

# **Infrastructure in the Possible Futures of Network-centric Manufacturing**

**A Modest Contribution to Thought Leadership**

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This note has a simple goal: to offer some orderly thoughts about the infrastructure (or, perhaps, infrastructures) required to help realize the most desirable development of “network-centric manufacturing.” We hope to engage the widening circle of thought leaders who now wrestle with this important challenge for enterprise strategy and public policy.

Let’s begin with a **provisional definition**: Network-centric manufacturing (NCM) manages the manufacture of products throughout their life cycle within an enterprise in which agile partners exploit new capabilities in connectivity, new skills in collaboration, and new strategies for network visibility.

A wave is gathering. We think that network-centric manufacturing is the probable and preferred future dominant mode of manufacturing. As network-centric manufacturing emerges, corporations and the enterprises they extend across the global economy will seek competitive advantage through exploiting the technologies and practices that converge as NCM. As global market forces drive network-centric manufacturing forward, we believe that intelligent public investment in NCM can give the United States a future competitive edge in manufacturing. That belief motivates this note.

Network-centric manufacturing has transforming potential comparable in impact to the great historical transitions driven by steam and electrical power -- but NCM will arrive far more swiftly than either of those great mode-transformations and will have reach and impact that is inherently global.

As with steam and electricity, the NCM transformation is driven by a fundamental ubiquitous technology. Digital technology brings a revolution in manufacturing that transforms the speed, reach and coherence with which the forces of production are mobilized on a global scale. The digital revolution enables a much more robust, rapid, fluid, and transparent sharing of data between devices, operations, locations and participants within enterprises. The challenge is to transform this explosion of information into knowledge that can guide decisions, speed action, elevate performance and inspire deeper collaboration based on success. We believe this is already happening within some corporations where leaders see the power of NCM. In the future these leaders will create, we envision these **NCM characteristics**:

- The manufacturing/supply network will contain small and large entities with all having access to exactly the information and capabilities needed to realize their value proposition within the overall network;

- Management of the enterprise (the network of manufacturing entities that create the needed product) will be enabled by new capabilities in connectivity, new skills in collaboration, and new strategies on network visibility and metrics;
- The network will be designed for robust incorporation of innovation, addressing challenges of diminishing suppliers, and feed-forward of manufacturing capability data for incorporation in product design and support;
- Connectivity of the manufacturing/supply network will provide network-wide real time visibility to manufacturing status; and
- Intense collaboration will generate commitments within the network that are foundational to achieving results.

We believe that network-centric manufacturing is as inevitable as the historical transformations driven by steam and electrical power, but that NCM can take many forms as it evolves. Our present contains several possible futures for NCM – some more desirable than others for both enterprise possibility and human society. From our perspective, the **preferred NCM future** would:

- 1) Emerge rapidly to realize the global efficiency and continuous innovation made possible through robust realization of the digital revolution;
- 2) Open global enterprise to all wellsprings of innovation, independent of spatial location or legacy relationships; and
- 3) Reward the trust required to swiftly form collaborative enterprises among agile partners who ally and align to realize new market opportunities.

Market forces can move enterprise toward this preferred future, but the most desirable dimensions of the network-centric manufacturing future can be achieved only through robust investment in infrastructure that supports and quickens the emergence of NCM.

Some elements of this infrastructure will be built by private enterprises seeking immediate returns to investment. Corporations large and small will provide software and communications and transportation technologies that shrink space and time and enable ever more advanced collaboration. Corporations large and small will buy and apply these capabilities to participate in the most rewarding extended enterprises. Global consultancies that serve multinational corporations will compete to offer NCM expertise. Associations of manufacturers will seek to serve the NCM needs of their members.

