ARC STRATEGIES

By ARC Advisory Group

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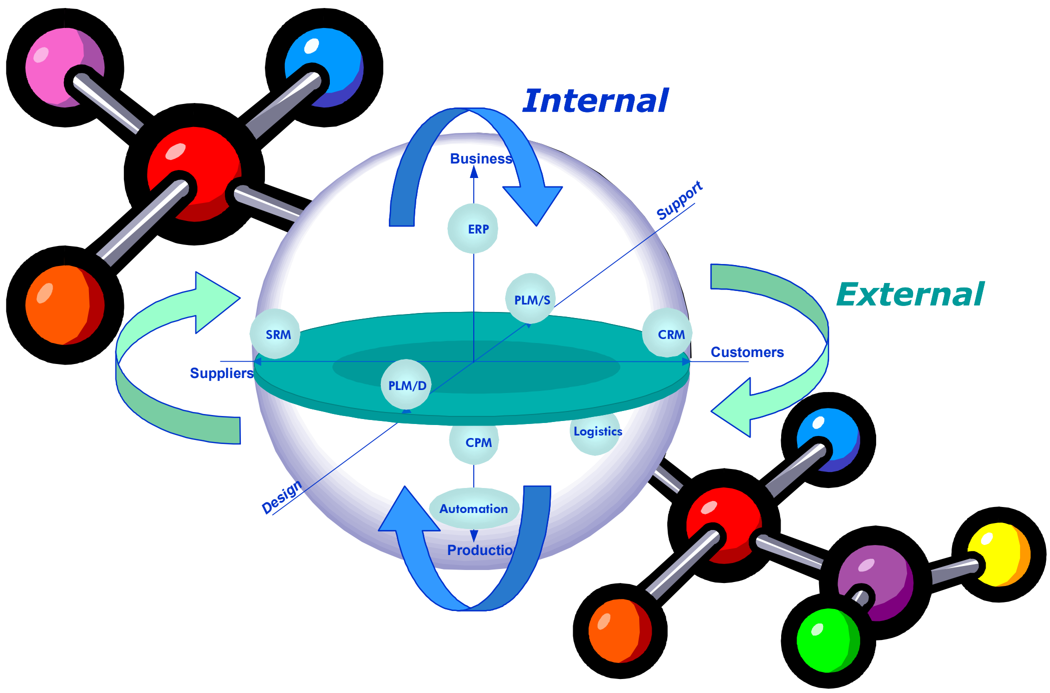
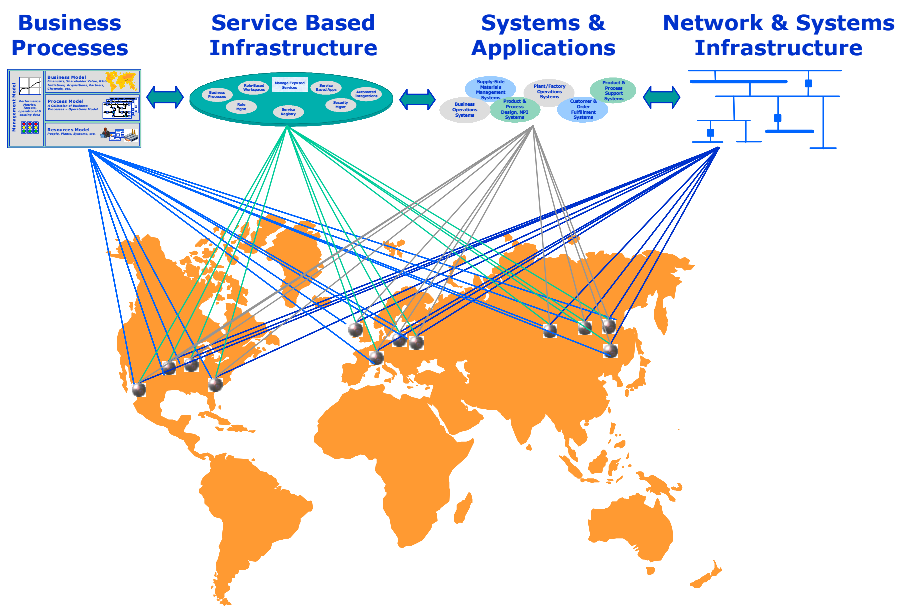
Collaborative Manufacturing Management Strategies

ARC Advisory Group



ARC's CMM Model - World-Class Manufacturers Achieve Operational Excellence through External and Internal Collaboration



Controlled Migration: Manufacturers Can Migrate to Full CMM by Introducing BPM and SBI to Leverage Existing Systems

Executive Overview

Manufacturers are under pressure. Customers demand better product quality with tighter delivery requirements. Shareholders demand more profitability. Global competition is increasing. Pressure on prices, smaller orders, shorter life cycles, more suppliers, more governmental regulations, and increasing material and energy costs make things more difficult. Manufacturers must continue to improve their performance in order to survive. Many manufacturers have squeezed all of the performance they can from their existing organizational structures and systems. The next round of operating improvement will come from changes focused on business processes and CMM. Embracing collaboration - though it can be complex and time-consuming – is preferable to continuous "firefighting" and reactive change, which in the end may not be adequate. It is critically important to correctly make collaboration decisions today.

