



Supply Chain Integration: Key to Aligning the Network-Centric Enterprise

Findings, Recommendations, & Next Steps

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“American manufacturers are a cornerstone of the American economy and embody the best in American values. They enhance U.S. competitiveness while improving lives domestically and internationally.”

*Manufacturing in America: a Comprehensive Strategy to
Address the Challenges to U.S. Manufacturers*
January 16, 2004

The National Council for Advanced Manufacturing (NACFAM) is an industry-led, 501(c)(3) research and education organization committed to enhancing the productivity and competitiveness of U.S.-based manufacturing. It develops national policies and programs to accelerate the development and deployment of advanced technologies and related workforce skills, as well as supply chain integration and performance improvement. This is done by providing manufacturers and government – reinforced by academia, research, manufacturing extension centers, and labor – a non-partisan, non-adversarial forum to work together to strengthen U.S.-based manufacturing.

More information about NACFAM can be found at <www.nacfam.org>.

SUPPLY CHAIN INTEGRATION: KEY TO ALIGNING THE NETWORK-CENTRIC ENTERPRISE

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Supply Chain Integration: Key to Aligning the Network-Centric Enterprise

Executive Summary

Enhancing U.S. manufacturing competitiveness depends on the effective integration of the skills, capabilities and the innovation of small and medium size manufacturers into the network of organizations required to realize superior, affordable products. This research is focused on the issues and barriers, from the perspective of the small and medium size suppliers, which must be overcome to realize manufactured products in today's network-centric enterprises.

Key Findings

- Prime contractors in distributed manufacturing have not effectively communicated requirements nor assured that risk-reward is properly addressed throughout the network of participants.
- Existing policies are not designed to encourage or provide incentives for network-centric collaboration or connectivity.
- There are numerous government and industry programs focused on individual supplier capability but very few that focus on improving the network-centric environment the suppliers must operate within.

NACFAM strongly supports the recommendations from the *Manufacturing in America: A Comprehensive Strategy to Address the Challenges to U.S. Manufacturers* report issued by Secretary of Commerce on January 16, 2004.

As NACFAM explored the mechanics of how these recommendations might be achieved, the profound importance of manufacturing products in network-centric enterprises emerged as an important initiative. We call this initiative "network-centric manufacturing."

Network-centric manufacturing brings together distributed manufacturing capabilities and solutions, integrated communication networks providing real time situational awareness, and metrics across all nodes within the network.

Most problematic in this integration are the small and medium size manufacturers (*suppliers*) who often times do not have a sufficient balance in risk-reward to even consider proactive involvement in such a network of manufacturers.

NACFAM established an internal *Issue Team on Supply Chain Integration* to determine if a viable approach might be developed to address the topic. The NACFAM Board of Directors, after reviewing the findings of the team, approved a Supply Chain Integration (SCI) initiative on June 9, 2005 with the intent to address the challenge of supply chain integration within a network-centric manufacturing environment.

Figure 1 pictorially shows the network and states the overall intent of the NACFAM SCI initiative.

Nation-wide Supply Chain Integration

How to collectively design and build the national infrastructure that supports the collaboration and connectivity within the US manufacturing base supply chain – to make network-centric manufacturing a reality

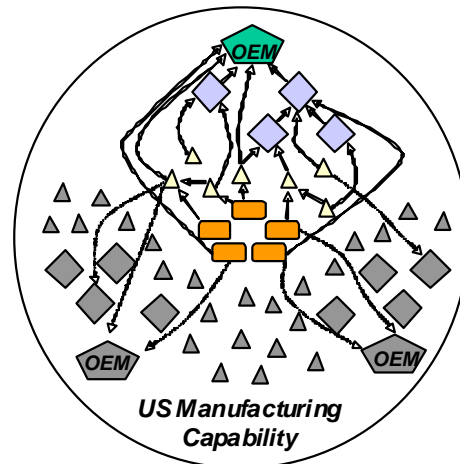


Figure 1: Supply Chain Integration – The Challenge

Funding for the SCI initiative was provided by Lockheed Martin Aeronautics Company ... and significant time and talent was provided by numerous individuals from NACFAM member organizations.

The SCI initiative overall strategy is depicted by Figure 2 (next page) and consisted of three major objectives:

1. Identify issues and barriers to achieving the supply chain integration needed for competitive network-centric manufacturing.
2. Develop a total solution package (identification of stakeholders and their value proposition) required to overcome issues and barriers within the network, especially for the small and medium size organizations.
3. Spur diverse public and private stakeholders to work together (due to the defined value propositions) to achieve the integration effectiveness required.

Intent → *Enhance the (multi-tiered) network’s operational capability and competitiveness as a whole*

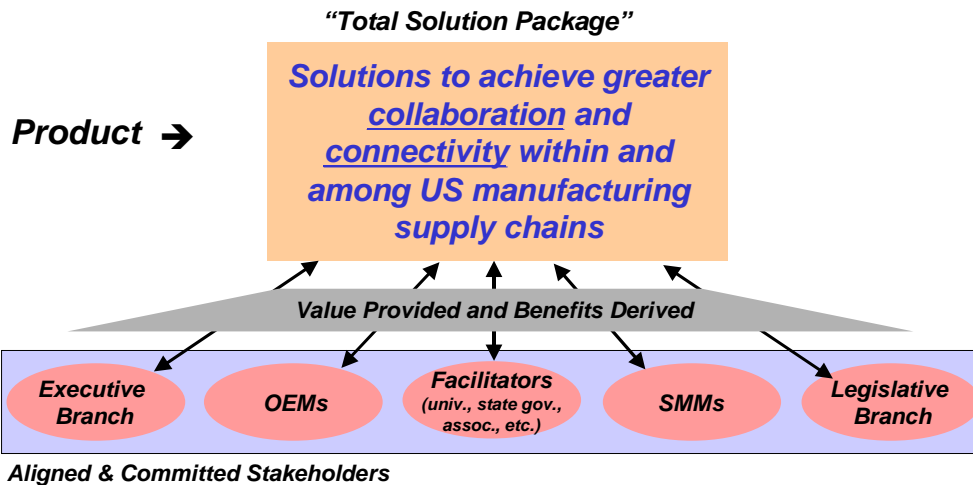


Figure 2: Intent, Product and Stakeholders

This 12-month SCI effort focused primarily on the Aerospace and Defense manufacturing sector. An Executive Steering Group (ESG) was established (Appendix A) with executives from other manufacturing sectors. THE SCI ESG reviewed the intent and the results of the three sequential workshops with a focus on assuring that the findings were broadly applicable across all U.S. manufacturing sectors.

