

Att. Critical National Needs Ideas –

***A Highly Effective and Collaborative Manufacturing Industrial Base***

Submitted on behalf of PDES, Inc. - <http://pdesinc.org/>

By

Darla Nettles, PDES Inc./SCRA  
5300 International Blvd.  
North Charleston, SC 29418  
Phone: 843-760-3232  
Fax: 843-760-3787  
[darla.nettles@scra.org](mailto:darla.nettles@scra.org)

**Contributing Organizations: Rockwell Collins, ITI TranscenData, InterCAX, SFM Technology, SCRA, ICF International**

Kevin Fischer  
Rockwell Collins  
M/S 108-105  
400 Collins Rd NE  
Cedar Rapids, IA 52498  
Phone: 319-295-8666  
Fax: 319-295-2393  
[klfische@rockwellcollins.com](mailto:klfische@rockwellcollins.com)

Manas Bajaj  
InterCAX LLC  
75 5th Street NW, Suite 314,  
Atlanta, GA 30308  
Phone: 404-592-6897  
Fax: 404-806-6211  
[manas.bajaj@intercax.com](mailto:manas.bajaj@intercax.com)

Greg Pollari  
Rockwell Collins  
M/S 108-105  
400 Collins Rd NE  
Cedar Rapids, IA 52498  
Phone: 319-295-1629  
Fax: 319-295-2393  
[gmpollar@rockwellcollins.com](mailto:gmpollar@rockwellcollins.com)

James A. Stori, Ph.D.  
SFM Technology, Inc.  
110 S RACE ST STE 201  
Urbana, IL 61801  
Phone: 217-344-8078  
Fax: 217-344-9089  
[james.stori@sfmtech.com](mailto:james.stori@sfmtech.com)

Rendall Hughes  
ITI TranscenData  
5303 DuPont Circle  
Milford, Ohio 45150  
Phone: 513-290-8382  
Fax: 513-576-3994  
[rh@transcendata.com](mailto:rh@transcendata.com)

Phil Rosche  
ICF International  
5300 International Blvd.  
North Charleston, SC 29418  
Phone: 843-760-3593  
Fax: 843-760-3349  
[rosche@scra.org](mailto:rosche@scra.org)

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## **AN AREA OF CRITICAL NATIONAL NEED**

The area selected as Critical National Need is “A Highly Effective and Collaborative Manufacturing Industrial Base.” This critical national need was selected with the larger view that a viable manufacturing base is absolutely essential to stimulate and sustain the U.S. economy, maintain our national security, and ensure our preeminent leadership in technology and innovation. Inputs regarding potential areas of this critical national need were obtained from government agencies and advisory bodies, industry organizations, leading researchers and academic institutions, and others.

The current administration has described two primary objectives for manufacturing in the next four years. First, invest in our Next Generation Innovators and Job Creators to identify the most compelling advanced manufacturing strategies. And Double Funding for the Manufacturing Extension Partnership: The Manufacturing Extension Partnership (MEP) works with manufacturers across the country to improve efficiency, implement new technology and strengthen company growth. The goal of providing “A Highly Effective and Collaborative Manufacturing Industrial Base” requires innovation and technology to achieve higher levels of efficiency that ultimately drives industry growth. The manufacturing sector continues to decline in terms of jobs for American workers. The primary driving factor is cost. The only way to drive cost down and turn around the decline is to make U.S. based manufacturing enterprises the most efficient in the world. These efficiencies are within the enterprise and across the extended enterprise. There are many elements necessary to achieve this including creating the ability for companies to interact with each other seamlessly and instantaneously. This capability requires the use, application, integration and synthesis of multiple standards and technologies within and between manufacturing enterprises.

