U.S. Resilience Project

CASE STUDY

National Aeronautics and Space Administration
Based on an interview with Michael Galluzzi, Supply Chain Manager, NASA

NASA Supply Chain Challenge: Maintaining the Vitality of its Space Industrial Base

In a Nutshell

The National Aeronautics and Space Administration (NASA) faces a significant challenge: not just assuring the security and integrity of the components in the supply chain but, given the hiatus in space operations, assuring that there is a viable industrial base at all. NASA's focus has been on creating new tools to assess how program changes impact the financial liquidity of the supplier base and map the multi-functional relationships of the lower-tier suppliers in the supply chain. This approach helps catalyze a regional innovation cluster approach to encourage virtual collaboration, advanced manufacturing, and shared infrastructure in order to sustain the industrial base for multiple NASA missions. The big picture approach simultaneously advances manufacturing competitiveness, commonality, inter-agency interoperability, supply chain readiness, technology innovation, and security.

NASA's Supply Chain Challenge

From a historical perspective, the last several decades have seen relatively few human space flight programs, with an average of 4.5 shuttle flights per year, and a handful of unmanned missions. That was barely sufficient to keep the industrial base viable. The recent cancellation of shuttle programs and the Constellation program, coupled with the economic crisis, creates the risk of a major disruption to the U.S. domestic space industrial base — not just the primes, but the lower tiers as well.

NASA's challenges include the following:

- In the years between the retirement of the shuttle and the beginning of flight operations for new programs, how will the space program's industrial base survive?
- What will happen when the next human space flight program needs parts, subsystems and critical spares, but many of the qualified suppliers of space hardware are long gone or have discontinued their product offering? How can NASA avoid the cost of building and certifying a supplier base?
- With such stress on the suppliers, how can quality be maintained? A study of the airline industry demonstrated a direct link between financial health and quality — declines in bond prices shortly began to manifest in quality problems.

NASA supply chain challenges are not limited to the space mission. Initial findings from a 2010 Department of Commerce survey of the NASA human space flight supply chain network indicated that many other government agencies and missions are affected by a decline in the viability of NASA's supplier base.

Definition of Supply Chain Management

For NASA, supply chain management is an integrated, information-driven approach to all aspects of a product's lifecycle at various planetary and interplanetary regions. The approach — which comprises people, processes and technology — is the integration of both information and material between agency organizations that share common support approaches and data architectures. The philosophy is focused on perfect order fulfillment, virtual 3D computer-aided design (CAD) modeling and simulation, agile operations, flexible manufacturing, design-to-order production, and vendor-managed inventories at strategic locations.

Previously, NASA employed two more conventional approaches: integrated logistics support (ILS) and performance-based logistics (PBL). ILS was implemented by the U.S. Army in the early 1970s under Military Standard 1388 and served, for the most part, as the foundation for shuttle logistics. This paradigm takes an inventory-centric approach, using such metrics as mean time between failures, mean time to repair, probability of sufficiency and repair generation rate forecasts, and reliance on the prime contractor. However, there is a problem with this approach. In a dynamic engineering environment that realizes frequent design changes and low product demand, chances are good that there will be some obsolete inventory on the shelves, and no visibility beyond the Tier 1 supplier level, which increases the risk of counterfeit parts entering the supply chain.

PBL provided a more evolved process, relying on the prime contractor to support operations and sustainment on a fixed-cost basis. PBL was introduced around 1994, at roughly the same time that the commercial off-the-shelf initiative was introduced at the Department of Defense (DoD). Today, without the proper contract language in place, this approach is also dated. But more importantly, it offers limited government oversight. The problem with the PBL approach is that it assumes that the industrial base would remain constant and available. Newer supply

chain management approaches offer a way to share information sources, master data files, CAD systems, materials requirements planning, and supplier relationship management applications to provide a secure information sharing environment — within the supply chain and across programs and agencies — that protects the intellectual property rights of the supplier.

New Tools/Approaches

PrimeSupplier™: The primary function of PrimeSupplier is to identify suppliers that may be negatively impacted from program changes and the resulting viability impact to a supplier or product line. The model identifies a number of risk indicators and creates a risk value for each. These indicators are then integrated into a framework that creates a meaningful and consistent risk value for each supplier. The model captures financial risk indicators (including profit margin and debt-to-equity ratios), operational risk indicators (including perfect order fulfillment, schedule achievement and defects per million opportunities), and supply chain risk indicators (including upstream/downstream information flow and supply chain readiness levels).