The highlights of the workshops follow:

- Workshop I: “Voice of the Supplier”. An OEM view on network-centric manufacturing requirements was provided to a group of small, medium and large manufacturing suppliers. The suppliers responded by giving their perspectives on the challenges they faced in meeting the OEM requirements and in engaging within a network-centric environment. This “voice of the supplier” approach resulted in the identification of gaps and barriers within two major categories:
 - Collaboration – “What is keeping us from making the whole greater than the sum of the parts.” These barriers tended to fall into the categories of capabilities, infrastructure and incentives.
 - Connectivity – “How can relevant information be made available, accessible, and useable when needed.” These barriers tended to be deficiencies in capabilities and lack of standardization.
- Workshop II: “Best Practices and Solution Options”. The supplier-identified collaboration and connectivity gaps/barriers were presented to a broad set of potential solutions

providers, i.e. technical information and knowledge provided from industry, education, government, and other non-governmental organizations. These solutions providers shared their perspectives on closing gaps and eliminating barriers. A broad set of solutions approaches was explored: policy, technology, training/education, levers to change behaviors/culture, and leadership. Affected stakeholders (prime contractors, suppliers, academia, industry associations, already in-place Federal programs, Executive Branch departments, Executive Branch Interagency Working Group on Manufacturing, Congress, state governments, etc) needed to address the broad solutions sets were identified.

- **Workshop III: “Solutions and Next Steps”**. Representatives from many of the stakeholder groups identified at Workshop II came together to discuss the supplier-identified issues, the proposed solutions, and the value of their own participation. The result was the identification of a straw man “solutions package” – listing the key stakeholders and what each stakeholder provides to the initiative along with the value they obtain (see Figure 3). This SCI “solutions package” that responds to the issues identified by the small and medium size suppliers provided the research product that was chartered by the NACFAM Board on June 9, 2005.

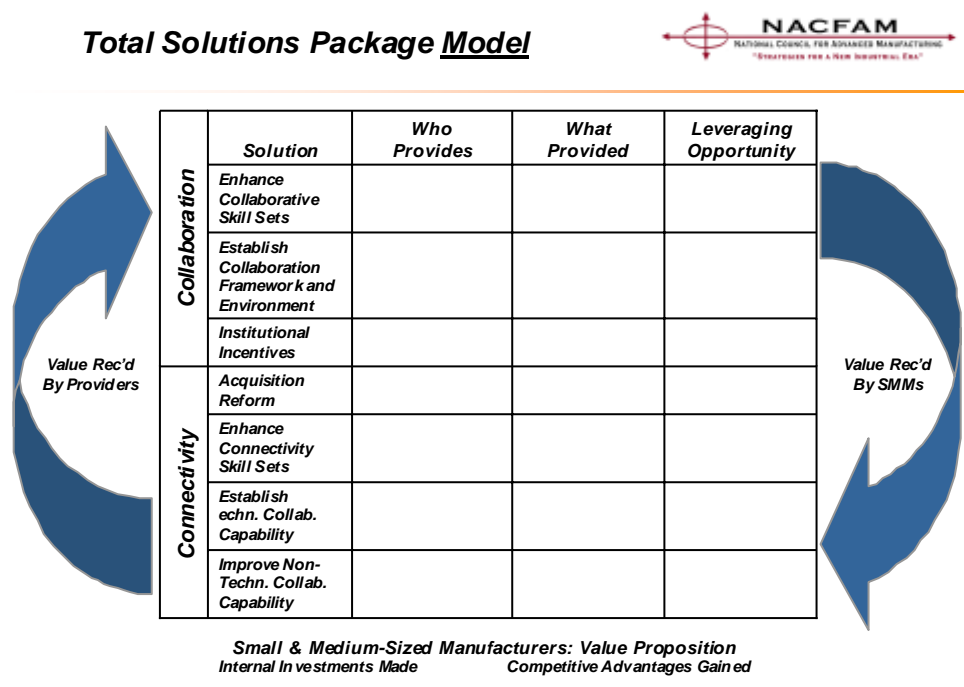
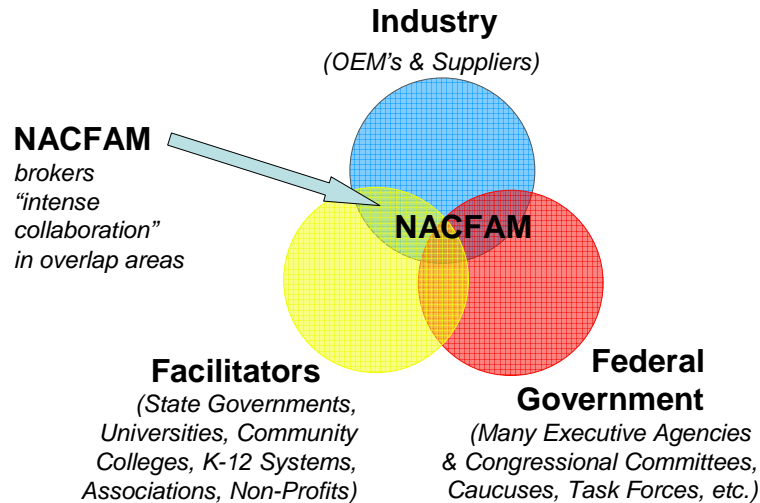


Figure 3: Total Solutions Framework

The findings of the year long research project were presented on June 6, 2006, to the NACFAM Board and at the NACFAM Advanced Manufacturing Leadership Forum (AMLF) in Washington DC. These two meetings provided a clear description of the SCI critical stakeholders. (See Figure 4 next page).

Network-Centric Manufacturing ... Requires “Intense Collaboration”



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Figure 4: The Public-Private Stakeholders Required for Achieving True Integration

The participants in the NACFAM workshops and at the AMLF agreed that success in achieving the SCI for network-centric manufacturing would demand *intense collaboration* by the public and private stakeholders.

There was a pragmatic realization that *intense collaboration* at multi-tiers among private and public organizations would be very difficult. As an advanced manufacturing “think tank” in Washington, DC, NACFAM is in a unique position to catalyze this difficult initiative since it has members from many of the public and private organizations involved in manufacturing. The participants of the SCI workshops suggested that NACFAM determine the feasibility of gaining public and private interest and support for implementing the actions required.

To determine the interest in the public and private stakeholders in pursuing the *intense collaboration* required for success, the NACFAM Board approved three actions:

1. NACFAM’s CEO and appropriate NACFAM members should meet with key leaders within the government’s Interagency Working Group (IWG) to determine this critical stakeholder group’s interest in pursuing the *intense collaboration* needed to achieve the supply chain integration capability that results in a highly competitive U.S. network-centric manufacturing capability.
2. If the public sector interest is high, NACFAM will establish a “Road Show” and will visit key stakeholders in the private sector and in organizations that are required for facilitating the solutions.

3. Based on a positive outcome from actions 1 and 2, NACFAM will form and convene a new Executive Steering Group (ESG) consisting of executives from the public and private stakeholder organizations. This ESG will guide the overall NACFAM effort to catalyze the U.S. manufacturing base to overcome existing issues and barriers to effective supply chain integration. Minimizing the barriers to effective supplier integration is foundational to a competitive U.S. network-centric manufacturing capability. Barrier elimination and deployment of capability will require “intense collaboration” among the key stakeholders. (See Figure 4 previous page).

Full Report

Background

On January 16, 2004, the U.S. Department of Commerce published a report entitled, *Manufacturing in America: A Comprehensive Strategy to Address the Challenges to U.S. Manufacturers* – also known as the “President’s Manufacturing Initiative”. This report contained 57 specific recommendations related to strengthening the U.S. manufacturing base.

While much has been done to implement these recommendations, there still remains significant effort to effectively align the Congress and other stakeholders via public policy, investments, and “intense collaboration to realize the competitiveness gains described by Manufacturing in America.

