. competitiveness. It is increasingly true that to out-compete, we must out-compute.

The proven competitiveness benefits of HPC are far from being fully exploited today, however. A relatively small group of highly experienced HPC users in industry are shining examples of this technology's effectiveness and stand out as islands of leading-edge innovation. They are surrounded by a much larger group of entry-level HPC users who have not moved up the performance curve to realize the full benefits of HPC. This lack of advancement gives the HPC market a "missing middle" that represents a substantial productivity loss for our country. An even larger number of American businesses—primarily small and medium-size entrepreneurial firms—have never tapped into the advantages of HPC because they view it as beyond their means. We call this group the "never evers." In addition, many U.S. regions and states do not yet understand that HPC is crucial for economic development, for attracting the best-and-brightest companies and individuals. Council research has shown that even for the highly experienced users of this important technology, inadequate production-quality application software and access to needed talent are barriers to more aggressive exploitation of HPC.

> "By investing in an HPC-based ecosystem, America can unleash a new era of innovation-driven growth, create new industries and markets, fuel wealth creation and profits, and generate higher-value, higher-paying jobs."
>
> Deborah L. Wince-Smith
> President
> Council on Competitiveness

A new 21st-century infrastructure is needed to make HPC more widely available for national, regional and business prosperity, and to increase the return on America's public- and private-sector investments in HPC facilities and expertise. The Council has begun an initiative called the National Innovation Collaboration Ecosystem (NICE), under the guidance of its HPC Advisory Committee and in partnership with leading organizations, including the University of Southern California's Information Science Institute. The Council envisions NICE as a powerful resource that will allow businesses of all sizes, as well as entrepreneurs and inventors throughout the nation, to access HPC capabilities and expertise. NICE will be an enabling platform for a new generation of public-private partnerships.

We must aggressively advance this initiative. Failure to take aggressive action will inhibit the competitiveness advantages we need to maintain U.S. leadership in the global economy. "By investing in an HPC-based ecosystem," Ms. Wince-Smith concluded, "America can unleash a new era of innovation-driven growth, create new industries and markets, fuel wealth creation and profits, and generate higher-value, higher-paying jobs."

Conference Proceedings

Keynote Address
The New Frontier in High Performance Computing

Through partnerships and multidisciplinary collaborations, the Department of Energy's Argonne National Laboratory has been transforming our understanding of complex systems—even in fields that historically have not exploited HPC, such as supply chains, sociology, history and anthropology, according to Dr. Robert Rosner, director of the laboratory.

Dr. Rosner described four examples of collaborations in which the lab's HPC systems and expertise are spurring innovation and competitive advantage:

> "This was really an intimately-linked collaboration, right from the start, between the code builders, computer scientists and applied mathematicians, and the physicists and astrophysicists."
>
> Dr. Robert Rosner
> Director
> Argonne National Laboratory

Nuclear Power Plant Design: Keeping America in the Forefront

In collaboration with Argonne and other DOE National Laboratories (through the Global Nuclear Energy Partnership), the commercial nuclear power industry aims to apply experimentally validated HPC modeling and simulation for rapid prototyping and safety risk assessments of nuclear power plants. The financial stakes for U.S. industry are high, Dr. Rosner explained: "The French, for example, are among the very likely competitors for American companies in this field world-wide, and CEA, the French equivalent of the U.S Department of Energy, is working on very similar problems. The question is: will U.S. industry be positioned to participate effectively in the world-wide revival of nuclear energy?"

In this industry, costs are heavily driven by regulatory expense. The ability to shorten the design cycle, and to demonstrate the safety of complex reactor systems to the satisfaction of regulators, is an enormous cost advantage. A science-based, experimentally validated approach, made possible by HPC modeling and simulation coupled to thorough code validation (as opposed to a program based primarily on phenomenology), makes it possible to understand how complex systems will behave even when they are perturbed far beyond their design points. Establishing a margin of safety purely by experimental means is actually risky in the absence of fundamental understanding, and tends to lead to inappropriate risk assessments.

Using experimentally validated HPC, it is also possible to do sensitivity analyses to determine which areas of research and development will produce the best return on investment. Argonne, in collaboration with other national laboratories and universities, is developing the HPC simulation tools that can do this, and that can be easily adapted to new HPC systems as they are introduced.

Astrophysics: When Going It Alone Won't Work

The University of Chicago, together with Argonne, is using HPC to transform our understanding of how Type 1a supernovae explode, and in the process has gained critical insights into multidisciplinary HPC collaborations. These complex stars are the classic yardsticks for measuring the size and age of the universe, and for understanding other fundamental questions about its makeup. While developing the specialized codes to understand these explosive processes, we gained insights into the importance of multidisciplinary collaboration in complex problem solving.

At first, the University/Argonne collaboration thought that a group of computational physicists or astrophysicists could write the simulation code on their own, with occasional interaction with computer scientists. That approach failed—the collaboration learned that a multidisciplinary team was needed, and that the team members had to work collaboratively from the start. "If you want to hold a team of physicists, computer scientists and applied mathematicians together, you can't afford to have one group go off, have deep thoughts for a while, and then expect them to come back some time later and still engage with the folks that have been waiting around," Dr. Rosner explained. "That simply will not happen. This was not a matter of the physicist telling the computer scientist, 'Could you just do this for us?' This was really an intimately-linked collaboration, right from the start, between the code builders, computer scientists and applied mathematicians, and the physicists and astrophysicists."

Dr. Karen A. Holbrook, president, The Ohio State University and co-chair of the Council on Competitiveness HPC Advisory Committee; Dr. Robert Rosner, director, Argonne National Laboratory.

History + Anthropology + Sociology: Mesopotamia Goes Multidisciplinary

The University of Chicago's National Science Foundation-funded collaboration with Argonne used HPC to develop new techniques for multidisciplinary study of history. The team chose to study the evolution of the Tigris/Euphrates area over the past 5,000 years—including population dynamics, weather, land use, and other factors. They successfully constructed a simulation of the physical and sociological environment of that ancient era. And, as Dr. Rosner pointed out, "This is a case where you can actually do validation. You can make predictions taking a certain slice of time, and see whether these are borne out by actually going back and doing the archeology. No one would have thought that archeology would become an HPC application, and here it is."

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> Argonne National Laboratory

Dr. Rosner also pointed out that sociology is rarely considered an HPC computational science today, except perhaps for statistical analyses performed on very large databases, e.g., data mining. Having worked on a simulation of the Tigris/Euphrates physical and sociological environment, one can imagine HPC simulations and modeling in diverse areas involving millions to hundreds of millions of 'actors,' exploring the consequences of individual societal interactions driven by processes such as advertising (and mass communication in general), kinship relations, economic forces, geography, and politics. This is an area in which the issue of code validation becomes supreme; and it is one of the great challenges in this field to understand how such simulation efforts will deal with the validation problem.

Challenges for Multidisciplinary Use of HPC

One major barrier to the use of HPC that spans disciplines, and has been mentioned often in Council conferences and workshops, is legacy software codes "that simply will not run on modern high performance computers," Dr. Rosner said. "Codes can live for decades, but the hardware rarely—if ever—lasts much more than a few years. The challenge is to engineer codes so that the changes in underlying hardware architecture become transparent to the higher-level software developers and users; so that one is not always starting from scratch when moving legacy codes between different generations of computing hardware."

Software also must be more "friendly" to the range of potential users. "We really have to distinguish in a much more systematic way, from the user point of view, different levels of expertise," Dr. Rosner continued. "Argonne is partnering to develop simulation tools from scratch that will be able to keep up with changes in hardware platforms."

Conference Proceedings

Panel
Driving Competitiveness Through Collaborative Computing

Public-private partnerships are evolving to help close the gap between the use of HPC in the public sector and in industry. Dr. Peter Freeman, assistant director for the National Science Foundation's Computer & Information Science & Engineering Directorate (CISE), chaired a panel discussion that explored public-private partnerships from the perspectives of a university HPC center, a national laboratory, and a private-sector business. The panelists provided important lessons on the aspects of collaborations that are working well today, and what must still be done to make the partnerships more successful. Dr. Freeman noted, "It is important to find a collaborative path that allows industry and other less-advanced users to gain early access to HPC technology. It is also important to prevent intellectual property rights issues from remaining a barrier to competitiveness."