The desired output of work funded through this competition is an implementable Model-Based Interoperability Infrastructure. Much as we depend on maintaining our Civil Infrastructure to quickly and reliably transport the physical goods and supplies used across our manufacturing industrial base, we need a strong viable Model-Based Interoperability Infrastructure to quickly and reliably transport our digital information used throughout the product lifecycle. This seamless modeling framework should be based upon the interoperability of open data standards as well as the plug-n-play characteristics of system oriented architecture; allowing digital models to smoothly “travel” over a well-defined ubiquitous and available infrastructure. Maximum value of the model-based industrial enterprise can only be realized if the models are highly interoperable across the product lifecycle applications and if there is a viable long-term perspective for the transport and archival of the model data.

Manufacturing is vital to the nation for both economic and security purposes. It is essential that the U.S. maintain and enhance its global manufacturing competitiveness through innovation and technology development. The need is critical because globalization and other external drivers increasingly shape our industrial base and the manufacturing enterprise. 21st century manufacturing requires not only innovative

fabrication and process technologies, but also effective design disciplines, globally collaborative networks and a highly capable workforce. This point has been underscored by industry in studies from associations such as the National Council For Advanced Manufacturing, Aerospace Industries Association, National Defense Industrial Association, and others. A recent NDIA white paper sent a strong message when it stated, “if we lose our preeminence in manufacturing technology, then we lose our national security.”

### **MAGNITUDE OF THE PROBLEM**

Model Based Interoperability Infrastructure – the seamless framework for Model Based Enterprise and Network Centric data systems – consists of open data standards and system oriented architecture. As the global competitiveness of manufacturing grows, we become more dependent upon our innovation and speed to market. A network-focused approach, organized around achieving a “single digital thread” helps fully leverage innovation from all tiers in the supply chain and across the total life cycle of products.

From the U.S. Department of Defense (DoD) perspective, the DoD ManTech Program draft Strategic Plan describes relevant critical needs through two of its Strategic Thrusts: *Active Support for a Highly Connected and Collaborative Defense Manufacturing Enterprise* and *Active Support for a Strong Institutional Focus on Manufacturability and Manufacturing Process Maturity*. One key enabling goal to accomplish the first Strategic Thrust encompasses the research, development and implementation of capabilities such as Model Based Enterprise, Network Centric Manufacturing, collaborative modeling and simulation, and best commercial practices. This goal supports developing industrial capabilities that allow a rapid response to dynamically changing defense needs. Another goal supporting the second Strategic Thrust describes the need for full integration of Design for Manufacturability.

Even though the ManTech Strategic Plan specifically addresses DoD needs, these issues are broadly applicable to the US manufacturing industry as a whole, including automotive, aerospace or consumer electronics.

The trend in manufacturing is toward a hypercompetitive global marketplace, driven by a growing number of nations striving to develop strong manufacturing economies.

- U.S. manufacturing faces stiff and ousting competition from low cost manufacturing in developing countries; 16% manufacturing jobs lost from 2000-2003 and 4% from 2003-2008 [EPI Paper] – approximately 3 million jobs lost in last decade, massive trade deficit in terms of goods (\$677 billion at the end of 2008). It is caught between developed countries leading on product and process innovation and developing countries competing on price and availability of large workforce.
- U.S. manufacturing must compete on innovative products, quality, productivity, environmental impact, skilled workforce, and other socio-economic factors.

- U.S. manufacturing must compete on design and operation of agile, lean, green, and sustainable manufacturing systems. Beyond the product, manufacturing systems must incorporate environment, infrastructure, government policies, business environment, and rapidly changing product/process technology landscape to be sustainable and viable in the long-term.

## **SOCIETAL CHALLENGES**

Societal challenges are defined as problems or issues confronted by society that when not addressed could negatively affect the overall function and quality of life of the nation, and as such justify government attention. In order to address the Critical National Need for a Model Based Interoperability Infrastructure, there are several societal challenges that must be overcome. The following societal challenges have maximum adverse impact on the resurgence of US manufacturing.

The cost savings, due to lower labor cost, of offshore manufacturing are partially offset with the cost associated with managing the offshore resources, dealing with language issues, lower quality, as well as distance and the time differences between countries. By applying innovative advanced manufacturing technologies in conjunction with other governmental policies regarding trade and taxes, we will be able to ensure significant amounts of manufacturing work in the U.S. However, without these advances, the practice of manufacturing offshore can only continue to accelerate.