NACFAM and its member organizations (public and private) strongly endorse the Federal Government’s highlighting the importance of manufacturing to America’s competitiveness and security. In response to the report, NACFAM members met on June 9, 2005 at the annual Advanced Manufacturing Leadership Forum (AMLF). At the AMLF, NACFAM Forum Issue Teams reviewed the scope of various elements of the report and discussed manufacturing and policy shortfalls that needed to be addressed at a National level.

One of the NACFAM Forum Issue Teams centered on the topic of “supply chain integration (SCI)” supporting a U.S. network-centric manufacturing capability. Such a supply chain is more accurately described as a “value network of manufacturing organizations of all sizes, capabilities, and interests”. The findings of this Forum Issue Team on SCI were as follows:

- Federal policies and programs were not generally well suited to the realities of manufacturing supply chains.
- Original Equipment Manufacturers (OEMs), the prime/lead contractors, and their many suppliers had not effectively articulated their needs as they relate to public policy.

The SCI Forum Issue Team determined that effective supply chain integration was very important to future American manufacturing competitiveness since it was foundational to the trend of network-centric manufacturing.

The SCI Forum Issue Team presented its findings and the comments from the AMLF to the NACFAM Board late in the day on June 16, 2004. A “Go-Forward Plan” for additional effort on SCI was approved by the NACFAM Board consisting of three significant tactics:

1. Understanding gaps and barriers:
 - What are the main challenges to supply chain integration from the perspective of large OEMs and their suppliers, the federal government, educational institutions, and other manufacturing stakeholders?
2. Explore solution options and best practices:

- Brainstorm solutions to the identified barriers and seek existing best practices from global activities.
3. Develop a “total solutions package” to overcome the identified barriers:
- Identify the total solution by first identifying the key public and private stakeholders required for a total solution. For each key stakeholder, construct a matrix of “what they must “contribute” to the SCI and what “they receive” from the SCI.

At the NACFAM Board meeting, Lockheed Martin Aeronautics expressed its interest, as a NACFAM member, to sponsor the year long research related to SCI.

Project Methodology

With sponsorship from Lockheed Martin Aeronautics and the time and talent of a number of NACFAM member organizations, NACFAM undertook the year-long Supply Chain Integration (SCI) initiative with the end goal of pursuing prioritized outcomes with policy makers and other network-centric manufacturing stakeholders.

The project kicked off with the formation of a cross-sector Executive Steering Group (ESG) to guide the SCI activities, validate the general findings, and assure that the findings were applicable across all manufacturing sectors. The ESG (Appendix A) was tasked with overseeing the focused set of three sequential working sessions that were designed to respond to the NACFAM Board approved “go forward plan”.

The SCI project execution was driven by:

- Chris Hayter, Research Director NACFAM, who managed the overall project and led Workshop III.
- Chuck Moritz, Director of Supply Chain Integration at Lockheed Martin Aeronautics, who served as the SCI subject matter expert for the project and who organized and led Workshops I and II.
- Eric Mittelstadt, NACFAM CEO, and Bill Kessler, Vice President Lockheed Martin Aeronautics, who served as the Co-Chairs of the Executive Steering Group

Supply Chain Integration ... Workshop Intents



“Voice of the Supplier”

November 9, 2005

- Understand problems and opportunities
- Identify barriers and challenges



“Alternatives & Solutions”

January 26, 2006

- Identify best practices and alternative solutions
- Understand risks and benefits



“Stakeholder Solution Package”

April 11, 2006

- Identify the set of stakeholders required to design and deploy the “requirement-driven supply chain”
- Establish a “total solution package” that addresses the value and contributions of principal stakeholders (OEM, SMM, Government, and Infrastructure Orgs)

Figure 5: Workshop Intents

The SCI project was structured around three workshops (See Figure 5). The three Workshops were intended to move from the discussion and focus from definition of issues, to finding solutions, to defining the “solution package”. Thus, each Workshop required a different mix and balance of participant skills. (See Figure 6 next page).

Workshop Attendees ... Balance of Skills and Focus Important

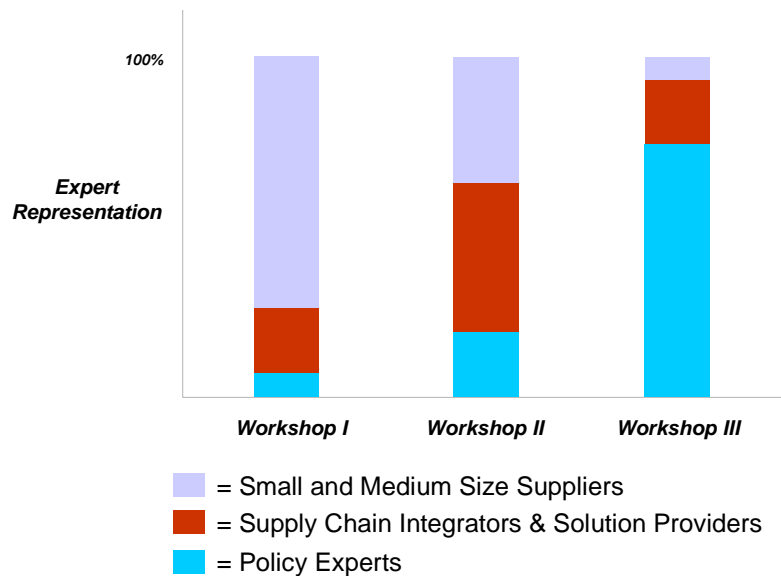


Figure 6: Attendee Makeup for Each Workshop

Key Workshop Findings

Voice of the Supplier Workshop - November 9, 2005

The “Voice of the Supplier” Workshop convened in Fort Worth, TX with the purpose of understanding and documenting the challenges and barriers existing with small and medium size suppliers as they try to collaborate and connect within manufacturing supply chains. Appendix B contains a listing of the participants along with a post-workshop document provided to the SCI ESG and workshop participants.

Challenges to network-centric collaboration were explored by asking: “What prevents us (all the participants in the network) from making the whole greater than the sum of its parts?”

Collaboration barriers tended to fall into one of three areas:

- Capabilities: collaboration, risk management, and conflict resolutions skills.
- Infrastructure: processes, communication protocols, and role and responsibility definition.
- Incentives: risk/reward imbalance, unresolved competing objectives, supporting metrics, contracting terms (length, Federal Acquisition Regulations, protection against litigation rather than encouraging trust).

Gaps and barriers to network-centric connectivity were explored by asking: “How can relevant information be made available, accessible, and usable when needed?”

Connectivity barriers tended to fall into one of two main areas:

- Capabilities: deficiencies in user-friendly systems, functionality (sub-tier schedule visibility), and training.
- Standardization: lack of standardized data formats, technical standards, and use of toolsets.

Best Practices and Alternative Solutions Workshop January 26, 2006

The session on “Best Practices and Alternative Solutions” was held in Fort Worth, Texas and examined how the collaboration and connectivity challenges identified by the small and medium sized suppliers in the first workshop might be resolved via existing best practice, adjustments in public policy, or new solutions. At this workshop, the term network-centric manufacturing was adopted to explain the changing nature of manufacturing supply chains. Appendix C contains a listing of the participants along with a post-workshop document provided to the SCI ESG and workshop participants.