The Pittsburgh Supercomputing Center (PSC) received high marks in the Council's recent study of industrial partnerships with National Science Foundation (NSF) centers.[1] PSC also has a strong history of outreach and collaboration at the state and local levels.

Executive Director Beverly Clayton said that PSC has collaborated with industry since its founding 20 years ago as one of the original NSF-funded university HPC centers. In addition to receiving funding from NSF, PSC has also been funded from its inception by the Pennsylvania Department of Community and Economic Development, with the understanding that PSC would provide HPC resources to Pennsylvania companies. Focusing at first on large firms, PSC today also serves small and midsize companies, reaching them through state economic development programs and private sector organizations such as the Pittsburgh High Technology Council.

In her remarks, Ms. Clayton summarized lessons PSC has learned from two perspectives: collaborating with industrial partners, and working with economic development officials.

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> Dr. Peter Freeman
> Assistant Director for Computer & Information Science & Engineering (CISE)
> National Science Foundation

1. See the Council on Competitiveness Study *Partnering for Prosperity: Industrial Partnerships through the National Science Foundation's Supercomputing Resources*, available at www.compete.org.

> "If university HPC centers want to be effective national resources and anchors for regional economic development, they must be able to support a broad spectrum of users, from entry-level to experienced, and assist with a wide range of problems."
>
> Beverly Clayton
> Executive Director
> Pittsburgh Supercomputing Center

University HPC centers and national laboratories must help government officials understand the value of HPC for local, state and regional economic development.

Noting that PSC does not have a "complete recipe for success yet," Ms Clayton stressed that HPC centers must work with executives at the top of state economic development agencies as well as staff "in the trenches" to ensure that they understand the value these centers can deliver. Only then can the officials promote these benefits effectively to companies and help link companies to the centers for regional economic gain. It's difficult to get these messages to stick, however, Ms. Clayton said. There is high turnover in the economic development agencies, and different Pennsylvania governors have shown varying levels of interest. "It's a constant process of education. Every four or eight years, we have to do it again," she said.

Deborah L. Wince-Smith, president, Council on Competitiveness; with Charles H. Holland, director, Information Processing Techniques Office (IPTO), DARPA.

If they are going to partner successfully with industry, university and national laboratory HPC centers must be highly flexible in helping companies to define the projects.

University HPC centers such as PSC need to be extremely flexible when collaborating with industry, according to Ms. Clayton. "We try to work with companies based upon their needs. If university HPC centers want to be effective national resources and anchors for regional economic development, they must be able to support a broad spectrum of users, from entry-level to experienced, and assist with a wide range of problems," she said. This is particularly true when companies come to the center without a well-defined project or model. HPC centers must be prepared to help companies define the model and even run it on the Center's HPC system.

Dr. Ian Foster, director of the Computational Institute, Argonne National Laboratory and the University of Chicago; and Beverly Clayton, executive director, Pittsburgh Supercomputing Center.

Industry-university partnerships will not succeed if companies do not appreciate the value of modeling and simulation.

Ms. Clayton stressed that for public-private HPC partnerships to succeed, companies must understand that HPC modeling and simulation is an important ingredient for business success. It is important, therefore, that companies hire people who have embraced this approach as a way of doing business. Ms. Clayton pointed out that companies won't be able to find appropriate talent if our educational system does not do a better job of teaching modeling and simulation as a third approach to scientific discovery, in addition to theory and physical experimentation. This effort needs to begin at the high school level.

> "Expertise encompasses not only high performance computing in the sense of modeling and simulation, but also large-scale data analysis, data mining, and related computational methods that can also have a dramatic impact on a company's bottom line."
>
> Dr. Ian Foster
> Director of the Computation Institute
> Argonne National Laboratory and the University of Chicago

Dr. Ian Foster, director of the Computation Institute at Argonne National Laboratory and the University of Chicago, shared Argonne's perspectives on partnering with industry. Industrial partnerships at Argonne cover a broad range of activities, ranging from formal cooperative research and development projects to industry use of (and sometimes collaborative development of) Argonne high performance computing software. Indeed, Argonne software for parallel computing, numerical modeling, and grid computing is used by tens of thousands.

Some companies approach Argonne for access to one of the fastest HPC systems in the world. However, Dr. Foster pointed out that access to Argonne's expertise was the attraction for many others, and that this expertise encompasses "not only high performance computing in the sense of modeling and simulation, but also large-scale data

analysis, data mining, and related computational methods that can also have a dramatic impact on a company's bottom line."

Dr. Foster also communicated some important lessons for collaborations and partnerships involving HPC.

National laboratories and their industry partners can enhance their mutual learning by spending time at each others' sites.

Dr. Foster stressed the importance of treating collaborations as opportunities for mutual learning. For example, companies can enhance their in-house HPC expertise by co-locating staff at the sites of their national laboratory partners. In this way, the company representatives can become familiar with new technologies and techniques that they can then incorporate into their business processes. But the most effective staff exchanges work in both directions.

"Having staff from the labs spend time in industry is equally valuable. We've done this at various times in our collaboration with Acxiom, for example," explained Dr. Foster. (Read further for more about the Argonne-Axciom collaboration.) This and other industrial partnerships showed Argonne that the problems industry wrestles with are often similar to those that the laboratory scientists are struggling to resolve. In the case of the parallel virtual file system that Argonne and Acxiom collaborated to develop, "clearly we are able to do more together than either of us could have done alone," Dr. Foster said. No money changed hands in this collaboration, but both sides gained considerable value from it.

The most effective staff exchanges work in both directions. "Having staff from the labs spend time in industry is equally valuable. … Clearly we are able to do more together than either of us could have done alone."

Dr. Ian Foster
Director of the Computation Institute
Argonne National Laboratory and the University of Chicago

Service portals could make software from the national laboratories available to much larger communities, but may require investment in support personnel as well as technologies.

There is a transition occurring in some parts of industry toward accessing software as a service, rather than downloading and installing it on company computers.[2] Dr. Foster expanded on this concept, suggesting that HPC Centers such as those at Argonne and PSC could provide software to a much larger community than they serve today by creating portal interfaces to enable easy access and usage. Argonne is doing this with bioinformatics software,

2. See the Council on Competitiveness *High Performance Computing Software Workshop Report*, 2005; and *Second Annual High Performance Computing Users Conference Report: Accelerating Innovation for Prosperity*, 2005, available at www.compete.org.

for example, by making available substantial data resources backed by large-scale high performance computing that is not visible to the users. As Deborah L. Wince-Smith outlined in her opening remarks, the Council sees service portals as an integral component of its National Innovation Collaboration Ecosystem (NICE) initiative. Dr. Foster cautioned, though, that it is expensive to produce a portal with user-friendly interfaces. Even then, additional investment may be needed in the human expertise to support people using the service portals and to help them formulate their problems. "You can only go so far in automating the process," Dr. Foster pointed out.

Dr. Foster also echoed Ms. Clayton's observation that the value of modeling and simulation should be taught in our educational systems. He recommended that students spend time in national laboratories to enhance their HPC skills.

Partnerships and portals can expedite knowledge transfer between the national laboratories and industry, to the benefit of both.

Dr. Terry Talley, chief architect for Acxiom Corporation's Products and Infrastructure Technology Organization offered an industrial perspective on public-private partnerships drawing on his firm's experience working with Argonne National Laboratory. Acxiom is a mid-sized company ($1.3 billion in revenue) that builds large data warehouses to provide business intelligence and decision support for Fortune 500 companies. "The whole idea," said Dr. Talley, "is to apply lots and lots of data, and logically integrate all that data and put it into a decision support system, so that you can make good business decisions based upon that data. Because of the volume of that data, we were very interested in trying to exploit high performance computing."