Principles of CMM:

1. Focus on Business Processes
2. Leverage Existing Investments
3. Bridge Traditional Boundaries
4. Move to Adaptive Real-time Collaboration

ARC defines Collaborative Manufacturing Management (CMM) as the practice of managing for best performance by controlling key boundary-spanning business and manufacturing processes of a manufacturing enterprise. CMM leverages new technologies to build robust relationships with trading partners. Its emphasis on Business Process Management (BPM) leads to improved operational and competitive performance. CMM knits together internal manufacturing and business processes, and connects them seamlessly and in synchrony with external business processes of strategic partners.

Recognizing that today's manufacturer needs to operate on information in real time, CMM provides a holistic approach to manufacturing that is equally well-suited to global multinational companies and small, local operations, as well as process, discrete, or hybrid production models. This does not mean that CMM is a one-size-fits-all solution – far from it. CMM recognizes that each manufacturing situation is unique and depends on such factors as industry, size, manufacturing technique, degree of verticalization, consumer or industrial customer mix, competitors, and more. CMM provides a useful model for manufacturers, regardless of their particular circumstances, to help think through all the complexities of collaboration that they need to consider. CMM also establishes the idea that emerging technologies and business management practices can be applied almost universally to obtain significant benefits. And it prescribes an architectural approach that manufacturers can follow in order to take advantage of these technologies and practices.

The CMM approach leverages the investments manufacturers have made in Enterprise and Plant systems. It is not a grand scheme for ripping out legacy applications and systems. Instead, it is an approach that recognizes that manufacturers already have many enterprise applications in place, as well as many plant-level systems. These systems embody or contribute to today's business processes. They may well play a similar role going forward, but certain aspects will change as the organization shifts to a business process orientation.

CMM builds upon a collaborative infrastructure, BPM services, and real-time strategic business management tools. It connects critical applications, production systems, and enterprise information, to maximize the responsiveness, flexibility, and profitability of the manufacturing enterprise, in conjunction with its value network partners. This is a response to important shifts in the overall value proposition of manufacturing companies. Global competition and downward pressure on prices have led manufacturers to recognize their position within a Value Network. They have begun to optimize processes for overall enterprise-wide effectiveness rather than individual plant efficiency; and many are moving from isolated business processes to distributed, synchronized BPM.

Real-time process control is not a new idea for many factory floor or plant systems, but it is a radical departure for traditionally passive, transaction-based business systems.

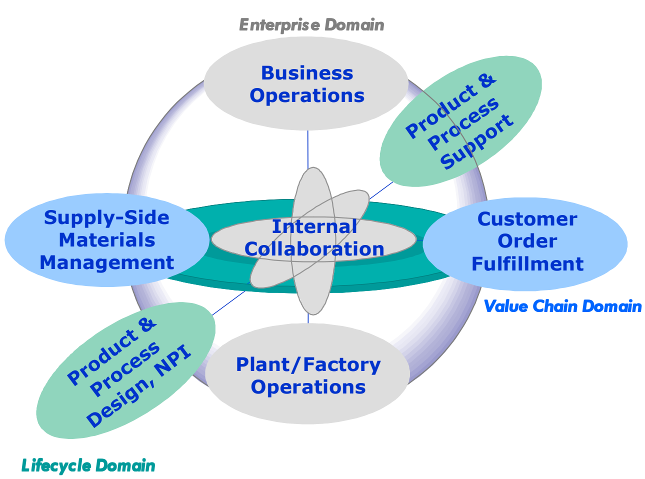
The Internet has proven to be a paradigm-shifting disruptive technology, but much of the impact has yet to be felt. Software suppliers are just coming to grips with the implications for packaging, delivering, and supporting their applications. Next-generation applications will be service-based, and they will not simply share information, they will operate in real-time in the context of a broader business process workflow. This in not a new idea for many factory floor or plant systems, but it is a radical departure for traditionally passive, transaction-based business systems. ARC believes that information that now takes weeks or months to flow from end to end of the Value Chain will soon move in days, if not hours.

Manufacturers need not and should not wait. Solutions are available, the technology and implementation roadmaps are foreseeable, and CMM can be deployed around legacy systems today, with a clear migration path forward.

In these times, it is important to pay attention to return on investment. Because CMM often involves multiple solutions, phases, and suppliers, manufacturers will want to work out detailed ROI for each piece of the CMM investment. Most suppliers will offer a hard dollar value proposition that manufacturers can factor into their assessments. CMM can improve responses to changing market conditions, streamline product introductions, improve asset utilization, increase or maintain market share, reduce inventory, and reduce cycle times. All these improvements are important contributors to profitability, competitive advantage, and shareholder value.