Core to these societal challenges is the ability of U.S. manufacturing enterprises to develop and adopt innovative product, process, and systems technology. Costs and schedules for manufacturing are driven primarily by activities “above the shop floor”, that is, in enterprise level processes, business practices, and interactions across the supply chain. 21st century manufacturing will rely on a networked, collaborative and increasingly global supply base. To enable a highly connected manufacturing enterprise, it is critical to research, develop, and implement capabilities that allow for a highly collaborative Interoperability Infrastructure. Specific initiatives include Model Based Enterprise (including Model Based Manufacturing), Network Centric data environments, Integrated design and operation of manufacturing systems, and Collaborative Modeling & Simulation capabilities.

Recent industry studies on Network Centric Manufacturing and Model Based Enterprise concepts suggest that these initiatives hold promise. The objectives of MBE include a highly integrated design for manufacturability capability, increased fidelity in cost modeling, pre-production test and validation, and first article quality. Major elements required for implementation include 3-D modeling, manufacturing simulation, verified system, component, and process models, as well as visualization of end-to-end production and test processes. The promise is the ability to cycle through multiple design, model, and test cycles before producing the final system with confidence. All of which depends upon infrastructure to seamlessly transport and use data across the product lifecycle.

But challenges exist that prevent the U.S. from achieving highly effective and collaborative manufacturing enterprises across all enterprises, their software and hardware environments, the national information networks (internet and telecommunications) and information technology and integration service providers. Historically these challenges have been met with “point-to-point” solutions and standards. Most of these point-to-point standards exist today but industry has not successfully deployed interoperability capabilities that require the use of multiple standards and technologies. Furthermore, small manufacturing enterprises are not able to participate in the integration process due to cost, time and expertise barriers. Research is needed to understand how industry can begin to achieve higher levels of efficiency across technologies and standards. The impact of a tightly coupled, seamless manufacturing industrial base will be significant cost reductions such that the cost of keeping work onshore is equal to or less than the total cost of off shoring work, thus helping to reduce the number of manufacturing jobs going offshore and helping to increase the number of manufacturing jobs onshore.

Another societal challenge to consider is the competitive nature of business as it drives companies to protect their intellectual property. This appears to be in conflict with the need to seamlessly collaborate and share knowledge and information. The complexities of the 21st century business landscape create situations where the same companies can simultaneously be in a supplier-customer relationship, a competitive relationship and a collaborative relationship. The resulting uncertainty can create an unwillingness to collaborate, which in turn can make it difficult to compete globally. This yields inefficiencies that increase societal costs as seen in wasted time, missed opportunities and inefficient use of resources.

### **EVIDENCE OF COMMITMENT**

Technological innovation creates new products, opens new markets and creates new ways of making products we depend upon. Some economists estimate that about half of the U.S. economic growth since World War II has been the result of technological innovation. The U.S. not only boasts the highest-skilled workers in the world, but also the most innovative scientists, businesses and entrepreneurs who develop new products and innovations. However, America is in danger of losing its technological edge. The U.S. is today a net importer of high-technology products. The U.S. must invest in the most compelling advanced manufacturing strategies. The U.S. must retain its competitive advantage in industries of national importance. Ensuring the competitiveness of U.S. technology-based business ensures that 21st century jobs can and will grow in America. It is often federally-supported basic research that has generated the innovations to create markets and drive economic growth. America’s long-term competitiveness depends on the speed and flexibility of a highly collaborative manufacturing industrial base. This can only be achieved with a ubiquitous Model-Based Interoperability Infrastructure.