According to Dr. Talley, the company began looking for a way to boost its competitiveness by accelerating the process of building data warehouses. But as Acxiom enhanced its computational capabilities through grid computing, it quickly ran into input/output challenges. That's when the company became aware of Argonne National Laboratory's work with the Parallel Virtual File System (PVFS). Acxiom discovered that PVFS was a good match for the types of input/output problems it was tackling, where data had to flow in parallel through a large number of processors. Acxiom entered into a co-development partnership with Argonne to access and enhance this open source software together. Access to Argonne's large HPC systems was also important for the co-development.

Although Acxiom approached Argonne for its unique software expertise, the knowledge flow throughout their collaboration has not been one-way. Although people usually talk about knowledge transfer from research labs to industry, "It goes the other way around as well," Dr. Talley explained. "We spend a lot of time explaining to our partners in the research community what our business problems are, and those are often foreign to them. It's been surprising to me how much time we spend actually doing this."

Like Dr. Foster, he also elaborated on the potential benefits of portals to HPC resources. "I think the idea of having portals is very important because it allows us to identify resources that we could use and adapt to our particular problem." Dr. Talley was also enthusiastic about the advent of service portals that would allow Acxiom to "demonstrate a proof of concept, so we can make an intelligent investment. Those are all really important things."

HPC collaborations have the potential to transform companies and entire industries.

In summing up Acxiom's partnership experience, Dr. Talley outlined three tangible competitive benefits the company has received:

"First, Acxiom has been able to reduce the transactional cost for its computing in a significant way by accessing Argonne's HPC systems. As a mid-sized company, we simply could not afford to purchase commercial machines with that much horsepower. So on the cost side, we're more competitive," Dr. Talley explained. Second, he said, thanks to the Argonne collaboration, Acxiom now can deal with data volumes and transformation complexity "that our competitors simply can't." And finally, as a result of its work on the grid and the parallel virtual file systems with Argonne, Acxiom has entered into a relationship with EMC to jointly develop a commercial product.

DreamWorks Animation is also partnering with a national laboratory. Through the Department of Energy's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program, the company successfully competed for a large block of time on a high performance computer at Oak Ridge National Laboratory. DreamWorks Animation's goal is to use this resource to transform the way animated films are created.

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Dr. Terry Talley
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Acxiom

In the computer graphics (CG) animation industry, the pace of change and the competitive pressures have increased dramatically over the last decade. When Pixar released *Toy Story*, the first CG animated film, in 1995, it created an entirely new art form. Twenty films, approximately two per year, were released over the next decade. Now, the CG animated film industry averages one new release per month. This has created more competitive pressures for every company in this market.

Ed Leonard, chief technology officer for DreamWorks Animation, SKG, explained that the most computationally intensive part of creating an animated film is rendering, the important process of applying the light and texture to otherwise finished scenes. This process gives animated films exceptional visual interest. "We have to tell great stories," explained Mr. Leonard, "but we need to tell them in a way that keeps the audience's interest. It's no longer possible to keep people's attention with a painted background. People want to see trees that move, and leaves that move."

Today, the final step of rendering has to be done overnight on "batch farms" of computers. Through Department of Energy's INCITE grant, DreamWorks Animation is exploring possibilities for a radical advance that would transform the animated film industry—eliminating the need for overnight batch processing and making rendering part of the interactive, daytime "artist-in-the-loop" process of creating an animated film. Advances are especially important, because rendering consumes ever-increasing amounts of computational power. *Shrek 1* (2001) required five million render hours; *Shrek 2* (2004) took 10 million render hours, and *Over the Hedge* (2006) consumed 15 million render hours.

DreamWorks' engagement with the INCITE program offered lessons applicable far beyond the animated film industry.

From left: Ed Leonard, chief technology officer, DreamWorks Animation, SKG; and Dr. Terry Talley, chief architect, Products and Infrastructure Technology, Acxiom

Partnerships with universities and/or national laboratories offer industry the opportunity to explore competitively important problems that are orders of magnitude beyond what they are currently solving in their production environment.

Market pressures demand that DreamWorks utilize its in-house system full time for the production of its films. Resource constraints do not permit the kind of forward-looking experimentation that drives competitive breakthroughs. Through its partnership with Oak Ridge via the INCITE program, DreamWorks Animation will have access to one of the most powerful high performance computers in the world to try out its cutting-edge ideas. "Our motivation was to figure out how we could gain not one

order-of-magnitude improvement, but three or four or five, and what that would do to our process," explained Mr. 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."

By partnering with the national laboratories, industry can get a "crystal ball" look at HPC systems several years before they are widely accessible in the commercial market, accelerating its ability to prepare for their use.

National security demands propel the national laboratories to invest in leading-edge HPC systems before they are widely available and affordable in the commercial market. When industrial firms are able to access these systems through partnership programs like INCITE, they gain a "crystal ball" look into their technical future and a head start in preparing their internal processes and programs to embrace it. Early access to cutting-edge HPC resources allows DreamWorks to experiment with new techniques to create imagery and characters, in worlds and environments that "actually separate us from a pack that's crowded," explained Mr. Leonard. This access also helps the company better understand what kind of HPC systems it will need to maintain market leadership in the future. "Our intention is to learn what's next for us in two or three years, not necessarily what we need today," Mr. Leonard emphasized. "It's not optional for us to stay on the leading edge—it's essential."

"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."

Ed Leonard
Chief Technology Officer
DreamWorks Animation, SKG

Conference Proceedings

NNSA, NSF Models for Public-Private Sector Partnerships

Suzy Tichenor, vice president and director of the Council's High Performance Computing project, summarized the findings of two pioneering new studies produced by the Council in collaboration with market research firm IDC. The studies document the experiences of companies that have participated in HPC partnerships with university-based centers affiliated with (1) the Department of Energy's NNSA/ASC Academic Strategic Alliance Program, and (2) the National Science Foundation. Both studies[3, 4] are available at www.compete.org. Executive summaries are included in the appendix of this report.

Industry's partnerships with the NNSA funded University HPC Centers were overwhelming successful, but collaboration tools may still be immature and cultural differences between businesses and universities were an impediment in some cases.

Ms. Tichenor reported that the findings of the NNSA study were based on discussions with 12 aerospace, automotive, energy and software firms engaged in HPC partnerships with the NNSA Alliance Centers at Stanford University, the University of Illinois, and the University of Utah.

The companies reported that the collaborations were overwhelmingly successful. A large majority of the firms said the partnerships had met their expectations, and that they would be willing to partner again with the same Center. One-third of the firms said they had achieved an important breakthrough or discovered something totally new. This is very encouraging, given the Council's belief that America needs to become even more innovative to remain at the head of the competitiveness pack in global markets.

For some of the companies, learning new problem-solving approaches proved to be transformational.

For some of the companies, learning new problem solving approaches proved to be transformational. And half of the companies reported solving a specific problem, bringing a product to market faster, achieving a cost reduction, or increasing profitability as a direct result of the partnerships.

The biggest impediment to progress reported by the companies was the slower-than-desired pace of some of the projects. They generally attributed this to cultural differences between businesses and universities. Additionally, the greatest progress occurred when project participants worked together "face-to-face", suggesting that collaboration tools may still be immature.

The NSF industrial partnerships produced many breakthroughs and created more demand for HPC

3. See Council on Competitiveness *Partnering for Prosperity: Industrial Partnerships through the National Science Foundation's Supercomputing Resources*, 2006, available at www.compete.org.
4. See Council on Competitiveness *Partnering for Prosperity: Industrial Partnerships through the National Nuclear Security Administration Academic Strategic Alliance Program*, 2006, available at www.compete.org.

Forty percent of the firms were able to assign a dollar value to the outcome of the partnership, ranging from $100,000 to $57 million. More than half of the companies achieved a breakthrough in their existing work, or discovered something entirely new.

tools, but the NSF centers' HPC resources are already oversubscribed.

This study, according to Ms. Tichenor, queried 38 companies about their partnerships with three NSF funded University HPC Centers: the Pittsburgh Supercomputing Center, the San Diego Supercomputer Center, and the National Center for Supercomputing Applications at the University of Illinois, Urbana/Champaign. Many of the firms had prior HPC experience. Three-quarters of the companies engaged in the partnerships to advance strategically important work. Some wanted expertise to help solve an immediate problem.