Approaches to resolving the collaboration barriers:

- Enhance collaboration skill sets
- Establish collaboration framework and environment
- Institutional incentives to encourage collaboration
- Acquisition reform

Approaches to resolving connectivity barriers:

- Enhance connectivity skill sets
- Establish technical collaboration capability and standards where required
- Improve non-technical collaboration capability

Solutions and Next Steps, or Solutions Package Workshop April 11, 2006

The session on “Solutions and Next Steps, or Solutions Package” was held in Washington, D.C. and sought to translate the findings from the first two workshops into a stakeholder “solutions package.” The intent of the solution package was to serve as a baseline of major SCI stakeholders collective commitments and required contributions/benefits. Appendix D contains a listing of the participants along with a post-workshop document provided to the SCI ESG and workshop participants.

The power of the SCI project methodology paid off at this session. The methodology forced the workshop participants to focus first on the supplier issues and barriers – the “voice of the supplier”. The supplier issues, related to participating effectively in network-centric manufacturing, could then be accurately examined. Two very important conclusions emerged from Workshop III when current solutions and needed solutions were aligned with the well-defined supplier issues and barriers:

1. Existing policies are not designed to encourage or provide incentives for network-centric collaboration or connectivity.
2. Although there are numerous existing government and industry programs focused on individual supplier capability, very few center on improving the network-centric capability that the suppliers must engage within.

Workshop III participants realized that they must advance a new paradigm to align the plethora of public policies and public/private programs with the changing network-centric nature of manufacturing. To this end, Workshop III (the final segment of the research project) produced a straw man “solutions package” of key network-centric stakeholders to describe what they provide to the network along with the value they obtain. The key stakeholders needed to achieve the supply chain integration that is foundational to network-centric manufacturing are:

Industry (Manufacturers)

- Original Equipment Manufacturers (OEM) and prime contactors
- All Tiers of suppliers, including the small and medium suppliers

Government

- Executive Branch (Departments of Commerce, Defense, Education, Labor, and the National Science Foundation)
- Legislative Branch (House of Representatives and the Senate)

Facilitating Organizations

- Government
 - Interagency Working Group on Manufacturing
 - National Institute of Standards and Technology
 - National Science Foundation
 - Existing Initiatives – Manufacturing Extension Program, Workforce Innovation Regional Economic Development (WIRED), Small Business Innovative Research, etc
- Industry
 - Technology and Capability Providers
 - Associations
 - Existing Supplier Forums and Initiatives
- Education
 - Universities, Community Colleges, Technical Schools

Conclusions

The one-year of research and intense collaboration by a wide spectrum of NACFAM members and associated organizations clearly “spikes out” that an effective supply chain integration capability is foundational to future U.S. competitiveness via network-centric manufacturing.

The central issues and barriers to achieving effective supply chain integration are dominated by shortfalls, or gaps, in abilities for multiple organizations of different sizes, skills, and interests to achieve the needed connectivity and collaboration to achieve a common, sustainable objective.

Numerous government policies and programs are directed toward improving supplier capability; however, most are not connected or aligned to achieve the network-centric capability needed for the future. Similarly, industry initiatives are often focused on instant results and not on building the network-centric capability needed for the future.

The findings clearly indicated that, within any network-centric manufacturing arrangement, the risk-reward and incentives for each node in the network (organization) must be considered and aligned with the overall objective to be achieved.

Based on this limited research and collaboration, NACFAM concludes that a different paradigm is needed to address the risk-reward (or value proposition) for each of the key public/private stakeholders required to realize effective supply chain integration. Furthermore, intense collaboration of public and private organizations will be required to eliminate existing policy, technology, knowledge, and behavioral barriers to supply chain integration.

Real progress toward network-centric manufacturing will not be possible unless the key public and private stakeholder organizations devise collaborative methods to eliminate the barriers.

Appendix A: Executive Steering Group

Paul Baird
Materials Manager
Lear Corporation

Bruce Beier
Manager Logistics Strategy
DaimlerChrysler

Chuck Ebeling
Production Programs Director
Northrop Grumman

Judy Hertzburg
Director, Supply Chain Management
Northrop Grumman

Richard Honan
President
Richards Screw Machine

Art Kennedy
Vice President for Quality
Lear Corporation

Bill Kessler
Vice President, Enterprise Initiatives
Lockheed Martin

Eric Mittelstadt
Chief Executive Officer
NACFAM

Lawrence J. Rhoades
Chief Executive Officer
The Ex One Company

Rick Rosenjack
Vice President and General Manager
Progressive, Inc.

Rick Schiffman
Sourcing & Procurement Manager
New Balance Athletic Shoe, Inc.

David Smith
Supply Chain Manager
Raytheon

Jim Tonder
Director of Airborne Processors
Raytheon

Peter Weiss
Director, Transportation & Customs
DaimlerChrysler

Appendix B: Participants and Documentation Workshop I

“Voice of the Supplier” November 9, 2005

Participants for Workshop I

Chris Layne
General Manager
Aero CNC

Vernon Harris
President
Harris Composites

Jacque Keeney
Supply Chain Integration
Lockheed Martin

Toxey Leonard
Representative
Alken Industries

Trevor Shannon
Operations
Interconnect Wiring

Mark Miller
Director, Procurement
Lockheed Martin

Wilma Martin
Vice President
Alken Industries

Charles Hughes
Supervisor
JD Morris

Anthony Perrotta
Senior Manager,
Supply Chain
Lockheed Martin

Sam Symonds
Senior Vice President
Co-Operatives Industries

Russell Pompa
Supervisor
JD Morris

Tom Plungis
Senior Manager,
Supply Chain
Lockheed Martin

Dale Westerfeld
President & Owner
Essner

Gary Bailey
Vice President, Material
Management
Lockheed Martin

Carol Alaniz
Savage

Bruce Lawson
General Manager
Farrow Machine

Roger Denton
Sr. Manager, Supplier
Lean Development
Lockheed Martin

Bob Holmes
Marketing Manager
Solidform

David Hodges
Representative
FMH

Amy Gowder
Senior Manager, Supply
Chain Integration
Lockheed Martin

Nancy Nix
Exec. Director, Supply &
Value Chain Center
Texas Christian Univ.

Willie Gandy
Contracts Administrator
H. M. Dunn

Jeff Holmlund
CAD/CAM Engineering
Lockheed Martin

Bernard Fontaine
Texas Manufacturing
Assistance Center

Debra Harris
Chief Executive Officer
Harris Composites

Steering Committee for Workshop I

Paul Baird
Lear Corporation

Judy Hertzberg
Northrop Grumman

Eric Mittelstadt
NACFAM

Larry Rhoades
The Ex One Company

Rick Rosenjack
Progressive, Inc.

SCI Project Leads for Workshop I

Chris Hayter
NACFAM

Chuck Moritz
Lockheed Martin

Documenting Findings (Workshop I)

Background

Historically, Aerospace & Defense primes have been piece-part and individual component purchasers who possessed the internal, vertical infrastructure for building and delivering complete products. In recent years, industry capabilities in manufacturing, engineering and software have expanded and become more advanced and accessible. This plus the need to *mandate for affordability* and *capacity rationalization* have fueled the Aerospace & Defense primes' transformational journey toward becoming system integrators to reduce internal costs and to focus on core competencies.