The tool was developed to manage the additional risks of manufacturing source and material shortages, and identify cross-program commonality, potential supplier procurement/contract gaps, and areas for potential pooling of non-recurring program funds required for obsolescence mitigation. See Appendix 1 (page 6) for an in-depth discussion of the tool and its capabilities.

NASA's PrimeMap–VSAAM: Initially designed for the Missile Defense Agency, PrimeMap–VSAAM (Visual Supplier Analysis and Assessment Modules) is a supplier mapping software application acquired for the purpose of identifying cross-element and cross-program utility and impacts. The application includes:

- A geographic and tabular view of the programs' supplier base;
- A visual representation of supplier relationships based on program and element; information from a NASA database;
- Congressional district mapping;
- Supplier demographics;
- Supplier customer diversification; and
- Natural disaster visualization.

PrimeMap provides the agency with an industrial base big picture. The application is based on work that was conducted at the Massachusetts Institute of Technology and is currently being applied commercially by Advanced Core Concepts. The tool, which is hosted on a NASA internal server with a secure firewall, identifies and maps cross-element suppliers and their multi-functional capabilities to support the agency supply chain. The intent for PrimeMap is to eliminate the search lead time for secondary sources while improving the environment for collaborative interagency demand planning, interoperability, product commonality, and product line viability through strategically planned procurements. Ultimately, the visibility of critical processes and critical vendors to allow for a configurable supply chain will reduce indirect, non-recurring costs associated with product discontinuance and obsolescence.

Currently, the software provides the following benefits:

- The ability to compare supplier quality, performance, and risk across programs and elements;
- A mechanism for members of the supply chain to comply with the requirements of ISO 9001:2000 to evaluate supplier performance;
- A standardized approach to supplier management and rating that would contribute to the "interagency" approach by improving communication between the government, prime contractors and lower-tier suppliers;
- Uniform supplier performance and utility data to be provided to the Defense Contractors Management Administration;
- Resource allocation based on supplier performance; and
- The tracking and evaluation of supplier performance trends (this will include sorting by commodities).

See Appendix 2 (page 10) for a discussion of the anticipated capabilities for a second generation of PrimeMap–VSAAM.

Virtual Design and Manufacturing Cluster

Finally, the implementation of a Space Commerce Network known as a Virtual Design and Manufacturing Cluster (VDMC) could provide an opportunity to "rescue" industrial resources in danger of being terminated. The concept is that the burden on the U.S. manufacturing base can be reduced substantially by developing standardized processes for collaborative forecast demand planning, by standardizing agencies' hardware requirements and processes, and by allowing for better visibility of hardware demands.

A VDMC is a new manufacturing business model that uses a shared physical and virtual infrastructure (hardware, software, facilities and services) to reduce costs and uses network-centric technologies and product- and service-oriented architectures to facilitate the smart design, rapid assembly, and seamless coordination of dynamic supply chains to accelerate production, reduce costs, and mitigate risk.

A VDMC is much like traditional company-focused "supplier cities" created by Toyota and other large companies to reduce inventory costs and increase efficiencies. A VDMC does the same. However, a VDMC is different from the traditional supplier city in three fundamental ways:

1. **Demand aggregation.** A VDMC is not driven by the purchasing volume commitments of a single large company. Instead, the demand is aggregated from different buyers, ranging from commercial companies to government agencies. Because the demand is aggregated, buyers that may not have been able to generate enough demand on their own can support the vitality of the industrial base.

2. **Infrastructure.** VDMC infrastructure is not dedicated to a particular customer's systems. Instead, VDMC infrastructure is a combination of technologies, standards, and processes that allow both buyers and suppliers to connect their existing systems to a common backbone. This allows for the sharing of information throughout the supply chain, regardless of disparate software technologies. The potential impact from this type of manufacturing coordination infrastructure is significant. In addition to reducing the cost for buyers and suppliers to connect, VDMC infrastructure opens the door for new efficiencies: linking suppliers; enabling buyers and suppliers to collaborate on manufacturability issues; and providing visibility into the manufacturing process throughout the supply chain while also providing visibility to previously unknown sources and capabilities, including gaps in production capability of critical technologies.