The commercial firms were highly positive about their experiences working with the experts and the large HPC systems at these facilities. All reported meeting their objectives, including advancing their R&D efforts. An impressive 88 percent said they had solved the specific problem they set out to conquer. Forty percent of the firms were able to assign a dollar value to the outcome of the partnership, ranging from $100,000 to $57 million. More than half of the companies achieved a breakthrough in their existing work, or discovered something entirely new.

As in the NNSA study, the emphasis on face-to-face collaboration raised questions about the adequacy of today's advanced collaboration tools. And cultural differences between the commercial businesses and the university-based Centers were noted as the largest impediment to project progress.

Study participants also agreed that the NSF and the Centers have an opportunity and a responsibility to market the Centers' HPC resources more aggressively, so that more U.S. businesses can take advantage of them. Today, as Dr. Freeman pointed out, the Centers are oversubscribed. The NSF and the Centers will therefore need to make a strategic decision on how much time they can devote to industry partnerships while still fulfilling their mission to support the university research community. Interestingly, 38 percent of the firms in the NSF study reported upgrading their HPC systems, or purchasing new ones, following the NSF partnerships. Because of the partnerships, they were able to see the bottom-line value of using larger systems.

The industrial partnerships programs of the NSF and NNSA, as well as the Department of Energy's INCITE program (see page 21), address two key challenges stalling more aggressive use of HPC by U.S. firms: the need for state-of-the-art HPC expertise, and the need for access to large-scale HPC systems.

The Council will build on these successful partnership models in the development of the National Innovation Collaboration Ecosystem (NICE).

Conference Proceedings

Public-Private Partnerships Through the Department of Energy's INCITE and SciDAC Programs

Dr. Raymond Orbach, director of the Department of Energy Office of Science and recently named the nation's first Under Secretary of Science, reinforced earlier conference speakers on the importance of public-private partnerships. At his luncheon keynote address, he praised the Council's initiatives to advance the collaborative use of HPC to boost innovative and competitive gain, and then discussed two Department of Energy programs that enable industry to access some of the nation's most powerful HPC systems.

INCITE: Fostering Innovation through Access to High-End Computers

The Department's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program gives American industry, universities and laboratories access to some of the nation's most powerful high-end computers for scientific and engineering discovery. This successful program, now in its fourth year, grants large blocks of computing time to proposals with great potential for breakthrough discoveries. For fiscal year 2006, 18.2 million hours of computing time were made available on five supercomputers at four DOE national laboratories: Argonne National Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory and Pacific Northwest National Laboratory. And for the first time, researchers from four companies were among the 15 awards that passed DOE's strict peer review process: Boeing, DreamWorks Animation, General Atomics, and Pratt & Whitney.

In fiscal year 2007, DOE will dramatically expand the amount of computing time it will make available to 95 million hours.

SciDac2: $60 Million A Year For Collaborations

The Department of Energy's Scientific Discovery through Advanced Computing (SciDAC) program complements the INCITE program by bringing together computer scientists, mathematicians, physicists, chemists, engineers and others in a collaborative framework that can adapt physical problems to powerful high-end computers. To support the winners of the SciDAC2 competition, the Department of Energy will invest nearly $60 million a year in 30 projects involving 70 institutions and hundreds of researchers and students. The department will provide support for three to five years for the projects, which span a wide range of scientific application areas, including fusion energy, turbulence, climate change, chemistry, nucleosynthesis, groundwater transport of contaminants, computational biology and materials science.

Dr. Orbach described three related initiatives within the SciDAC program that are designed to foster multidisciplinary research:

- A unique feature of the SciDAC program will be the integrated set of nine centers for enabling technologies. These centers will specialize in applied mathematics, computer science, distributed computing or visualization, and will be closely tied to specific science applications and meeting the challenges of petascale computing.

And for the first time, researchers from four companies were among the 15 awards that passed DOE's strict peer review process: Boeing, DreamWorks Animation, General Atomics and Pratt & Whitney.

- SciDAC will create four new institutes that tap into some of the nation's leading intellectual resources, in order to help educate and train future generations of computational scientists. Through hands-on workshops and tutorials, the institutes will also help researchers to learn from SciDAC teams how to prepare their applications to take advantage of the increasing capabilities at supercomputing centers around the country.
- Finally, the new SciDAC Outreach Center will act as a service portal to provide "one-stop shopping" for support services and outreach to scientists outside of SciDAC who are located in universities, national labs, and industry. This center is a pilot program to leverage existing support services at National Energy Research Scientific Computing Center, and to gather data about the breadth and specific needs of the emerging petascale community. The National Science Foundation and The Department of Energy's National Nuclear Security Administration (NNSA) have joined the Department's Office of Science in this partnership.

Conference Proceedings

Panel
Driving HPC Through the Supply Chain

Microsoft Corporate Vice President Marshall Phelps moderated a panel discussion of industry executives representing both suppliers and purchasers. They explored the challenges and benefits of using corporate supply chain partnerships to drive HPC to a broader user base, as well as the role of HPC in optimizing a company's supply chain for added profitability and competitive gain.

The panel included Gary Abyad, president of Clopay Plastic Products Company; Tom Lange, director of corporate R&D modeling and simulation for The Procter & Gamble Company; Dr. Jayant S. Sabnis, chief engineer for systems analysis & aerodynamics, Pratt & Whitney; and Nancy Stewart, senior vice president and chief technology officer, Wal-Mart Stores, Inc.

In a nutshell, supply chain management means optimizing the flow of materials, information and money all the way from a company's suppliers to its customers, including what happens within the company itself. Efficient management of supply chains is increasingly important for competitiveness and profitability. There are strong competitive pressures to obtain parts quickly for assembly and to deliver finished goods quickly to outlets. Modeling complex supply chains for maximum efficiency and cost control, particularly within large companies, often presents enormous data management and data analysis challenges. Increasingly, HPC is required for the task, and supply chain management is emerging as a critical HPC application. Because of the close relationships that many companies within a supply chain maintain with each other, the supply chain could be a vehicle for expanding modeling and simulation with HPC to companies that are not currently using this technology.

Expanding HPC usage through supply chain partnerships

Panelists expressed differing views on the practicality and suitability of using supply chain relationships to introduce companies to high performance computing. Often the difference in opinion reflected the depth, or lack of depth, in supplier options.

Pratt & Whitney: Actively Helping Suppliers Learn To Use HPC

According to Dr. Sabnis, Pratt & Whitney has long used HPC for the modeling and simulation of jet aircraft engines. As he explained, "whether they recognize it or not, everybody utilizes modeling and simulation. Your models are either analog, also known as prototypes, or you build your models on a computer." Pratt & Whitney builds computational models because the process is faster and lower cost than building physical prototypes. "It's all about taking cost out, and meeting the schedule," Dr. Sabnis emphasized. "And if the supply base does not meet the specifications and if the things they are supposed to deliver don't arrive on time, we have to ultimately bear the cost." Dr. Sabnis also pointed out that in the jet engine business; there is not the depth of suppliers that might be available to other businesses that are designing/delivering commodity

> "We take a lot of time to drill deep, and discover what the capability of the supplier is, to understand what questions they should be asking, and what boundary conditions they should be posing on a specific analysis. And if they don't have the capability, we will actually work with them to make sure they come up to speed on that."
>
> Dr. Jayant Sabnis
> Chief Engineer, Systems Analysis and Aerodynamics
> Pratt & Whitney

products. "I have to ensure that whomever I have picked actually succeeds."

For these reasons, Pratt & Whitney introduces key suppliers to HPC. "They don't always come willingly," Dr. Sabnis pointed out, "because this is something they have not done in the past." And so Pratt & Whitney is careful to first assess the "technology readiness" of a supplier. "We take a lot of time to drill deep, and discover what the capability of the supplier is, to understand what questions they should be asking, and what boundary conditions they should be posing on a specific analysis," Dr. Sabnis explained. "And if they don't have the capability, we will actually work with them to make sure they come up to speed on that."