Concurrently, the war fighters' needs have also advanced and evolved. Emerging network centric warfare strategies involve fresh thinking into how missions are accomplished, how the battle space is viewed, and how the systems that support the mission are acquired and fielded. The tenets of Net Centric Warfare include:

- A robustly networked force improves information sharing
- Information sharing enhances the quality of information and shared situational awareness
- Shared situational awareness enables collaboration and self-synchronization and enhances sustainability and speed of command
- These in turn dramatically increase mission effectiveness

These tenets clearly resonate in the demands of today's manufacturing environment. This notion of "network centric manufacturing" requires an enabling infrastructure to allow the creation, integration and management of supplier networks. The infrastructure exists only in part today, severely restricting the effectiveness of a globally-dispersed supply chain. Execution in the new state is not supported by people skills, business models, infrastructure or connectivity.

Understanding the nature and degree of supply chain integration required to enable net-centric manufacturing is fundamental to assuring a competitive US manufacturing capability for the future. To address this challenge for supply chain integration, the National Council for Advanced Manufacturing and Lockheed Martin Aeronautics Company conducted the first of three workshops to determine how to achieve greater collaboration and connectivity within and among US manufacturing supply chains. The focus of this effort was not on improving the competitiveness or productivity of individual companies, but rather enhancing the (multi-tiered) network's operational capability as a whole. Participating in this full-day session were representatives from small to medium sized component manufacturers including a first tier automotive supplier, various Lockheed Martin disciplines, and supply chain specialists from academia and advanced manufacturing non-profit organizations.

Below describes the consensus of the team regarding the key challenges being faced in the critical areas of collaboration and connectivity.

Collaboration – “What is preventing us from making the whole greater than the sum of the parts?”

Collaboration barriers tended to fall into one of three areas: capabilities, infrastructure and incentives.

Capabilities

The first barrier to collaboration resides in the capabilities of the supply chain. The missing capabilities consist primarily of skills and training throughout the supply network, at the primes and with the customers. These absent skills that combine to create the barrier to collaboration include formal collaboration skills, technical skills, risk management skills and conflict resolution skills, and the ability for prime points of contact to navigate their internal organization to find the required information or decision maker. Employees have not been adequately trained to effectively operate in a highly complex, horizontally integrated and interdependent network that operates most effectively via collaboration. The impact of poor training or lack of consistency in skill sets is exacerbated by changes in personnel. This instability or turnover in people often leads to reversals in decisions and the need to reestablish and rebuild relationships resulting in time delays and lost efficiency.

Additionally, the defense industry faces unique challenges in the area of collaboration that are not experienced by commercial industries. Federal acquisition regulations encouraging arms length relationships to ensure competition and objectivity in some scenarios do not foster the close relationship and trust required for effective collaboration. Restrictions on length of contracts do not allow for long term relationship security. Changing customers and their political influences affect stability of requirements and focus areas as well as budget decisions.

Infrastructure

The second barrier to collaboration is inconsistent or insufficient infrastructure. The infrastructure required to achieve the benefits of vertical integration in a horizontally integrated supply chain has not been fully established. There is no confirmation or assurance that processes that are now outsourced were transitioned appropriately. This infrastructure is lacking in clearly defined processes, communication protocol, and mutually agreed to roles and responsibilities.

Currently there is no standard approach to collaboration processes or interoperability either between primes or among the primes and the supply network. No standard service levels in communication protocol have been established to ensure the timely flow of changes, decisions, expectations, priorities or resolutions to issues from the primes to the supply base and within the extended tiers of the supply network. Also, the lack of a two-way communication mechanism to understand each others realities and allow for suggestions/changes creates barriers.

The lack of infrastructure and standards extends to the area of clear definition of roles and responsibilities between the prime and the supply network. The proper use of Prime resources and capabilities such as leverage over unresponsive sub-tiers is not effectively utilized. Additionally, opportunities among the primes to standardize on materials, specifications and processes or collaborate for critical materials shared within the industry have not been implemented or in some cases even considered.

Another poorly executed infrastructure element is the legal/contractual language that discourages collaboration. For both the primes and supply network, legal and finance are rarely involved in development of collaborative relationships and processes. The result is conflicting or restrictive clauses that protect against litigation rather than encourage trusting relationships. Intellectual property protections and recent Sarbanes-Oxley measures may have implications and erect barriers to collaboration efforts. Most importantly, the short-term, fiscal year contracting approach inhibits long-term efficiencies and relationships and effectively blocks collaboration opportunities.

Incentives

The last barrier to collaboration is incentives. Effective incentives to collaboration reinforce a goal alignment and reflect a shared value proposition. Current incentives either articulate rewards that do not match the risk or the rewards are unclear and do not promote taking on risk. Often the risk being requested of the supply bases consists of items beyond their control or influence. Risk is inherent in long-term commitments, material costs and cost of capital. Risk must be assigned where it is most comfortably accepted. To more effectively collaborate, risk assignment among the supply base and primes should be revisited to match resources and capabilities. Additionally, current incentives focus on short-term gains, not long-term efficiencies. They do not promote the discipline required for long-term effective performance and collaboration to achieve that performance. Consequently, metrics, supporting these incentives, do not measure a suppliers' capacity to collaborate or achieve long term performance goals. Current metrics employed by the OEM's capture material costs not value stream costs.

Lack of collaboration capabilities, complete infrastructure, and desirable incentives prevent effective collaboration efforts.

Connectivity – How can relevant information be made available, accessible, useable when needed?

Connectivity is defined as the ability to exchange data, interface and communicate required information to effectively manage operations. Connectivity barriers discussed are deficiencies in capabilities and lack of standardization.

Capabilities

In the software industry, there is not a state-of-the-art, web-based communication tool that is able to create a full digital thread through the supply network. The toolsets that exist are often complex and not user friendly. They lack effective translators to communicate and correctly share data among systems. As a result, data are often distorted or missing throughout the supply network. Software functionality can also be an issue. There are limited software tools to effectively plan and schedule jobs within the sub-tiers and share this schedule data back to the primes. Another capability barrier to connectivity is the access and cost prohibitions to sub-tiers. The sub-tiers often can't fund multiple software systems required to access the required data.

Additionally there is a lack of effective training on the toolsets. This training is vital to the correct use since these toolsets as mentioned before are very complex and unintuitive. The training that does exist is often "canned" and does not reflect "real – life" situations or is not applicable when the resources begin to use the tool. The incorrect use of the toolsets further distorts data transmission. Finally, these toolsets require the supply base to interrogate prime/customer systems to retrieve data and the relevancy or priority of the available data is not clear nor actionable. For effective connectivity, data must be transmitted in a clear, timely and efficient manner.

Standardization

The lack of standardization further prohibits connectivity – particularly in the sub-tiers. The software industry, operating in a competitive, technology-based market, offers a variety of formats, standards, and choices in data exchange. While competition is healthy, this proliferation of options often does not promote better fundamental connectivity but rather allows for increased complexity in integration and increased risk in data distortion during translation. The government consciously does not offer incentives to standardize to promote competition. However, in some cases the government will dictate toolsets. The forced selection of toolsets can drive further inconsistencies and increase the lack of standardization.