3. **Shared facilities.** Traditional supplier cities typically require suppliers to invest in buildings, equipment, and so on. The large customer behind a supplier city will sometimes contribute land or shared utilities, but most of the cost is borne by the suppliers. A VDMC differs in that it typically has, at its core, buildings already equipped with advanced and expensive manufacturing equipment. These buildings are often made available to regional groups, such as economic development organizations, by large companies or by government agencies that no longer need the facilities. In many cases, economic development organizations have obtained government monies to update these facilities and outfit them with new equipment. These facilities, such as NASA's Michaud Assembly Facility in Louisiana which is managed by NASA's National Center for Advanced Manufacturing, may already have large, expensive equipment that small- to medium-size manufacturers could not afford on their own. By sharing facilities, many suppliers can capture business opportunities they might not otherwise. Whether available on a time-and-materials basis or as part of a permanent residency, suppliers can leverage this capital-intensive equipment, along with their own, to expand their offerings.

The intent is that manufacturers will have access to shared tooling, an associated workforce, manufacturing training, commercial financing, foreign trade zone benefits, a lower corporate tax base and an advanced-skill labor pool at no upfront direct cost to the small-to-medium enterprises. This approach is intended to strengthen the U.S. aerospace and defense industrial base.

From an economic competitiveness point of view, the VDMC model is a tool to revitalize America's manufacturing competitiveness. From a security point of view, the model enables shorter supply chains, more domestic sourcing, and an information-sharing environment with stronger intellectual property protections. See Appendix 3 (page 12) for a more in-depth look at the VDMC roll-out strategy.

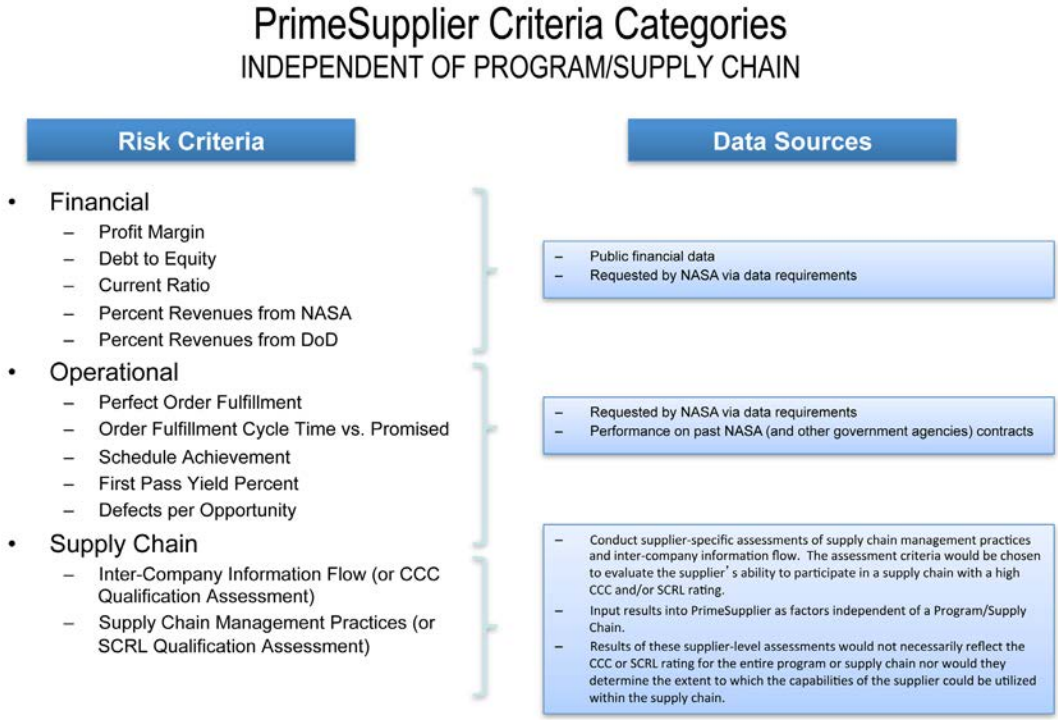
Appendix I: PrimeSupplier™

This model, also known as the Galluzzi-SIB Index, determines the economic stability of a program's industrial base as a whole using the programmatic influences on the individual supplier's economic stability and liquidity posture.

Structure of the Enhanced Model: Overview of Concept

The primary function of PrimeSupplier is to identify suppliers that pose a risk to a program/supply chain. To accomplish this objective, the model must utilize the data for each risk indicator, converting it into a meaningful risk value. In doing so, the model should consider the relative utility function associated with each risk indicator. Finally, these risk indicators should be integrated in a consistent fashion to generate a meaningful and consistent risk value for each supplier.