Pratt & Whitney's hands-on approach has been successful. As their suppliers see the benefits that Pratt & Whitney accrues from modeling and simulation with HPC, they are adopting it themselves.

Procter & Gamble: Letting Market Forces Decide

Consumer products giant Procter & Gamble provided insight as both a large supplier and customer. It is one of the largest suppliers of finished product to the demanding retail giant Wal-Mart. And like Pratt & Whitney, P&G relies heavily on HPC for designing and testing its products in order to meet its customers' requirements. "It's part of our innovation equation," explained Mr. Lange. "Every dime we spend on computing and software and hardware, and the people to do it, is a dime we don't spend on prototype molds, prototype equipment, full-scale experiments and physical tests."

However, despite the benefits it derives from using HPC, P&G normally does not introduce its own suppliers to modeling and simulation with this technology as Pratt & Whitney does. "We will respond to a mentoring or partnership request when asked," Mr. Lange said. But, he pointed out, they don't get asked very much. Instead, P&G relies on market forces to push suppliers to adopt the tools they need to meet P&G requirements. If HPC can help P&G's suppliers "reduce inefficiency, make higher quality product, reduce weight, and reduce waste, we strongly applaud and encourage that," explained Mr. Lange. But "we're going to rely on standard market forces to make that happen, or not."

In Procter & Gamble's world, there are some important barriers inhibiting the use of HPC by suppliers. For example, software licensing restrictions often prevent P&G from allowing a supplier to use its HPC system. Another barrier is a generally lower level of engineering ability among P&G's suppliers than among, for example, auto or aerospace-industry suppliers. Related to this is a shortage of user-friendly middleware. "Not enough people are producing higher-quality middleware to get this scientific capability out into industry for things that are done every day. We need middleware to get some of the routine analysis automated, so people who are not experts in finite element analysis and computational fluid dynamics can run it," Mr. Lange explained. Finally, Mr. Lange pointed out that most of P&G's suppliers simply do not have the scale to make what might appear to be a risky investment in HPC. "It's taken Procter & Gamble, with all of our scale and all of our focus, 20 years to learn how to migrate work that we used to do physically to a virtual environment."

> "It's part of our innovation equation. Every dime we spend on computing and software and hardware, and the people to do it, is a dime we don't spend on prototype molds, prototype equipment, full-scale experiments and physical tests."
>
> Tom Lange
> Director, Corporate R&D and Modeling and Simulation
> The Procter & Gamble Company

Wal-Mart: Assisting Suppliers as Needed

Ms. Stewart said Wal-Mart, the world's No. 1 retailer with about 8,000 stores, also does not require its suppliers such as Procter & Gamble to use HPC. But Wal-Mart expects its suppliers to use HPC if that is what is needed to produce the highest quality, lowest cost product. "To the degree that our suppliers, like P&G and others, can demonstrate to us that they are producing high value at low cost, that's what's germane. That's the value of HPC for us and that's the value that it also brings to our customers who are looking for the highest value at the lowest cost."

However, like Pratt & Whitney, Wal-Mart occasionally finds that only one or two suppliers can meet its requirements. "Sometimes we really have only one or two suppliers that can meet the need because of the volumes we require," Ms. Stewart explained. In these instances, Wal-Mart will assist its suppliers as needed with the HPC systems and expertise it uses in-house to manage its global supply chain and network of stores. Ms. Stewart went on to relate a recent incident in which a supplier was unable to fulfill a commitment. Wal-Mart stepped in and used its HPC technology and techniques to make the needed improvements. "We did the analysis," Ms. Stewart said. "We did the work such

From left: Nancy Stewart, senior vice president and chief technology officer, Wal-Mart Stores Inc.; Gary Abayd, president, Clopay Plastic Products Company; Tom Lange, director, Corporate R&D and Modeling and Simulation, The Procter & Gamble Company.

> "We did the analysis. We did the work such that our supplier could get the product to market on time and at the prescribed cost metric. But we used our systems to accomplish that. And he was made successful, and we were made successful by getting the work done."
>
> Nancy Stewart
> Senior Vice President and Chief Technology Officer
> Wal-Mart Stores, Inc.

that our supplier could get the product to market on time and at the prescribed cost metric. But we used our systems to accomplish that. And he was made successful and we were made successful by getting the work done."

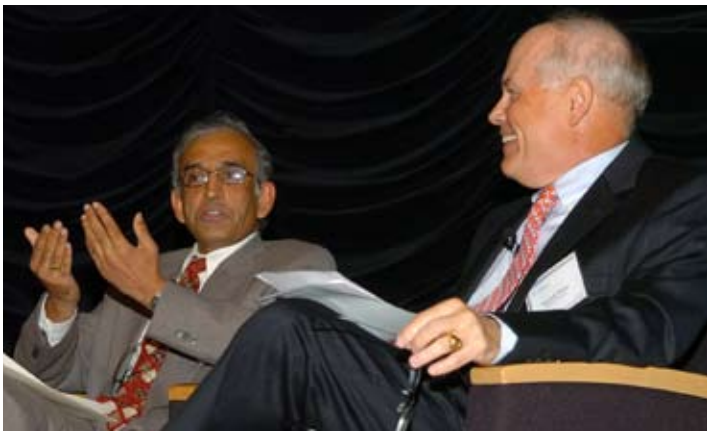
Clopay Plastics Products: Not Seeing the Need Yet

Mr. Abyad provided the perspective of a medium-sized company that must meet the stringent demands of Wal-Mart and Procter & Gamble, but does so without using HPC. Despite the fact that his firm, Clopay Plastic Products Company, is a supplier to two committed users of HPC, Clopay isn't convinced yet of the value of this technology. Clopay is therefore unwilling to make what it deems to be a risky investment in HPC.

Echoing Mr. Lange's comments about the importance of "scale," he noted that as a division of a public company (Griffon Corporation), "we don't have the luxury of a ten-year investment in this technology for the sake of a potential payout." Clopay has a fixed resource base and finds that this is "well spent, on a daily basis, trying to come up with the very next iteration of innovation by our traditional (i.e., experimental) means." Siphoning off dollars to invest in HPC "has not made the radar screen." In addition, although Clopay feels the pressure from its customers to reduce innovation cycle time and cost, Mr. Abyad is not aware that any of Clopay's competitors are using HPC and gaining a competitive edge.

What would it take to make HPC flicker on Clopay's

radar? Mr. Abyad was candid in his reply. "We don't use HPC because we don't understand the value of it, and we don't understand how to use it. We don't have the tools, and we don't have the skills in our company. We need to be introduced and led with user-friendly tools that can produce results." And although he thinks that "larger partners can mentor smaller firms like ours in the use of HPC," he acknowledged there are competitive issues. "Using these tools provides a competitive advantage, so P&G would need to decide how this would affect their own competitive position."



From left: Dr. Jayant S. Sabnis, chief engineer, Systems Analysis and Aerodynamics, Pratt & Whitney; Marshall Phelps, corporate vice president, Microsoft Corporation.

Using HPC to model supply chains for optimal efficiency and cost

In addition to discussing the use of supply chain relationships as a venue to expand HPC usage, Ms. Stewart pointed out an emerging and increasingly important industrial HPC application: using HPC to manage and optimize the supply chain process itself for maximum efficiency and cost control. "The value we derive from using HPC for cost reduction is what drives us," Ms. Stewart explained.

On a typical day, Wal-Mart sees 27 million customers and processes 500,000 transactions worth $2 billion of revenue. (On the day after Thanksgiving, Wal-Mart's busiest day of the year, the company processes about a billion transactions worth $20 billion in revenue). The company ships about 740,000 items daily and Wal-Mart Supercenters stock about 500,000 products each. Suppliers compete fiercely for shelf space.

Every day between 3:00 and 5:00 a.m., the com-

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Gary Abayd
President
Clopay Plastic Products Company

Wal-Mart "couldn't do these kinds of things without this level of technology value. That's why we made the investment in HPC. We can see the return and it's helped make us that much more efficient."