Evidence of commitment has been shown in the U.S. for the past three decades. NIST has helped sponsor and support the standards for product data exchange, networking standards, file format standards, etc. Industry associations such as AIA have interoperability initiatives working to address part of the problem. The DoD ManTech program supports numerous initiatives in the areas of Model Base Enterprise and Network Centric Manufacturing. Industry participates in numerous organizations that support interoperability and standards development. Examples include PDES, Inc., Open Applications Group (OAG), NACFAM, INCOSE, OMG, OASIS, CAM-I, NDIA, etc. Many of these standards organizations are working more effectively together to harmonize the various standards and ensure they interoperate. Some companies are able to achieve success in a few areas by themselves but the key is to have a significant percentage of companies achieve success for a significant percentage of the problem areas. A notional interoperability infrastructure is essential to the viability of U.S. manufacturing.

### **STIMULATING THE NATION'S SCIENTIFIC FRONTIERS**

A robust and reliable Model Based Interoperability Infrastructure is a critical national (even global) need that must be addressed in order to ensure U.S. leadership. The National Research Council identified key technologies for the future of manufacturing that include interoperability and interoperability standards; pervasive and adaptive process control; advanced learning technology; global collaborative capabilities; enterprise-wide supply network management; knowledge management and navigation tools; security and other protection systems; modeling and simulation technology; wireless and remote communication; software to enhance moving from ideas to products; and the incorporation of intelligence into processes and products.

### **Research to be Developed**

Advances in commercial manufacturing that have the greatest potential impact include: industry collaboration, adaptive enterprises, high-performance organizations, life-cycle perspectives, advanced manufacturing processing technology, environmentally compatible manufacturing, and shared information environments. These advances interact with each other and are composed of the following elements:

- Advanced approaches to product design, including life-cycle design, integrated product and process development, three-dimensional digital product models, simulation and modeling, and rapid prototyping.
- Advanced approaches to manufacturing processes, including generative numerical control, adaptive machine control, predictive process control, high-speed machining, flexible tooling, soft tooling, tool-less assembly, embedded sensors, flip chips, nanotechnology, and biotechnology.
- Information and communications technologies, including electronic commerce, virtual co-location of people, data interchange standards, Internet technologies, intranet technologies, browser technologies, intelligent agents, seamless data environments, telecommunications, and distance learning. This will enable the creation of a ubiquitous model based interoperability infrastructure to quickly

and cost effectively transport digital information across the manufacturing industrial base.

## **MEETING TIMELY NEEDS NOT MET BY OTHERS**

### **Complexity**

Today, manufacturing systems are large scale complex systems. Design, development, operation, and maintenance of such systems require the use of a systems approach and systems engineering toward manufacturing entities. The manufacturing system is a product itself – with its own lifecycle. Manufacturing systems must fulfill roles beyond just manufacturing products. These systems must:

- Quickly adapt to fast changing business landscapes and custom requirements for better, faster, and cheaper products
- Efficiently and productively reduce costs and afford business to be economically sustainable
- Efficiently use energy and enable reduction of fossil fuel dependency
- Respond to the environment – emissions of greenhouse gases, use and disposal of toxic and hazardous materials, recycle waste and energy
- Account for socio-economics issues – support the livelihood of thousands of families, account for the education of future generations, help build a long-term career stability
- Account for government regulations and policies

### **Interoperability**

Manufacturing enterprises are no longer self-contained organizations; they are part of a globalized supply chain. The different computer systems used by each member of a supply chain are not able to seamlessly interoperate with the others. This implies that information created in one type of software at one organization cannot be read or shared with other similar types of software applications in the same or other organizations. Examples of lack of interoperability of CAD, CAE, CAM tools even after decades of application and standards development include:

- Interoperability issues with sharing information between partners in the supply chain; typically the leading organization forces its supplier base to use the same computer software systems – leading to large scale overhaul, training, and competency issues with the supplier organizations. And when a supplier serves multiple customers, each demanding alignment, there is significant overhead, cost and waste that cannot be absorbed in competitive manufacturing.
- Lack of interoperability impedes the access and integration of information anywhere, anytime; thereby creating problems in analyzing product designs, measuring quality, and verifying requirements. Quality control which ought to be a continuous process through the product development cycle cannot be accomplished until later in the design and manufacturing stages.
- Lack of interoperability forces manual and semi-automated methods of quality control; automated verification of product designs still subject to specific

modules provided by COTS computer systems. If an enterprise wants to setup new techniques for evaluating manufacturability of products or measure quality, it must endure long-term, costly software development, integration, and qualification processes.