We believe that these necessary elements of infrastructure also created by the fundamental power of market forces will still be insufficient to realize the preferred NCM future as swiftly as is technically possible and socially desirable. Thus some elements of the required infrastructure must be established through wise and sustained public investment. This investment will take many forms. We identify here **ten objects of public investment** that can support desirable development of network-centric manufacturing:<sup>1</sup>

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<sup>1</sup> Some forms of investment in some of these areas have been summarized effectively in *Supply Chain Integration: Key to Aligning the Network-centric Enterprise* (NACFAM, February 2007).

- **Basic science.** Understanding fundamentals has always been and will ever be the foundation for long term economic progress, including the NCM transformation, and in our time government has become the essential investor;
- **Pre-competitive collaboration in applied research and development.** The value of such public investment to enable swifter and stronger emergence of market forces has now been amply demonstrated;
- **Development and deployment of enabling standards.** Over time, publicly driven and mandated standards reduce waste and increase coherence;
- **Thought leadership.** Intelligent government can help identify, team and support the good minds that together can help all see the way forward on NCM;
- **Best practices.** Government can identify, document and promulgate best practices in many forms that will inspire emulation and help NCM advance;
- **Innovation.** Government investment can refresh the wellsprings of innovations that provide superior solutions to NCM challenges and support broad analysis to define those challenges for innovators;
- **Human capital.** Knowledge, skills and attitudes held by millions will be an essential condition for NCM. Government can invest in the education, training and acculturation needed from K-12 systems to university doctoral and executive education programs;
- **Procurement.** Government can model NCM best practices through intelligent procurement of manufactured inputs for national defense, energy independence and many other missions;
- **Development of the industrial base.** NCM will extend enterprise to all innovators who can contribute, especially to the creative small- and medium-sized manufacturers in the industrial base who have acquired the agility to align in network-centric enterprises;
- **Policy leadership and coordination.** Leadership and mandates from the top are essential to assure that all the forms of public investment above are supported and well-orchestrated by strong policy directives.

We believe all these forms of public investment are necessary to complement the market forces that will drive NCM forward. We hope a growing community will advocate and more public leaders will emerge to champion these investments. All advocates and champions should understand that some forms of investment will have more potential than others to give manufacturing based in the United States a competitive advantage. All are necessary for NCM; some can deliver an advantage to America.

Investments that should be made without regard to their effect in advantaging national and regional manufacturing economies include those in basic science, pre-competitive collaboration, standards, and thought leadership. Since Vannevar Bush, America has invested billions to help human kind understand the universe, confident that there will be a long-term return to the nation. NCM-enabling technologies emerging from pre-competitive collaborations are the elixirs without boundaries, the genie that no bottle can contain. NCM-enabling standards that help articulate enabling softwares should be,

by all logic, globalized as quickly as possible. Thought leadership in our world is an immediate international currency. Because NCM will be driven forward by multinational corporations less-and-less anchored in any one national economy, governments that fund NCM-nurturing infrastructure must understand and accept that some of their investments may make further globalization possible.

On the other hand, forms of public investment in NCM that, with scale and smart deployment, can be effective in at least temporarily advantaging our national and regional manufacturing economies include those in human capital, procurement, development of the industrial base, and policy leadership and coordination. Even today, most people are far less mobile than capital. Workers, professionals, most managers and many executives provided with the opportunity to acquire knowledge and skills relevant to NCM are likely to remain productive here in the United States. Procurement practices that model NCM can prefer and reward 'made in America.' Investment in infrastructure to help U.S.-based small- and medium-sized firms gain and sustain NCM-capabilities will support that part of our manufacturing endowment that is most likely to keep a substantial part of their productive assets and procurement on national turf, even as they become NCM-able participants.

Assuring that all these wealth-anchoring investments in infrastructure are made at the scale required is perhaps the most important task of policy leaders and those who will coordinate their directives. The world is getting flatter fast, but with intelligence, will and investment, NCM can be a competitive advantage for the U.S. economy -- one always vulnerable to gains elsewhere, one that must always be sustained by robust investment and vigorous execution, but one that can mean millions of good jobs and billions in revenue here at home.