Nancy Stewart
Senior Vice President and Chief Technology Officer
Wal-Mart Stores, Inc.

pany runs very large models on high performance computers to determine what is selling well in each store. That information is then sent to Wal-Mart suppliers so that they know what to stock in each store. It is also sent to every store so that shelves can then be "reformatted" to meet customer needs more appropriately.

"If you really understand your information or your data, then you can do your predictive analysis," Ms. Stewart explained.

In addition to using HPC for shelf space determinations, store planning and resource planning, the company also uses HPC for operational "ergonomics." From its headquarters in Bentonville, AK, Wal-Mart services all of its stores worldwide, right down to turning on the lights in the stores. "Within a day, I basically process a petabyte of data," Ms. Stewart stressed.

Ms. Stewart emphasized that Wal-Mart "couldn't do these kinds of things without this level of technology value. That's why we made the investment in HPC. We can see the return and it's helped make us that much more efficient."

Conference Proceedings

HPC Reveals a Major New Oil Trend for Chevron and its Partners

After spotting Chevron Chief Technology Officer Dr. Donald Paul in the audience, Conference co-MC Dr. David Shaw asked him to come forward and comment on the recent, highly publicized discovery by Chevron and two of its partners of a new field in Gulf of Mexico deepwater that could yield 3-15 billion barrels of oil—boosting U.S. reserves by up to half.

Dr. Paul said HPC was a crucial feature, "not just an add-on," for enabling this important discovery. HPC has been used for seismic processing for many years, but Chevron's "Jack-2" reservoir was at the very edge of current seismic imaging capability. Imaging at the scale of this project was unprecedented, with data sets up to a quadrillion (10^{15}) points. Processing such vast data sets was impossible until the past few years brought advances in HPC capabilities and visualization technologies.

The features of the newly discovered reservoir were invisible until recently because of a huge canopy of salt that is sometimes miles thick, and geologists were skeptical about the amount of potential oil in that region. But with high performance computing, what was invisible became clear. "The HPC systems become significantly faster, so you can see more, adjust the algorithms, and finally image what you're looking for. This opens up an enormous exploratory area 300 miles long and 100 miles wide," said Dr. Paul.

> "It would not have been possible to have had this exploration success five years ago. We just didn't have the horsepower to do the computations to apply in practice this kind of imaging, drilling, and reservoir modeling technology. HPC was absolutely critical."
>
> Dr. Donald Paul
> Vice President and Chief Technology Officer
> Chevron Corporation

Once HPC permitted Chevron to "see" the possibilities, the company had the confidence to proceed with the enormously expensive process of drilling a test well. HPC was used again for the even larger challenge of modeling in real time what the drilling process might be like. Specialized ships costing up to $1 billion each were needed to drill through 7,000 feet of water and 20,000 feet of underlying rock. The steel drillstrings were five miles long (8 kilometers).

The next stage is to use HPC to model these reservoirs so that decisions can be made about how best to develop them. This will involve simulations with tens of millions of cells, eventually some of the largest models ever. Again, the modeling will not be done in the lab, but "on the front line of production work."

"It would not have been possible to have had this exploration success five years ago," Dr. Paul summarized. "We just didn't have the horsepower to do the computations to apply in practice this kind of imaging, drilling, and reservoir modeling technology. HPC was absolutely critical."

Dr. Donald Paul, vice president and chief technology officer, Chevron Corporation

Conference Proceedings

Bridging the Gaps with a Collaborative Ecosystem

Dr. Shaw concluded that exploiting the full potential of HPC to advance U.S. competitiveness is a significant challenge, but "we're making enormous progress already," thanks to the Council's work and a pattern of increasing participation and collaboration. Referring to the Council's HPC Initiative, Dr. Shaw said, "This isn't just an independent research project. It's something we wanted to be driven by the various stakeholders, and that has really happened. You're making a very significant contribution to high performance computing, on the one hand, and to U.S. competitiveness, on the other."

While the Council continues to do HPC-related research and evaluation, it will also move forward on important efforts that have grown out of the HPC Initiative, including the National Innovation Collaborative Ecosystem (NICE). "This is exactly what we need," Dr. Shaw said. "It's a way to bridge the gaps and get people working together. NICE is going to be a very exciting program, with high risk and very, very high potential returns." He told conference attendees that the Council's HPC Advisory Committee "will continue to rely on your help and your insights as we move ahead."

Appendix A

Conference Agenda

3rd Annual HPC Users Conference
Moving Beyond Islands of Innovation
Ronald Reagan Building and International Trade Center
1300 Pennsylvania Ave., NW
Washington, DC

7:30 a.m. Breakfast/Registration

8:15 a.m. Welcome

- Deborah L. Wince-Smith, President, Council on Competitiveness
- Dr. Karen A. Holbrook, President, The Ohio State University, and Co-Chair, Council on Competitiveness HPC Advisory Committee

8:45 a.m. Keynote Address

- Dr. Robert Rosner, Director, Argonne National Laboratory

9:15 a.m. Panel 1: High Performance Computing – Driving Competitiveness Through Collaborative Computing:

Industry, university and government executives will discuss the potential for expanding HPC usage for regional economic development and industrial competitive advantage through public-private sector collaboration, the strengths and weaknesses of different partnership models, and how we can better leverage the country's HPC assets for a national competitive lift.

Moderator

- Dr. Peter Freeman, Director, Computer & Information Science & Engineering Directorate, National Science Foundation

Panelists

- Beverly Clayton, Executive Director, Pittsburgh Supercomputing Center
- Ed Leonard, Chief Technology Officer, DreamWorks Animation, SKG
- Dr. Ian Foster, Director of the Computation Institute, Argonne National Laboratory and the University of Chicago
- Dr. Terry Talley, Chief Architect, Products and Infrastructure Technology, Acxiom

10:45 a.m. Break

11:15 a.m. Partnering for Prosperity: Harnessing our HPC Assets for Competitive Strength: Results of two new user surveys examine partnership programs through the Department of Energy's National Nuclear Security Administration and the National Science Foundation.

- Suzy Tichenor, Vice President and Director, High Performance Computing Project, Council on Competitiveness

12:00 p.m. Adjourn to Atrium Ballroom for Luncheon

12:15 p.m. Luncheon

- The Honorable Dr. Raymond Orbach, Under Secretary for Science, U.S. Department of Energy

1:30 p.m. Return to Amphitheater for Afternoon Session

1:45 p.m. Panel 2: Driving High Performance Computing Through the Supply Chain: Industry executives representing both suppliers and purchasers will explore the challenges and benefits of using the supply chain to drive HPC to a broader user base, as well as the role of HPC in optimizing a company's supply chain for added profitability and competitive gain.

Moderator

- Marshall Phelps, Corporate Vice President, Microsoft Corporation

Panelists

- Gary Abyad, President, Clopay Plastic Products Company
- Tom Lange, Director, Corporate R&D Modeling and Simulation, The Procter & Gamble Company
- Dr. Jayant S. Sabnis, Chief Engineer, Systems Analysis & Aerodynamics, Pratt & Whitney
- Nancy Stewart, Senior Vice President and Chief Technology Officer, Wal-Mart Stores, Inc.

3:15 p.m. Next Steps/Building the Strategy

- Dr. David E. Shaw, Chairman, The D.E. Shaw Group and Co-Chair, Council on Competitiveness HPC Advisory Committee

3:45 p.m. Adjourn

Appendix B

Partnering for Prosperity: Industrial Partnerships through the National Science Foundation's Supercomputing Resources

Executive Summary

This was a collaborative study conducted by the Council on Competitiveness and IDC on behalf of the National Science Foundation (NSF). The study evaluated the experiences of industrial HPC user organizations engaged in partnerships with the NSF Centers at the National Center for Supercomputing Applications (NCSA), the Pittsburgh Supercomputing Center (PSC), the San Diego Supercomputer Center (SDSC), and the Texas Advanced Computing Center (TACC). The study included 40 industrial partners and was conducted from December 2005 to January 2006.

