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Council on Competitiveness

Toward Adoption of Digital Modeling and Simulation in the U.S. Manufacturing Supply Chain

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Council on Competitiveness Summit & Workshop
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Introduction

Computational modeling, simulation and analytics (MS&A) is a well-documented driving force behind the innovation and competitive abilities of America's leading manufacturers. Instead of relying on expensive and time-consuming design processes, these companies digitally prototype and refine their products with great speed and precision.

Now, the federal government is calling for MS&A to be an integral part of design, testing and quality production of U.S. manufacturers. The imperative is clear—by adopting and increasing their use of MS&A, U.S. manufacturers will:

- Lower costs
- Increase quality
- Decrease time to market
- Enhance capabilities offered in bidding
- Create highly-skilled technical workforces

The U.S. supply chain can leverage the use of MS&A for competitive advantage through strategic and collaborative partnerships.

A public-private partnership is required to give all U.S. manufacturers access to this competitive tool that other countries (Germany, France, UK, EU, South Korea, China, Japan) are providing their manufacturers. This is the best metric of the importance of MS&A technology.

Goal

The goal of this Summit & Workshop is to produce an action plan for a new MS&A pilot program for the U.S. manufacturing supply chain. A viable, sustainable business model, plan and funding must be developed.

Items to be decided include:

- Type of service
- Professional education
- Hardware, software and middleware required
- Startup funding needed
- Expertise (subject matter, computational, etc.)

The stakeholders are:

- The manufacturing supply chain that are leaders in quality, engineering and R&D
- Original equipment manufacturers (OEMs)
- Hardware and software vendors
- U.S. government, including Department of Energy, the Office of Science & Technology Policy (OSTP), Department of Commerce
- Universities
- National laboratories

This cross-section of interested parties will be asked to instill the mindset of a startup business into the process of understanding how to best support R&D, engineering and quality production goals of the manufacturing supply chain through MS&A.

Output & Outcome

The Summit & Workshop output will inform a proposed pilot program to introduce and expand the use of MS&A among Midwest-based small- to medium-size manufacturers, the results of which would be documented and widely reported to (1) drive additional pilots in other regions, (2) inform OEMs that want to independently pursue MS&A adoption in their supply chains, and (3) guide federal policies and funding to assist the U.S. manufacturing sector.

The outcome for the proposed pilot is to achieve:

- A viable, sustainable model for MS&A national infrastructure for U.S. manufacturing
- Successful public-private partnerships
- Increased productivity and competitiveness in U.S. manufacturing

Requirements for Success

All parties must communicate effectively and clearly to make this Summit & Workshop a success. Most importantly, the manufacturing supply chain must articulate their chief concerns and cost-benefit requirements for building a long-term strategy for integrating MS&A into critical levels of the American manufacturing industry. Their input into this Summit & Workshop is the most important requirement as it will be the primary driver in how planning for the proposed pilot program proceeds. Likewise, the scope of the proposed pilot program must be carefully crafted so as to primarily focus on the common themes of the manufacturing supply chain issues while remaining inclusive of the differences that will likely emerge. This challenge of finding the proper balance to apply to the pilot program is critical to its ultimate success.

Known Competitive Concerns

Fortunately, some of the competitive concerns of the manufacturing supply chain have been identified through prior studies and discussions, and will be addressed during the Summit & Workshop. They include, but are not necessarily limited to:

- Lowering design and production costs
- Enhancing product quality, reliability and safety
- Decreasing time-to-market
- Matching workflows with demand cycles
- Increasing product customization
- Improving collaboration with OEMs

Interest in Digital Modeling and Simulation

The Summit & Workshop will likely reveal a full spectrum of existing competence and interest in MS&A. Broadly defined, suppliers fall into one of the following categories:

- No digital MS&A capability currently, but very interested in adopting
- Minimal MS&A capability, and need additional and affordable access to software, hardware and trained personnel
- Moderate MS&A capability, and need additional and affordable access to software, hardware and trained personnel
- Strong MS&A capability, and want to expand its use to other areas

Digital Modeling and Simulation Challenges

The challenges OEMs face in optimizing the efficacy and accessibility of the necessary resources are well-documented. They include, but are not necessarily limited to:

- Acquiring software that fully leverages the latest hardware technologies
- Decreasing barriers to MS&A tools, including commercial software and hardware
- Increasing the integration of MS&A into product workflows
- Training a workforce skilled in leveraging MS&A tools

The manufacturing supply chain is likely to have similar concerns, but may prioritize them differently or introduce entirely new considerations. For instance, suppliers are often more sensitive to issues of change than large OEMs. Technology platform shifts, for example, can paralyze and overtax firms without vast human and financial resources.