Figure 1: Risk Indicators



Financial Risk Indicators

The model includes financial risk indicators for profit margin, debt-to-equity ratio, current ratio, percent NASA revenue, and percent DoD revenue.

Profit Margin. Profit margin is defined as the ratio of net income to total revenue. This metric reflects how much profit is derived from every dollar of total revenue. Profit margins indicate how well a business has managed its operating expenses and can be an indication of whether a business is generating enough revenue to cover minimum fixed costs and still preserve an acceptable profit.

Debt-to-Equity Ratio. Debt-to-equity ratio is another financial risk indicator. It measures the number of dollars in borrowed funds a company has received for each dollar of invested funds. The metric is calculated by dividing the company's total liabilities by the total equity. In general, most U.S. companies will have a debt ratio between 0.40 and 0.60. The debt-to-equity risk indicator utility function would have a curve showing the risk component value as increasing as the debt-to-equity ratio approaches 1.0.

Comparing PrimeSupplier Financial Risk Indicators to Publicly Reported Metrics. The U.S. Census Bureau collects financial data on industry sectors and reports the results on a quarterly basis in the Quarterly Financial Report.

Operational Risk Indicators

Operational performance risk indicators include indicators for perfect order fulfillment (POF), order fulfillment cycle time (OFCT), schedule achievement, first-pass yield (FPY), and defects per million opportunities (DPMO).

Perfect Order Fulfillment. POF is defined in the supply chain operations reference (SCOR) model as the percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage. The SCOR is a process reference model that has been developed and endorsed by the Supply Chain Council as the cross-industry standard diagnostic tool for supply chain management. SCOR enables users to address, improve and communicate supply chain management practices within and between all interested parties. The POF is calculated by dividing the total number of perfect orders by the total number of orders. A supply chain is considered perfect when original commitment made to the customer is met. As the measured historical order fulfillment decreases, the risk of future orders not being fulfilled as committed increases.

Order Fulfillment Cycle Time. According to the SCOR model, OFCT is the average actual cycle time consistently achieved to fulfill customer orders. In the PrimeSupplier model, the OFCT is evaluated by comparing the actual total OFCT to the required total OFCT.

Schedule Achievement. Another operational risk performance indicator is schedule achievement, which measures, as a percentage, how well a company adheres to its targeted production schedule. Schedule achievement is calculated by dividing the number of scheduled end items produced to schedule by the total number of end items produced.

First-Pass Yield. An additional operational metric that measures quality production performance is FPY, which measures the ability of the company to manufacture a product correctly the first time. A low FPY is an indication of poor quality, which increases the probability of defective products and creates diversions from the nominal process flow. These off-nominal activities usually result in longer lead times, increased costs and late deliveries. As one might expect, as the FPY value decreases, the risk component value increases.

Defects Per Million Opportunities. A final operational risk indicator is DPMO, which is the number of defective parts divided by the total number of opportunities, multiplied by 1,000,000.