The partnership program between NSF Centers and U.S. businesses clearly has been successful. All 40 of the companies interviewed for this study were overwhelmingly positive about the expertise of the NSF Centers, and 95 percent said they would like to partner with the same NSF Center in the future (78 percent said they already had plans in place for continuing to work with NSF Centers). Virtually all (93 percent) said the NSF Center partnerships advanced their research and development efforts, 88 percent said the collaboration had "solved a specific problem," and the vast majority (80 percent) concluded that the partnerships with the NSF Centers had met their objectives. That percentage could climb even higher, since 13 percent of the projects were still in progress when this study was conducted.

Even more noteworthy is how often the partnerships directly benefited the companies financially, competitively, or both. More than half the sites (55 percent) reported that the partnerships had advanced new product development, and 60 percent said the collaborations with the NSF Centers helped them get products to market faster. Related areas of value included revenue growth (38 percent of the sites), increased market share (30 percent), and the ability to respond to actual competitive threats (33 percent). Perhaps even more impressive, more than half (55 percent) of the 40 sites reported that their partnerships had "achieved a breakthrough or discovered something totally new." This is particularly important in today's global marketplace, where competitive advantage is increasingly driven by the ability to create new value through innovation.

A major theme (cited by 43 percent of the sites) was how little was known in the business community about the valuable resources of the NSF Centers that were available to companies. They see the Centers as "one of America's best kept secrets/national treasures—and shouldn't be kept secret." Respondents felt that NSF has both a great opportunity and a responsibility to share these important resources.

For most of the NSF Center business partners, HPC is indispensable. More than three-quarters of the sites (77 percent) stated that they could not operate as businesses without access to HPC resources, and 80 percent said they could not compete effectively or bring products to market fast enough without HPC. The most frequently cited benefits of HPC were time savings and better science.

Three out of four (75 percent) of the companies entered into partnerships with the NSF Centers to advance critical strategic work, that is, ongoing work central to their missions. The primary motivator for the remaining 25 percent was to solve an immediate problem. Sixteen of the sites (40 percent) were able to assign a dollar value to their partnerships, ranging from $100,000 to $57 million. The most common objective for the partnerships (78 percent of the sites) was access to the scientific and HPC expertise of the Centers. Next in importance was access to the Centers' HPC systems. Although 33 of the 40 respondents (83 percent) reported having technical servers or supercomputers at their sites, they placed high value on being able to use much larger systems. This access to systems and expertise was deemed so important that 22 sites paid for aspects of the partnership, with costs ranging from $25,000 to $7 million. It is noteworthy that 15 sites (38 percent) installed HPC systems after their experiences with the NSF Center partnerships, although study data did not indicate whether these were system upgrades or first-time purchases.

Seven in 10 of the sites described their HPC work within the NSF partnerships as primarily research-oriented, while the remaining 29 percent said they were mainly focused on production work.

The companies' primary suggestions for improvement concerned access to the Centers' HPC resources, the cultural gap between businesses and universities, and red tape related to intellectual property issues. The cultural differences ranged from difficult-to-address broad issues to specific problems open to consideration ("We needed some help during a school break, which caused big problems."). Red tape issues were mentioned by just 15 percent of the sites, but in at least some of these cases, they became substantial impediments.

Key Findings in the Study

- The companies view the NSF Centers' HPC resources as a hidden gem and believe NSF has not just an opportunity, but a responsibility to market and promote these resources far more aggressively to U.S. businesses that exploit or wish to exploit HPC.
- The partnerships between NSF Centers and businesses have been remarkably successful. Companies that partner with NSF Centers are achieving real results, from shorter time-to-market to higher quality products to better visualization and breakthrough insights. In more than half the cases, the partnerships directly benefited the companies financially, competitively, or both. Even more impressive, more than half (55 percent) of the 40 sites reported that their partnerships had "achieved a breakthrough or discovered something totally new." All 40 of the surveyed firms were overwhelmingly positive about the scientific and HPC-related expertise of the NSF Centers, and 95 percent of the firms want to partner with the same NSF Center again.

- The aspects of the partnership the companies rated most important were access to HPC resources and expertise (scientific and HPC) within the NSF Centers. More than three-quarters of the sites said they could not operate as businesses without HPC.
- Recommendations for improvement focused on enhancing technical support (especially documentation), narrowing the cultural gap between businesses and universities, alleviating red tape (particularly related to intellectual property rights), and choosing HPC systems with the needs of industry in mind.

Implications For NSF

- NSF and the University HPC Centers it funds have a strategic opportunity to provide a competitive lift to the country by better promoting to industry the availability of the Centers' advanced HPC systems and expertise. Current industry partners see these centers as hidden gems whose HPC systems and expertise could be used to accelerate innovation for competitive advantage if they are publicized more widely. Further, by helping industry solve its most complex, competitively important problems, NSF also is advancing its own mission of supporting "high-risk, high pay-off" ideas and novel collaborations.

  "One of America's best kept secrets/national treasures–and shouldn't be kept secret."

  "There is untapped potential at the Centers for many organizations and businesses."

  "More people need to know about these resources."

  "Do a better job of promoting this resource to the business community."

  "NSF needs to a better job of promoting the availability of these tremendous resources."

  "We've advanced our R&D efforts dramatically."

  "Advanced our understanding of the dynamics within the solar interior."

  "It has offered tremendous advancements in our research and our understanding of HPC."

- By further promoting this availability and reaching out to industry, NSF and the Centers can also help to grow the HPC market by stimulating increased private sector HPC usage among experienced users, periodic users, and even companies that have "never ever" used HPC. Survey data indicated that 38 percent of the industrial partners purchased HPC systems after partnering with the NSF Centers. Although study data did not indicate whether these were system upgrades or first-time purchases, clearly the industrial users saw value in increasing their in-house HPC capabilities after exposure to the systems and expertise at the NSF-funded University Centers. Such market growth will help reduce the cost of HPC systems and software,

benefiting NSF, academia, U.S. industry, and the country. Respondents even suggested a new NSF-sponsored grant program to support the proliferation of HPC into new industries.

"NSF does not focus on how they can contribute to the American economy."

"NSF's contribution to private industry in the U.S. is not nearly as great as it should/could be."

"Expend resources into tools for traditional industrial apps rather than leading-edge apps."

"An untapped resource that many in industry don't know about."

"A competitive grant program to encourage companies and universities to think seriously about partnership opportunities (like an SBIR program)."

- Data from the study confirms that the NSF Center-industry collaborations are helping to address two important barriers that studies from the Council on Competitiveness indicate are preventing more widespread private sector usage of HPC: lack of access to large-scale systems and the need for "talent."
- This NSF-funded Centers program can provide much-needed access to large HPC systems not generally available to industry.

  "We can run larger jobs (instead of many smaller jobs)–more efficient."

  "We've advanced [our research] much faster than we dreamed we could."

  "This is a critical resource for the research community."
- Companies were stimulated to partner with the NSF Centers to gain access to expertise. Their comments about what they learned reflected this:

  "Immeasurable value from the Center's personnel."

  "It's been a great opportunity to meet and learn from others in our field."

  "The Centers provide access to great technical experts."

  "Success in HPC is more about access to people and relationships than it is about hardware. That's what makes huge breakthroughs possible. 'A supercomputer unused is a useless supercomputer. Partnering with the right people in a team is what makes a supercomputer useful.' I've seen a lot more emphasis on hardware than on people. This needs to change–people are the magic ingredient."
- Clearly industry sees partnering with the NSF-funded University Centers as a way to access the larger HPC systems and added expertise it needs to solve some of its most difficult problems for competitive gain. And more competitive U.S. companies help the country to maintain national security and economic strength.

"We've advanced [our research] much faster than we dreamed we could."

"HPC has allowed us to make several scientific breakthroughs."

"It dramatically reduces our costs for [oil and gas] exploration."

"We've been able to discover many new things about the brain and contribute this to the world."

"It's a telescope into the future."