Next Steps

The obstruction to connectivity reduces the effective and timely response to changes. The lack of connectivity prevents the supply chain from being flexible and able to operate at efficient performance levels. Lack of capabilities including technical toolsets and required skills as well as lack of standardization of data exchange create barriers for effective supply network and prime connectivity. Finally, directed toolset selection can undermine efforts to standardize technology and toolsets within and among primes, programs and the supply network.

Workshop II will focus on identifying best practices and alternative solutions while understanding the risks and benefits. To frame the workshop we should consider the following issues related to collaboration:

What might a net-centric enterprise look like? What infrastructure is required for optimal performance? How can we best align existing infrastructure, incentives, and other resources toward the net-centric enterprise? We should also determine who provides the infrastructure and begin to discuss how enterprise stakeholders advocate for the required resources. Can

initiatives be aligned and can we leverage incentives, subsidies and grants? What incentives will affect collaboration and how can those incentives be implemented? Specifically what acquisition reform solutions should be available that are currently not an option? How can we align other supply chain integration initiatives? How do we overcome skill and training issues?

To address connectivity barriers the questions to consider include: What solutions will result in improved connectivity? How can cost and skill deficiencies be addressed in the sub-tier level? What standardizations in connectivity are fundamental and necessary versus optional performance enhancers?

Summary

Understanding the nature and degree of supply chain integration is fundamental to assuring a competitive US manufacturing capability for the future. To address this challenge, the National Council for Advanced Manufacturing and Lockheed Martin Aeronautics Company conducted the first of 3 workshops to determine how to achieve greater collaboration and connectivity within and among US manufacturing supply chains. Below describes the consensus of the team regarding the key challenges being faced in the critical areas of collaboration and connectivity.

Collaboration

Barriers Specific to the OEM Relationship with their Extended Enterprises:

- The training and skills of OEM “purchasing personnel” and supplier personnel must be reflective of the technical needs and the changing nature of manufacturing supply chains
- Infrastructure processes and communication protocols are not clearly defined; Sub-tier suppliers [processing houses, raw material providers] are not fully integrated into the overall communication networks
- Existing manufacturing networks often do not leverage the resources and capabilities in confronting unresponsive sub-tiers, including raw material suppliers and markets (e.g. Titanium)

Barriers Specific to the U.S. Industrial Base:

- Federal acquisition regulations discourage collaboration and integration
 - Contractual incentives and metrics measure PO cost, not value stream costs
- Federal contracting personnel do not possess the skills and technical capability; they are not fully aware of the barriers to collaboration created by the federal contracting process
- Intellectual property protections and recent Sarbanes-Oxley legislation may have implications and erect barriers to collaboration efforts
- Education regarding new manufacturing paradigms is required to convey the challenges in, and need for, an integrated infrastructure within the extended enterprise
- OEMs’ supplier performance incentives and corresponding metrics do not encourage collaboration, connectivity, and other factors related to a suppliers capacity to collaborate

Connectivity

Barriers Specific to the OEM Relationship with their Extended Enterprise:

- The training on toolsets is not reflective of “real” operational scenarios creating inefficiencies and data distortion throughout the users of the supply chain system

Barriers Specific to the U.S. Industrial Base:

- There is a definitive need for data exchange standards, especially to reduce the cost of involving sub-tier suppliers, most of whom cannot afford to conduct business with a wide variety of OEMs using differing standards

Questions and Next steps

- What might a net-centric enterprise look like?
- How can we best align existing infrastructure, incentives, and other resources toward the net-centric enterprise?
- How can we align other supply chain integration initiatives?

Appendix C: Participants and Documentation Workshop II

“Solutions and Best Practices” January 26, 2006

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Documenting Findings (Workshop II)

Understanding the nature and degree of supply chain integration is fundamental to assuring a competitive US manufacturing capability for the future. Of even greater importance is to understand how companies, supported by effective government policy, can ensure well-integrated, robust supply chain performance.

Lockheed Martin Aeronautics Company and the National Council for Advanced Manufacturing (NACFAM) held a Supply Chain Integration workshop on January 26, 2006 entitled: **Best Practices and Alternative Solutions** in Fort Worth, Texas. The workshop was the second of three workshops aspect of NACFAM's Supply Chain Integration Initiative which will result in a series of policy prescriptions as to how the federal government can improve and more effectively support a nation-wide supply chain infrastructure.

The first workshop, entitled **Voice of the Supplier** convened small and medium-sized suppliers, OEMs, and subject matter experts to understand and document emerging challenges and barriers to collaboration and connectivity within manufacturing supply chains. During the second workshop, participants from small to medium size component manufacturers, various Lockheed Martin Aeronautics functions, academic and industry specialists as well as local and national manufacturing organizations reviewed the challenges identified in the first workshop and discussed how these related to best practice, potential solutions, and public policy. Below describes the consensus of the team regarding the key areas of focus for solutions in the critical areas of collaboration and connectivity.

Collaboration: “What is preventing us from making the whole greater than the sum of the parts?”

Challenge: *training and skills of OEM “purchasing personnel” and supplier personnel must be reflective of the technical needs and the changing nature of manufacturing supply chains*

Solution discussion:

- OEM investment to develop multi-functional skills in purchasing organization
 - A “collaboration technician” - being “only a buyer” is the elevator attendant of today
 - Collaboration, technical, and business skills are necessary
 - A commodity team approach may be a good alternative
 - “Can you collaborate externally if you can’t collaborate internally?”
 - Understand many different types of business issues
- OEM investment in collaboration skills for its suppliers:
 - Communication clarity
 - Team operations
 - Goal setting
- OEM investment in supply chain skills for its suppliers:
 - Forecasting
 - Planning
 - Inventory management
- OEM collaboration with suppliers to help the latter understand where they (and their product) fit into the supply chain
 - Establish Trust and Verification Processes
 - Establish Clarity of Communication for how to operate in the supply chain
 - Write a “white paper” on how to collaborate to clearly articulate expectations
- OEM and supplier executive understanding of the benefits and requirements for effective collaboration
 - Executive sponsorship in all organizations for collaboration
 - OEMs need to recognize suppliers dilemma
 - Suppliers need to be flexible and know there is never “one” solution
- Better OEM definition of a career path for a cross-trained, multi-functional “collaborative technician;” e.g. general management which requires the same kind of integrative skills.