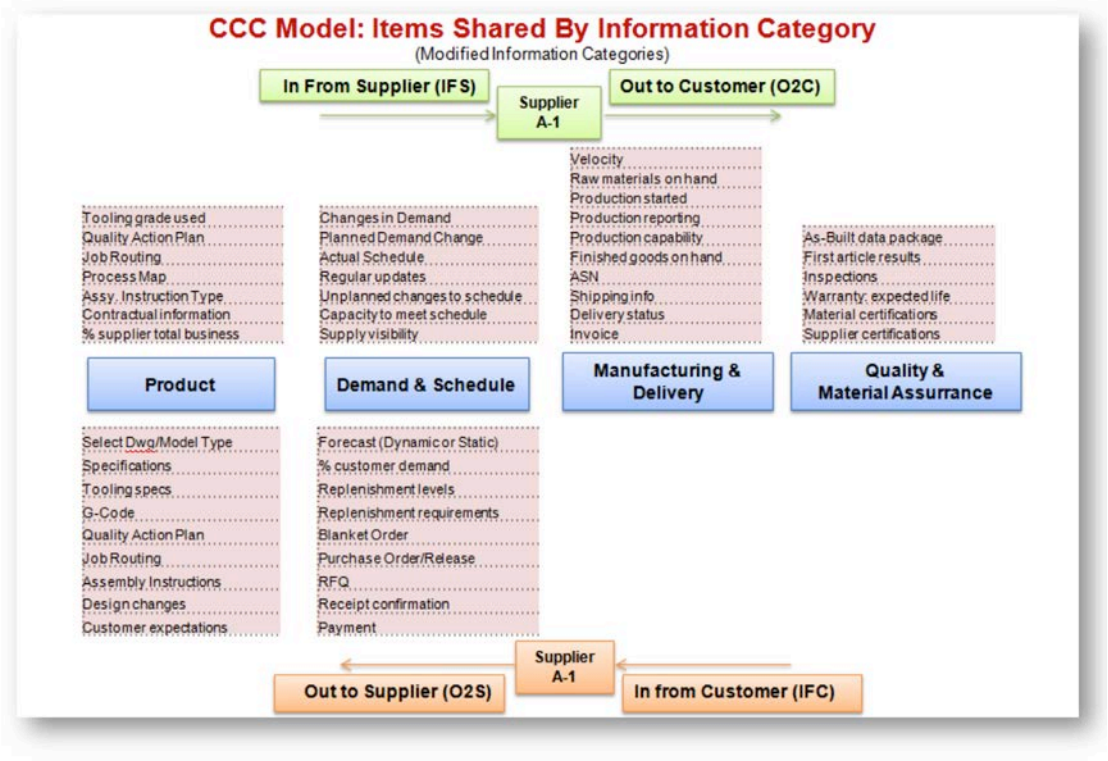
Supply Chain Risk Indicators

Supplier-Specific Supply Chain Management Assessments. Supply chain management risk indicators gauge a supplier's ability to effectively function with other suppliers and customers within a program or supply chain. The PrimeSupplier model considers risk indicators computed from supplier-specific assessments that evaluate the supply chain management capabilities in two areas:

1. **Intercompany information flow (CCC=communication, collaboration, coordination):** Supply chain intercompany information flow capability as measured by utilizing a modified CCC assessment
2. **Supply chain management practices (SCRL):** Assessment of supply chain practices as measured with a modified SCRL qualification assessment

CCC Model Assessment. In the case of the intercompany information flow, the CCC assessment evaluates the supplier's practices and capabilities related to upstream and downstream information flow and collaboration. There are four primary categories of information (see Figure 2) that must be shared between suppliers and customers. In addition, the assessment considers types of information that flow both from supplier to customer and also from customer to the supplier.

Figure 2: Intercompany Information Flow Model

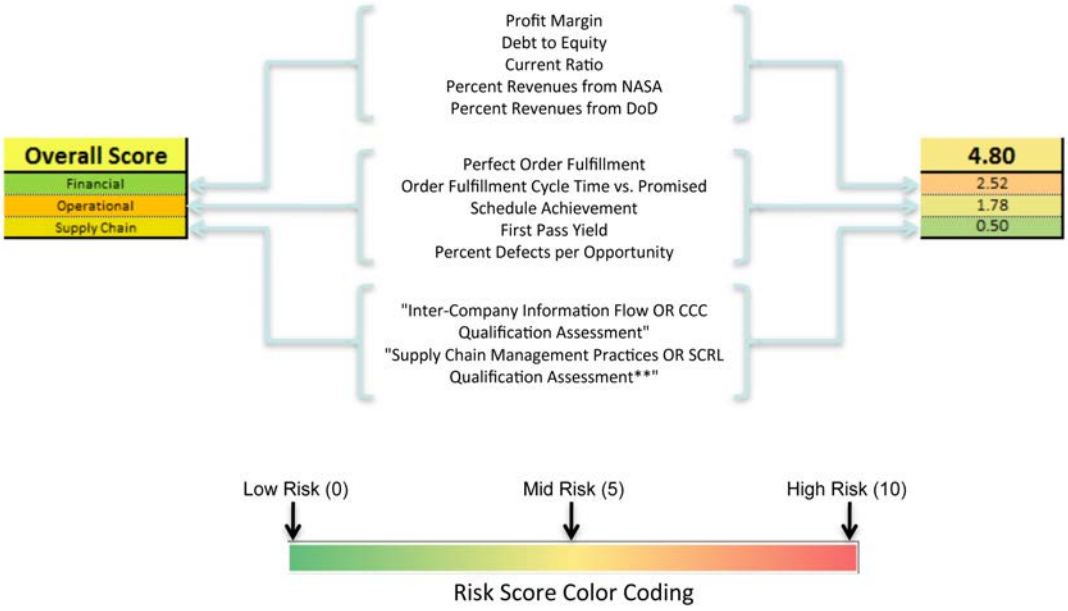


The assessment evaluates the practices related to the information flow for each of the categories resulting in a composite CCC score that reflects the potential for the supplier to perform at a high level in communication, collaboration and coordination.