- NSF and the Centers could make this valuable program even more successful by working to create a more user-friendly environment for industry, from including industry requirements in HPC system procurements to improving technical support and documentation and ensuring that industry researchers can obtain adequate priority and access to HPC resources. NSF and the Centers could use the results of this study as a partial road map and supplement this with face-to-face planning meetings with participating businesses to set expectations and address issues in advance, where feasible.

  "We needed some help during a school break, which caused big problems."

  "Machines need to be balanced between memory, disk, and CPU speeds."

  "Keep improving documentation and procedures."

  "The University stopped listening to industry."

- Red-tape related to intellectual property (IP) issues was a significant show-stopper for a small number of users. These IP barriers prevented companies from publishing results and showcasing their partnerships with the NSF-funded Centers. Addressing these would help the broader industrial community understand the benefits of using HPC, provide wider access to research results beyond the partnership company, and help the Centers to receive wider recognition for these valuable partnership programs.

  "Intellectual property issues were the ultimate problem."

  "IP has been a major stumbling block."

  "We would use it much more if IP issues were resolved."

Appendix C

Partnering for Prosperity: Industrial Partnerships through the National Nuclear Security Administration Academic Strategic Alliance Program

Executive Summary

This collaborative study was conducted by the Council on Competitiveness and IDC on behalf of the U.S. Department of Energy/National Nuclear Security Administration Office of Advanced Simulation and Computing (DOE/NNSA/ASC). The main study included 12 industrial partners and was conducted from December 2005 to January 2006. It is a testament to the perceived value of the NNSA/ASC Academic Strategic Alliance Program (ASAP) that when we asked the 12 companies interviewed for this paper to give us their summary recommendations (positive or negative) about working with the Alliance Centers, the vast majority (83 percent) of the respondents reported that their collaborations had met their objectives, and none claimed their objectives had not been met. Six of the 12 sites were able to assign an actual dollar value to the partnership results. The values ranged from $200,000 to $1 million.

All of the respondents agreed that the partnerships advanced their firms' research and development efforts. Even more remarkable is how frequently the partnerships directly benefited the companies financially or competitively, or both. An impressive one-third (33 percent) of the sites reported that their partnerships had "achieved a breakthrough or discovered something totally new." All 12 sites responded "yes" when asked about their willingness to partner with the Centers in the future.

Access to high-performance computing (HPC) resources is indispensable for the 12 commercial firms. Three of the firms stated outright that they could not operate as businesses without HPC, while many of the others said essentially the same thing in other ways. The benefits of HPC for the companies extend far beyond time and cost savings in the product development process. For many of the firms, HPC provides valuable new insights—breakthroughs in thinking that can result in superior products with important competitive advantages. Nearly two-thirds of the partnerships had existed for at least five years (many are still in progress). Six of the sites provided funding for certain aspects of their partnerships. Nearly seven in eight of the respondents' projects are primarily research-oriented, with the remainder focused on production work. In most cases (57 percent), the Advanced Simulation and Computing (ASC) Alliance Centers approached the commercial firms about partnering, but in about one-third of the cases, the businesses were the initiators.

The primary benefit the firms anticipated was knowledge transfer based on the assumed (or confirmed) greater scientific expertise of the Centers' personnel. The expectations for knowledge transfer were very specific in some instances ("to make use of turbo machinery code").

The aspect of the partnership the largest contingent (50 percent) of respondents considered important was access to experts within the Alliance Centers. Access to large HPC computers emerged as the second-most-popular benefit. Three-quarters of the commercial sites rated the responsiveness of the Centers as either "excellent" (42 percent) or "very

good" (33 percent). The remaining 25 percent of the sites expressed at least some level of dissatisfaction with responsiveness.

A full 89 percent of the responses to the question "What worked well?" had to do with the quality of the human interactions with the Centers' personnel. It speaks well for the Centers that such a high percentage of the commercial firms reported that these interactions "worked well."

The commercial firms offered constructive criticism as well. Disappointment with the pace of the projects can be attributed, at least in part, to cultural differences between the commercial firms and the universities. The focus or fit of the project was sometimes a problem, and inevitably some of the results were unwelcome surprises.

By far, the largest criticism (59 percent of all responses) concerned inadequate communication—the need for better advance planning and more regular, structured communication throughout the projects. Another important criticism was about "flying blind," that is, not understanding the universities and their resources before starting the projects. There were also some calls for improved technical communications.

Key Findings in the Study

- A full 83 percent of the commercial partners said the partnerships had met their expectations. All 12 of the firms said that the collaborations advanced their R&D efforts and that they would be willing to partner with the Centers again in the future.
- The primary benefit of the partnerships (anticipated and actual) was knowledge transfer from the Centers to the commercial firms. The firms planned to use this knowledge to gain competitive advantages in their businesses.
- Access to HPC resources is indispensable for all 12 firms. HPC provides not just time and cost savings but also valuable new insights that can result in superior products.
- What worked best were the human interactions between the companies and the Centers.
- What worked least well was bridging the cultural differences between the companies and universities, especially (from the companies' perspectives) the lack of adequate communications before and during the projects.

Implications for NNSA

- Although it was never a program goal, ASAP demonstrates that strategic public-private sector partnerships can provide significant value by lifting the country to a higher level of competitiveness. In particular, ASAP provides an opportunity for NNSA to demonstrate in quantifiable terms that it can successfully leverage its HPC resources to both meet national security mission needs and accelerate the nation's economic security and global competitive position—providing an enhanced return on the government's investment in HPC assets.

- ASAP benefits the NNSA by attracting (and providing the opportunity to attract) not only leading academic research organizations but also experienced industrial HPC users who can contribute some of the best thinking industry has to offer. These individuals are accustomed to using HPC in sophisticated ways.

  "HPC provides enhanced insight into our problems."

  "It allows us to solve more complicated problems in a reasonable amount of time."

- Data from the study confirms that ASAP can help address two important barriers that studies from the Council on Competitiveness indicate are preventing more widespread private sector usage of HPC: lack of access to large-scale systems and the need for "talent."
  - ASAP and its Alliance Centers can provide much-needed access to large HPC systems not generally available to industry.

    "Most companies cannot afford supercomputers at this time. It's not something the average large company can afford."

    "We entered into this partnership to acquire technical and computational resources."
  - By providing this access, ASAP is helping companies achieve breakthrough insights needed for competitive gain.

    "It gives us a glimpse of the future."
  - Companies were stimulated to partner with the Alliance Centers to gain access to expertise. Their comments about what they learned reflected this desire.

    "More knowledge of advanced algorithms."

    "Mathematical models themselves and how to apply them to large-scale computing."

    "New approaches to solving problems."
  - Clearly, industry sees partnership with the NNSA Alliance Centers as a way to access the larger HPC systems and the added expertise it needs to solve some of its most difficult problems for competitive gain. More competitive U.S. companies help the country to maintain national security and economic strength and raise the standard of living.
- Travel between the Alliance Center experts and industry participants was often substantial, indicating that collaboration tools are immature or not used. The program could provide a test bed for more mature collaboration tools in order to accelerate program accomplishments and reduce costs.

  "Usually innovation took place through meetings and conference calls. That process takes longer than doing it in a collaborative fashion. We need to move from serial to collaborative innovation."

- ASAP and its Alliance Centers could achieve better outcomes if industry is brought into the program "from the start." In addition, industry could help identify problems whose solutions would benefit both NNSA and industry, enhancing NNSA's ability to meet its mission-critical needs and at the same time accelerate innovation for national gain. Small modifications to the program would bring about a major competitive lift.
  - NNSA could specify in future RFPs that it will select a certain number of proposals that include industry participation. This will not preclude academic institutions from submitting proposals that do not need industry input, but it would encourage some universities to draw industry into the process at the beginning.
  - NNSA could further specify that any proposals that include industry participation must explain the competitive gain that industry anticipates from its participation, such as reduced costs, solving a currently intractable problem that will stimulate development of new products or processes for itself or its customers, faster time to market, and so forth.
- By continuing to engage industry in ASAP, NNSA can stimulate increased HPC usage within the private sector and provide a much-needed HPC market stimulant. The resulting market growth will help reduce the cost of HPC systems and software, benefiting NNSA, U.S. industry, and the country.

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