

Extreme Manufacturing: The Future Manufacturing Enterprise

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Definitions of both “extreme” and “enterprise” require definition to focus discussion and inquiry into the themes of the workshop. For the purpose of this working paper, extreme is thought of as exceeding the usual and extending beyond the norm. Enterprise is thought of in the sense of a business undertaking that expends beyond the individual firm or company. Additionally, the enterprise in this sense requires skills in agility, collaboration, innovation and is complicated and willing to take initiative and risks. The outcomes sought are directed toward profit and required the ability to compete in a global capitalist economy.

History shows that most every time there have been major technology innovations they have driven “discontinuities.” Examples are railroads, automobiles, telegraph, and computers. These discontinuities have caused dramatic disruptions but also great opportunities. The ability to take advantage of the opportunities presented by discontinuous change requires firms and enterprises to change or undergo what has been called “creative destruction,” or cease to exist. Incremental change and adaption to such disruptive technology innovations are not generally successful.

As described, NIST is exploring dramatic, likely radical and fundamental change which will create discontinuities for the manufacturing enterprise. Dealing with discontinuous change will be central to achieving the outcomes the US manufacturing needs. The extreme manufacturing enterprise of the future must be able to make changes in its structure, organization and culture at a faster speed - indeed at an extreme speed; as compared to what has been the norm in the past. An incremental approach will not work, nor will one that takes a generation. Compounding the difficulty of the future manufacturing enterprise is the tendency for organizations to attempt to perpetuate the status quo. How to approach this takes several forms.

First, a systems approach is needed. United States manufacturing enterprises have developed mostly focused on internal optimization over decades; mainly as relatively autonomous firms with a limited view of the “system” the collection of manufacturing firms and service providers. Over the past several decades advances in supply chain management and enterprise information systems have made incremental, or generally localized or very industry specific system (read “enterprise”) understanding.

A systems view is important to the understanding and collective management of an extreme manufacturing enterprise. Because changes in one element of a system can have positive impact, no impact or terrible results elsewhere; the interconnection and relationships of the elements need to be understood. The speed with which an extreme manufacturing transformation must to be “extremely effective” will likely require a good understanding of the system.

Second, to gain the understanding of the system (enterprise) dynamics, modeling and simulation is needed. Changes to the system and various courses of action can be describe in models and evaluated in simulations. The recent work done in model based enterprise (MBE) may be informative.

Third, for effective coordination and collaboration an extreme manufacturing enterprise, communication for alignment and measurement of performance is central. From a systems approach the feedback loops are important. The network centric manufacturing (NCM) initiative could be worth evaluating for this purpose.

Fourth, there are the technology and science innovations that must be dealt with in the extreme manufacturing future. These will create yet unknown organizational and management challenges for the enterprise. These include:

- Robotics that approach life-like states that are smart and self-aware (or even direct human interface with machines?)
- Optics and photonics used on a much broader scale and range
- Social networks of collective intelligence and knowledge to solve problems and create product
- Workforce challenges; will bullet above reduce the need for trained engineers, scientists, managers in a region or nation; if not how is the shortage dealt with?
- Advances in computing (e.g. quantum computing; HPC)
- Nanoscience/technologies
- Environmental (manufacturing and chemical issues – beginning to disposal)
- Energy (consumption, new sources)

Fifth, the external forces of politics, international trade, academia, law and finance will need to be considered.