Challenge: *infrastructure processes and communication protocols are not clearly defined; sub-tier suppliers [processing houses, raw material providers] are not fully integrated into the overall communication networks.*

Solution Discussion:

- OEM creation of an “Extended Enterprise Culture” with strategic suppliers
 - Corporate-level executive leadership, sponsorship and collaboration strategy definition
 - Clarity in goals and mission, then identification of gaps
 - Executive understanding of the business case for strategic collaboration
- OEMs executive-level capability for process mapping and value stream identification
- Executive dedication to collaboration
- OEMs must foster supply chain stability through semi-permanent ground rules and fundamental business goals
- Continual emphasis on Lean in a “Job Shop”
- Continual and robust contingency planning to react to potential disruptions in the supply chain

Challenge: *Existing manufacturing networks often do not leverage resources and capabilities in confronting unresponsive sub-tiers, including raw material suppliers and adverse market trends (e.g. Titanium)*

Solution discussion:

- OEMs and supply base cooperation to ensure clear incentives and transparent value stream
- OEMs willingness to re-evaluate terms when global market conditions change or issues arise:
 - Involve the customer when market changes occurs
 - Share resolution costs within the supply chain, do not just “push down” to a supplier
- Adequately assign risk and reward throughout the supply chain, do not just “push down” risk
- Reward actions to mitigate risk to drive the right behavior – example of Army paying higher profit margins to meet schedule dates resulted in prime buying raw material to mitigate schedule slips

Several models for benchmarking were discussed by participants in the room based on their experience. This list is not exhaustive but could serve as a starting point to explore further when developing solutions. These models for benchmarking include:

- Corporate Collaboration models:
 - Toyota/Honda
 - Textron/Cessna
 - Frito Lay
 - Nokia
 - Caterpillar
 - Linbeck Construction
 - Lin-Fung
 - Embraer
- Public-Private Collaboration Models:
 - John Deere/Harley Davidson/Oshkosh Truck Supplier Consortium Model through WMEP
 - DOD/Defense Industry Models
 - Army aviation mechanisms to deal with titanium market fluctuations, including OEM purchase of raw material to meet schedule
 - Army aviation incentives for meeting or exceeding delivery schedules
 - JDAM
 - DLA’s “Collaboration Group”
 - SEA
 - Educational Institutions
 - MIT
 - UT Austin
 - Penn State
 - Arizona State University
 - Ohio State
 - Stanford
 - Georgia Institute of Technology
 - Carnegie Mellon University
 - University of Tennessee
 - Defense Acquisition University
 - Community Colleges
- Competitive public-private practices and policies in other nations:
 - Japan
 - Singapore

- Germany
- Ireland

Areas of Focus for Third Workshop:

- What can policies and programs do to build on the successes of the models and lessons identified above
 - Economic development efforts that encourage a strong supply base, not just the recruitment of OEM facilities
- Educational and training systems that prepare students to meet the challenges identified above
 - A more “pull-based” education/workforce training system
 - Interdisciplinary and collaborative skills to prepare workers for the realities mentioned above: what is the foundation of the “collaborative technician?”
 - Interdisciplinary graduate programs, e.g. MIT’s LFM program
 - Training on common technical systems such as ERP
 - Expanding educational resources to include “at risk” workings and issues specific to the aging workforce. Filling the talent pipeline.
- A better understanding of the impact of regulation such as intellectual property protections and recent Sarbanes-Oxley legislation on collaboration efforts
- Defense procurement:
 - Changing FAR focus from order launch controls to order/contract management controls
 - How can we improve the skills, technical capability, and understanding of the value of collaboration for procurement personnel (they are not fully aware of the barriers to collaboration created by the federal contracting process)
 - How can we get contractual incentives and metrics to measure value stream costs not purchase order costs?
 - Resolve impact of bidding/competition requirements (at the expense of collaboration) required by FAR
 - Involving DOD in the resolution of defense supply chain issues identified above
 - Are there existing mechanisms through which DOD could do this?
- Institutional incentives for companies willing to embrace collaboration:
 - Tax relief on collaboration investments which ultimately generate more taxable revenue
- Making the business case for collaboration
 - Are there ways NACFAM can work with universities, government institutions, and the investment community to conduct research highlighting the risk/reward value of collaborative behavior?
 - OEMs’ supplier performance incentives and corresponding metrics do not encourage collaboration, connectivity, and other factors related to a suppliers capacity to collaborate
- Do/how do other countries use policies and programs to encourage collaboration and strengthen the development of strong supplier networks?

Connectivity: How can relevant information be made available, accessible, and useable when needed?

Challenge: *The training on toolsets is not reflective of “real” operational scenarios creating inefficiencies and data distortion throughout the users of the supply chain system*

Solution Discussion:

- Organizations can start with low technology solutions such as weekly teleconference with supplier teams
- IT systems are the enabler of collaboration, so OEMs and suppliers must understand that maximum return on connectivity investments is predicated on effective collaboration
- However complex, connectivity systems must provide visibility and business intelligence at all levels of the supply chain:
 - Information must be “brought up” the supply chain, not just flowed down
 - Information should be role based so the ‘right information’ is sent to the “right customer”
 - Suppliers at all levels must be able to “raise the flag” if a problem arises in their organization or supply chain
- OEMs and suppliers at all levels must have the skills and ability to determine:
 - Context of data exchange
 - Complexity of data being exchanged and
 - Precision versus accuracy required in the exchange
 - Develop business rules based on above decisions and process mapping
- Standardization
 - Commodity or Non-design collaboration
 - Many options: Hosted solutions / Web Portals (HTML/ XML) / Open standards
 - Commercial standards work well
 - More focus needed to share following data: Performance, Forecasting, Planning, Inventory
 - Product Data/ Design collaboration
 - Progress efforts of verification/metrics of successful translation
 - Resolve ability to communicate engineering changes in a timely fashion
 - Evaluate use of 2D drawings and standards versus solid models when communicating with supply base

Challenge: *there is a definitive need for data exchange standards, especially to reduce the cost of involving sub-tier suppliers, most of which cannot afford to conduct business with a wide variety of OEMs using differing standards*

- NIST, industry associations, and companies should focus on efforts to standardize translators to common systems
- Industries should expand the hub concept for standards (ExoStar, e2Open)
 - Note: Political reasons have caused past “Hub” failures

Several models for benchmarking were discussed by participants in the room based on their experience. This list is not exhaustive but could serve as a starting point to explore further when developing solutions. These models for benchmarking include:

- Corporate connectivity models:
 - Nissan – pursuing metrics/verification of translator accuracy
 - IBM – integrated community for supplier visibility
 - Dell – Supply Chain connectivity
 - Amazon – Supply Chain connectivity
 - New Balance – Supply Chain connectivity
 - Cisco – both supply chain and design connectivity
 - Telecom industry – supply chain connectivity

- Auto Industry – ECN communication
- Educational Institution Models:
 - Massachusetts Institute of Technology
 - Georgia Institute of Technology (PLM Center of Excellence)
 - University of Maryland – Net centricity lab for supply chain information exchange
- Programs
 - Intelligent Manufacturing Systems Program – Global Education in Manufacturing initiative (Started in Japan being reviewed by MIT, Clemson University)
 - STEP Program at NIST

Areas of focus recommended by the participants of Workshop II:

- What can policies and programs do to build on the successes of the models and lessons identified above?
- What are the primary challenges and enablers for successful industry hubs? Is there a role for the federal government?
- How does lean supply chain product development figure into connectivity?
- How can SMEs have more of a voice in the development of standards or systems?
- Other possibilities based on the many above-identified needs

Appendix D: Participants and Documentation Workshop III

“Solutions and Best Practices” April 11, 2006

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Documenting Findings (Workshop III)

Workshop III was very much a working session of public and private organization representatives identifying the key public/private stakeholders required to overcome the barriers to effective national-level supply chain integration. For each key stakeholder identified, the workshop participants discussed and documented the “value proposition” – what the stakeholder would have to provide and what the stakeholder gained by participating.