- Information must be managed at a much more granular level to be able to address IP issues as well as support analyses to verify product performance and quality. More often than not, analysis of products requires product information that is historically hidden and not shared by members of the manufacturing supply chain. For example, design of high-performance, better quality electronic systems necessitates system-level analyses that require detailed computer models of the components (PCB, chip packages, cables, etc.) that are controlled and not shared by the OEM.

### **Standards**

Lack of interoperability between business systems creates inefficiencies. When Information Technology (IT) systems cannot communicate and exchange data and information, manual processes must be employed. This can, in turn, be a source of errors and wasted time. While uncertainty and lack of interoperability creates confusion and waste, certainty and interoperability promote efficiency and productivity. One example of how the government can create certainty is through standards development. In this case, standards for data exchange and communication at the business and technical level would allow companies to collaborate while still protecting intellectual property. Competitiveness is also enhanced when recognized government and international standards support interoperability between IT solutions from different tool providers.

With the recent developments in the areas web services communication and information modeling standards technology, the necessary capability to address the interoperability issues exists and is ready for further extension and implementation. However, tool developers and software providers are reluctant to invest in the development of open standards on their own. Small companies cannot afford to do this alone (and likely do not have enough industry market share or clout) and large companies want to dominate the market by creating and pushing their own proprietary standards. What remains are industry collaborations or consortia who often rely on the “goodwill” of member companies to contribute effort and funds.

### **A TRANSFORMATIONAL RESULT**

Developing and implementing a national Model Based Interoperability Infrastructure would provide a truly transformational result that would enable disruptive changes over and above current methods and strategies. It would radically improve our understanding of systems and technologies, challenging the status quo of research approaches and applications.



The United States industrial base relies more and more on knowledge. Knowledge (in the form of innovation, intellectual property, and data exchange throughout the manufacturing supply chain) is the basis for significant value in industry. Inefficiencies in knowledge and data exchange, transfer, reuse, and visibility can be a severe drag on productivity – real and potential. Standards can streamline knowledge and information exchange both within a company and between companies, customers and suppliers. Eliminating these inefficiencies reduces waste and improves national productivity which in turn makes U.S. manufacturers more competitive globally while also leveraging global opportunities. Just as the digital revolution in computers has enhanced national productivity over the last two decades, so can a standards-based framework, architecture and modeling languages accelerate the digital data revolution through the elimination of errors and waste, faster development cycle time and leveraged reuse of intellectual property.

Imagine the competitive manufacturing position for U.S. workers if a ubiquitous interoperability infrastructure existed. The speed and flexibility to create highly innovative technologically advanced products would be phenomenal. The cost effectiveness from virtual models and analyzing new technology using virtual augmented reality, all through a common interoperability infrastructure, would be tremendous. Manufacturing processes could be optimized for maximum sustainability before any investment in facilities occurs. The most productive and innovative workers in the world would be provisioned with an interoperability infrastructure that is pervasive across the supply chain, unleashing tremendous collaborative capability.

The impact to the nation when a solution is discovered and pervasively deployed throughout the U.S. manufacturing industrial base will be dramatic cost savings in manufacturing that provides industry the opportunity to re-consider the cost-benefit of offshore manufacturing. This change could be the catalyst for re-invigorating U.S. manufacturing and creating a significant number of skilled job opportunities in the U.S. industrial base.

#### **WHY TIP?**

The Technology Innovation Program is in a unique position to provide the impetus to create a common U.S.-wide Model Based Interoperability Infrastructure. We have seen repeatedly in the course of history that large-scale infrastructure changes must be driven from the top down. One of the chief motivators for developing an interstate highway system was to end the economic stress of the country and create jobs – not just for the physical laborer, but for the designers, planners, and support systems that went with those highways. At the beginning of the 20th century, federal funding was given to the states, which in turn, developed their own systems of roads and even traffic laws. It was not until the 1950's that federal government provided the impetus, both in funding and direction, enabling nation-wide interstate commerce. A uniform infrastructure for moving manufacturing electronic data will do the same thing –

creating more jobs in science, technology, engineering and manufacturing for the nation and enabling nation-wide highly effective and collaborative manufacturing.