An additional method of evaluating risk associated with supply chain practices, the SCRL model can be used to assess supply chain management practices. The SCRL model allows any supply chain to be assessed based on proven characteristics required for flexibility, agility, viability and sustainability.

Risk Measurement Calculation. Figure 3 illustrates how the model is used to calculate the total risk measurement value. Total Risk Measurement Value = Financial Risk Category + Operational Risk Category + Supply Chain Risk Category.

Figure 3: Risk Score Components



Appendix 2. PrimeMap–VSAAM Version 2.0: Anticipated Capabilities

PrimeMap–VSAAM v2.0 will include extended user drill down of supply chain data such as:

- Total employees
- Contract dates
- Cross-agency utilization/identification
- Capabilities
- Manufacturing capacities
- Performance data
- Qualification data
- Government Industry Data Exchange Program alerts

Supplier Performance and Qualification

PrimeMap–VSAAM v2.0 will:

- Allow personnel across the enterprise to see the impact of breakdowns in supplier performance or qualification on individual products, product lines, and the enterprise.
- Provide an accessible area to conduct performance and qualification reviews, pulling information from various locations within the enterprise into a single location with consistent displays.
- Provide the capability to host current internal assessment tools with the ability to create and archive information that will be available enterprise-wide.
- Give access to supplier performance and qualification information as stand-alone information or in context with other assessments such as program, product line, and enterprise affiliation.
- Combined with other optional data sets, support capabilities such as supply chain flow paths and contract relationship assessment to provide insight into the potential disruption that can take place if a supplier underperforms or loses a critical qualification.
- Allow users to view the performance data for a supplier, a supplier sector, a product, a product line, or the entire enterprise.
- Enable drilldown to identify the root cause for performance issues.
- Generate reports for use in preparation of decision support materials.

Supplier Capabilities Search

A Supplier Capabilities Search allows users to identify suppliers based on capabilities and business classifications. To initiate a search, users will enter relevant search terms reflecting desired capabilities. The application will return a list of suppliers with those capabilities. The rank-ordered list will contain suppliers based on relevancy of search terms to the capability of the supplier. The application will also allow users to limit the list of suppliers by classification, e.g., Service Disabled Veteran-Owned Business, 8(a), Small Disadvantaged Business, etc. The application will also provide:

- Links to the supplier's website
- Available supplier contact information (email, phone number, address)
- Supplier's Small Business Administration (SBA) status (both self-identified and SBA validated)
- Supplier's Veterans' Affairs (VA) status (both self-identified and VA validated)

Appendix 3. VDMC Development: A Commercial Approach to Organically Develop a Regional Innovative Manufacturing Cluster

The U.S. government market consists of many departments and agencies purchasing billions of dollars worth of various types and quantities of hardware and services. During FY 2011, the following were the top five agencies by U.S. dollars obligated for system components (per Federal Procurement Data Systems):

1. Department of Defense, $366 billion;
2. Department of Energy, $25 billion;
3. Department of Health and Human Services, $18 billion;
4. Department of Veteran Affairs, $15 billion; and
5. National Aeronautics and Space Administration, $15 billion.

The Department of Commerce's Economic Development Administration and the Washington-based non-profit Council on Competitiveness, in conjunction with private industry, is considering expanding current National Digital Engineering and Manufacturing Consortium project activity to the southeast region of the United States by coalescing a small- and medium-sized manufacturing cluster, or Virtual Design and Manufacturing Cluster (VDMC), dedicated to:

- Stimulating the U.S. manufacturing industry of all USG system hardware with commercial application.
- Providing a resilient, traceable and viable supply chain for active or obsolete product still required for USG systems.
- Ensuring emerging technologies and research with multiple applications, e.g., smart grid.
- Certifying manufacturing sources as viable sources of products or services to the U.S. government.
- Establishing 3D modeling and simulation capabilities and standards within the aerospace and defense industrial base.