The following tables of stakeholders and their value propositions were created at the Workshop and are included here. These are not final and will be adjusted over time. However, they provide an excellent starting point for engaging with each of the organizations to determine their interest in “intense collaboration” on the topic of supply chain integration.

OEMs

Who Provides	What Provided	Leveraging Opportunity
OEMs Executives	Leadership, decision-making	<ul style="list-style-type: none"> ▪ Need to understand business case for collaboration ▪ Understand impact (true cost) of outsourcing/off-shoring decisions for company not just advice of consultants
OEMs Mid-level executives/ Decision-makers	Sourcing decisions, next generation of leadership	<ul style="list-style-type: none"> ▪ Need to understand business case for collaboration ▪ Understand impact (true cost) of outsourcing/off-shoring decisions for company not just advice of consultants
OEMs Consortia	Supplier solutions through: <ul style="list-style-type: none"> ▪ MEP/Techsolve ▪ Industry Associations (AIAG, OAG, APICS, ISM) 	<ul style="list-style-type: none"> ▪ Federal support with state funding ▪ Incentives ▪ Collaboration/ Connectivity training through industry and professional associations

UNIVERSITIES AND EDUCATION PROVIDERS

Who Provides	What Provided	Leveraging Opportunity
Universities/ Education Providers	Research, Education and Training	<ul style="list-style-type: none"> ▪ Help workers understand and become proficient in virtual business collaboration ▪ Provide continuous, life-long learning/retooling; mid-career training ▪ Applied learning, especially for manufacturing ▪ Interface with NSF, DOL, and DoEd programs ▪ Use business schools to influence network-centric thinking ▪ Use business schools to influence role of government in infrastructure and business

EXECUTIVE BRANCH

Who Provides	What Provided	Leveraging Opportunity
Department of Labor	Funds for Workforce Training	<ul style="list-style-type: none"> ▪ Could tailor training to emphasize collaboration ▪ Works through MEPs, could do more ▪ Could provide incumbent worker training, not just for unemployed ▪ WIA reform to emphasize coordination – current WIB system is outdated
Department of Education	Federal funding and standards to states	<ul style="list-style-type: none"> ▪ Could provide standards for collaboration curriculum, teamwork and team building
Department of Defense, DLA	Performance-based logistics; specifications and regulations for purchasing	<ul style="list-style-type: none"> ▪ DLA personnel could be capable of understanding technical components ▪ DLA could have better ability to evaluate PBL vs. OTS offerings – ex. MREs ▪ Should reevaluate need for raw

		<p>materials stockpiling function</p> <ul style="list-style-type: none"> ▪ Should evaluate relationship between order fulfillment and operational programs such as MEP
Department of Defense, Army Aviation	Interest and resources to address problems in the helicopter supply chain working through MEP	<ul style="list-style-type: none"> ▪ Collaborative model with MEP could be extended to other services, other platforms, other industries, and regions of the country
Department of Defense, Small Bus. Office	Coordination of small business policy, including SBIR and minority programs	<ul style="list-style-type: none"> ▪ Use SBIR to help suppliers move up the value chain and build capabilities; better alignment with President's manufacturing directive ▪ SBIR resources with MEP
Department of Defense, Leadership "Three-star general"	Critical Decision-making	<ul style="list-style-type: none"> ▪ Education in supply base issues, importance of supply chain issues in procurement ▪ Provide through "kitchen cabinet" ▪ SC Focus at NDA, Staff colleges, service academies
National Science Foundation	Funding for research, educational programs	<p>Funding research to support:</p> <ul style="list-style-type: none"> ▪ Supply Chain Integration ▪ Business case for collaboration ▪ Graduate students to work on the "basic science" of collaboration and connectivity: syntax and other challenges ▪ Work with industry and industry groups (AMR, associations, etc.) to understand how the research above impacts systems, accounting, corporate best practices, etc.
National Science Foundation (Cont.)	Funding for research, educational programs (Cont.)	
National Institute for Standards and Technology (NIST) Manufacturing Engineering Laboratory (MEL)	IT Infrastructure Connectivity solutions	<ul style="list-style-type: none"> ▪ Not going to "chase technology" ▪ Development of science of connectivity including an understanding of information needs ▪ Putting a human element (collaboration) into connectivity ▪ Test Bed development ▪ Work with DHS, DOD, CIA/

		<p>Intel community to help engineer connectivity solutions</p> <ul style="list-style-type: none"> ▪ Enhance Congressional awareness ▪ Take advantage of MOU with NSF
<p>National Institute for Standards and Technology (NIST) Baldrige Award</p>	<p>Standards for Quality</p>	<ul style="list-style-type: none"> ▪ Establish public sector quality standards ▪ Establish quality principles and metrics for small manufacturers through the MEP system ▪ Involve OEMs in the process ▪ Would provide an enhanced metric for suppliers
<p>National Institute for Standards and Technology (NIST), MEP</p> <p>NIST-MEP (Cont.)</p>	<p>Services to small manufacturers</p> <p>Services to small manufacturers (Cont.)</p>	<ul style="list-style-type: none"> ▪ Services must focus not only “Lean” but begin to include innovation and product development ▪ Greater involvement from the end customer (OEMs) ▪ Coordination challenges – little authority at the federal level ▪ Involvement of OEMs to help guide mission and services ▪ Role as 3rd party for OEM consortia ▪ Coordination and learning among and between Centers ▪ Raise MEP services to include product development and innovation services ▪ Funding of other agency services through centers ▪ More involvement in workforce issues with DOL funding ▪ Awareness to OEM and mission agency leadership of services provided – how to translate that into Hill support, e.g. NIH funding to MEP centers for manufacturing assistance
<p>National Institute for Standards and Technology (NIST) Adv. Technology Program (ATP)</p>	<p>Funding match for pre-competitive technologies</p>	<ul style="list-style-type: none"> ▪ Funding for SBIR Phase III ▪ Regional element, combine with state funding ▪ Funding of technology development for common OEM suppliers

EXECUTIVE BRANCH COORDINATING ENTITIES

Who Provides	What Provided	Leveraging Opportunity
Interagency Working Group for Manufacturing Competitiveness	Coordination of manufacturing policies and programs among agencies	<ul style="list-style-type: none"> ▪ Needs “teeth” ▪ Real strength lies in budget guidance for mission agencies
Interagency Working Group for Manufacturing R&D	Coordination of manufacturing R&D among agencies	<ul style="list-style-type: none"> ▪ Needs “teeth” ▪ Real strength lies in budget guidance for mission agencies
Manufacturing Council	Guidance on manufacturing policy for Administration	<ul style="list-style-type: none"> ▪ Needs “teeth”

CONGRESS

Who Provides	What Provided	Leveraging Opportunity
Congress	Legislation	<ul style="list-style-type: none"> ▪ Lawmaker education about “network-centric” manufacturing, MEP, policy practices in other countries ▪ Tax Code – credit for training, collaboration ▪ Incentives for collaboration ▪ Acquisition reform, especially ITAR ▪ Revisit Enterprise Integration Act ▪ SBIR reauthorization – potential for a phase III program