Another example of an exponential societal change driven from the top down is the development and implementation of an innovative infrastructure for transferring basic electronic information over a network. As early as the 1970's, a variety of networks existed, with none predominate until a single internet protocol was accepted as a de facto standard through government support. Government direction and investment accelerates innovation, so we don't wait 30 years for a technology change to transform the way we live. Other nations, such as China, have shown how government can transform a society in less than a decade by driving infrastructure. If a technology-based interoperability infrastructure is not driven by the federal government in the U.S., then our manufacturing will be completely overtaken by other nations. These foreign countries are striving to implement the same innovations developed by the U.S. but, aren't being implemented in our own nation due to a cultural inability to make sweeping changes, or even attempt to investigate the potential for making those kinds of changes to our infrastructure.

The challenges addressed in this whitepaper require support from TIP for the following reasons:

- Significant research is required to solve the problems. The research areas are such that no single private company can conduct the research due to the magnitude of investment and complications of non-compete legal issues.
- The problem is ubiquitous across the manufacturing industrial base from concept design to detail part fabrication. If solved, the U.S. manufacturing industry becomes the first fully networked manufacturing industrial base in the world with the ability to instantaneously share technical information for product development and enable higher levels of manufacturing resource utilization than previously possible.
- The technologies that emerge from this research are a combination of industry-wide standards and integration technologies that will be used or deployed with each mainstream CAD/CAM/CAE/PDM/PLM/ERP systems and within custom applications that provide significant competitive advantages for U.S.-based companies.

TIP is uniquely qualified to recognize the value of top-down reform for Model Based Interoperability Infrastructure. It is also in a position to initiate the direction and seed the definition and implementation of an innovative solution. If TIP doesn't rise to the challenge and light the fire for a highly effective and collaborative manufacturing capability in the U.S. it could easily be another several decades before common (standards-based) technology is implemented by commercial business. And over the course of that time, it is highly probable that our nation's manufacturing will be overcome by countries whose governments are willing to drive a top-down infrastructure.

## **WHY NOW?**

Businesses have largely made the transition from paper-based data exchange to digital data exchange. Even though the paper medium has been replaced by electronic files, the business model is still often one of simply substituting electronic data for physical data - an electronic file is created and passed along to the next person or tool. With the evolution of client-server technology and web services - part of the so-called "Web 2.0" - the concept of the standalone electronic data file is being replaced with the notion of data elements that can be accessed independently from the tool that created them. Frameworks such as Service Oriented Architecture (SOA) espouse this view. These new ways of piecing together existing internet and data exchange technologies are beginning to take hold in business and the application of these technologies has matured in the last five to ten years. Now is the time to bring a standards-based knowledge framework to bear so that industry does not waste its resources trying to sort out a "Beta versus VHS" approach to information interoperability and exchange. Without a standards-based framework, non-optimum solutions may result that could lead to low adoption.

US industry is suffering extensively through the downturn in the economy. Every day more American workers at all levels are being laid off, and more products are being designed and manufactured offshore. Currently the unemployment rate stands at 8.1% and according to some key economists it may be higher due to a number of factors. At the end of 2008 the U.S. trade deficit stood at over \$677B. U.S. industry cannot compete on a level playing field with developing countries on the basis of labor cost. U.S. industry depends upon technology and innovation to compete globally. Industry requires assistance from the Government in addressing the issues it faces today.

By providing direct government interest, guidance and investment through TIP, the ability for U.S. industry and its research partners exists to develop and implement a transformational Interoperability Infrastructure right now. The time is right to take on the hard technological issues and develop a top down infrastructure that will stimulate our national economy, generating many STEM jobs along the way, and ensuring that U.S. manufacturing truly is viable and competitive well into the next century.