Enabling Technologies and High Performance Computing

MS&A done on desktop computers is useful, but incapable of propelling American manufacturers ahead of their non-U.S. competitors. For that to happen, high performance computing (HPC) must be a significant part of 21st century strategies. HPC systems offer astounding benefits, as proven in various industry, government and university settings.

- **Improved accuracy**: HPC systems can deploy hundreds or even thousands, and soon millions, of processors at a single problem, turning design decisions from uncertain approximations into exact solutions. Predictive simulation is a stated goal of several large government initiatives in HPC.
- **Faster turnaround:** While a complex problem may run for several days on a desktop, HPC systems can complete the same work in hours or even minutes.
- **Coupled solutions:** A desktop may be able to model one part of a larger system, but HPC systems can simultaneously model multiple parts working together in real-time. Calculating the "multiphysics" of all the components working in parallel decreases design time and increases product quality.
- **Greater confidence in results:** Earning customer and government validation often requires lots of simulations to narrow the "uncertainty band" of initial results. HPC systems can perform up to and beyond 100,000x more simulations than desktops. These highly-resolved calculations provide unmatched statistical confidence.
- **Design optimization:** Only with HPC systems can engineers compare hundreds or thousands of designs in a timely and affordable manner.

Access to HPC assets is becoming easier all the time. No longer do companies need to house their own clusters and expensive IT staff specially trained in HPC cluster design and maintenance. Instead, HPC resources "in the cloud" are becoming increasingly available and allow users to pay-as-you-go for only the resources you use. Cloud services cover a broad range of flexibility to the end user, ranging from the ability to provision raw hardware over the internet on demand (infrastructure as a service, or IaaS), to slightly more

pre-packaged services that handle many of the details of the underlying operating systems and applications (platform as a service, or PaaS), to complete abstraction that bundles hardware provisioning and application access and licensing in a web-based graphical interface (software as a service, or SaaS). All of these cloud models offer a pay-as-you-go policy, and the ability to rapidly expand, contract or release provisioned resources. SaaS potentially holds the most benefit for those who are new to M&SA, yet its realization in the scientific computing domain is only in the nascent stages of development.

While cloud computing offers many benefits, it is a new and evolving technology space still in the early stages of acceptance. Understanding the challenges such as security, IP protection, reliability, storage and a host of other issues is important to any discussion attempting to weigh the cost-benefits.

Questions for Discussion

Summit attendees should consider the following questions in advance of what will surely be a lively discussion. Likewise, your own questions are critical to the conversation.

Questions for manufacturing supply chain

- What design and production activities can be addressed with modeling and simulation?
- What benefits do you see of using modeling and simulation in your processes?
- What barriers prevent you from adopting MS&A and leveraging HPC resources?
- How would you craft a cost-benefit analysis of adopting MS&A into your processes?
- How do you effectively train your current workforce to use new technologies?
- How would you measure the effectiveness of the pilot program?

Questions for OEMs

- What evidence can you provide to your supply chain that MS&A will help them achieve the ultimate goals of increased productivity and competitiveness?
- Do you have MS&A resources (e.g. hardware, software licenses, trained personnel, etc.) that you could expand or redirect in support of your supply chain?
- How would you measure the effectiveness of the pilot program?

Questions for software and hardware vendors

- What are you prepared to do to help broaden the market reach of your products?
- Have you considered, or are you developing, SaaS interfaces for your products?
- Would you consider bundling software and hardware in a single pay-as-you-go package?
- How scalable is your software? How are you preparing your products to fully leverage next-generation HPC technologies (e.g. massive fine-grained parallelism, extreme non-uniform memory access (NUMA) architectures, specialized accelerators, etc.?)
- What level of background in MS&A do you assume your customers have in the training you provide for your product(s)?

Questions for national laboratories, academic HPC centers, and service providers

- How do you currently interact with private industry?
- What restrictions, if any, do you face to working with private industry?
- Do you have standard agreements in place to define licensing, royalties, and IP protection issues with private industry?
- What are the primary barriers toward increasing private industry access to HPC resources?