The CMM Model

ARC's CMM Model has evolved and changed graphically over the years, but the central concept of three intersecting domains – Enterprise, Value Chain, and Lifecycle - has remained since its inception. It has proven to be a useful device for both suppliers and manufacturers.



CMM Model: Functional View

The evolution of collaborative value networks requires that manufacturers visualize the relationships among plant and enterprise applications, markets, value chains, and manufacturing nodes in order to understand the context for planning and implementing collaborative manufacturing systems. A collaborative manufacturing network consists of spheres or manufacturing nodes connected by material, information, and process flows. The nodal sphere encompasses three axes: Enterprise, Value Chain, and Lifecycle. Above the central plane or disc are business functions. Below it, are production functions, now performed using a number of manual processes and legacy applications. These will be supported by collaborative components capable of orchestrating the designated functions in concert with the business goals of the node and the competitive dynamics of the value chains in which the node or enterprise participates.

Today, this globe is populated with a multitude of standalone applications that a manufacturer has elected to install and support. These new and legacy systems are sometimes knit together by messaging and workflow-based EAI systems to optimize enterprise performance. Outside the domain of the nodal manufacturing sphere, Internet-based collaboration options are growing in power and functionality. Exchanges and portals provide more automated ways to connect with suppliers as well as customers along the value chain, while product lifecycle tools are emerging for collaborative product design and post sale product support via the Web.

Function	Typical Applications
Business Operations	ERP, MRP, Financials, Cost Accounting, HR, Strategic Enterprise Management (SEM), Business Intelligence, Analytics, Decision Support, Capacity/Resource Planning, Value Network Design
Supply-Side Materials Management	SCM, SCP, SRM, BPM/SCPM, Purchasing, supplier scorecarding, supplier performance monitoring, sourcing analytics
Customers & Order Fulfillment	CRM, SFA, Demand Forecasting, APS, TPS/TMS, BPM, Distribution Planning, WMS
Product & Process Design, New Product Introduction (NPI)	PLM/D, PDM, Formulation Management, Specification Management, CAD, Line Design & Simulation, Plant Design & Simulation
Product & Process Support	PLM/S, EAM, MRO, CRM/Help Desk, PAM, PSM
Plant/Factory Operations	Production Management, CPM, LIMS, Plant Services Connector, CPAS, CDAS, APC, PAM, AMHS, Production Planning & Scheduling, Tool Management, Batch, Energy Management, Waste Management
Internal Collaboration	BPM, Enterprise Integration, Plant Data Services, Change Management, Document Management

CMM Applications

ARC's CMM Model defines the requirements for an information system that addresses the key elements of collaborative manufacturing outlined above. The model also recognizes the need to support internal and out-sourced execution of all enterprise activities by defining solutions for different functional units and for an extended enterprise or supply chain.

Functional View

The functional CMM model highlights the relationships among the main functions in which all manufacturers engage. For many, this is useful because it can be used to map existing applications, as well as to quickly visualize other areas that may benefit from synchronization and information sharing. The main functions are Customer Order Fulfillment, Supply-Side Materials Management, Product and Process Design and New Product Information, Product and Process Support, Business Operations, Plant/Factory Operations, and Internal Collaboration.

Business Operations

In addition to HR, Financials, Resource Planning, Compliance, and other operational management tools, manufacturers need to provide executive management with tools to set targets, measure performance, and formulate strategy. Leading manufacturers incorporate real-time business intelligence, analytics, and decision support tools for top management, and employ activity-based costing and management, Balanced Scorecard, or similar tools designed to influence disparate divisions, plants, groups, and members of the enterprise to act together as a team.

Manufacturing executives are responsible for setting the overall metrics/business goals, which should be tied to business processes and made visible to supervisors and workers.

The next generation of Strategic Enterprise Management tools will provide for planning, creating, managing, and optimizing the enterprise in the context of its "value networks," where intimate partners cooperate to pursue specific business opportunities.

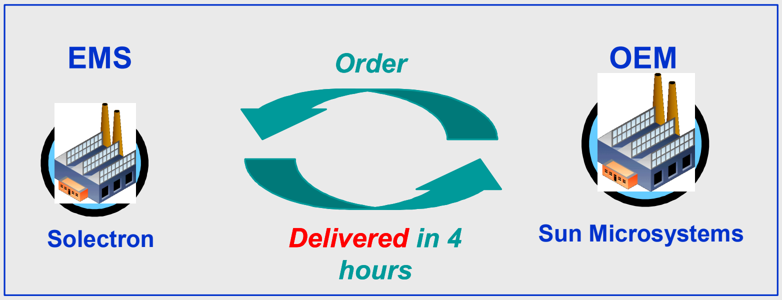
These tools will incorporate advanced business modeling capabilities and will allow managers to leverage technical capabilities in a strategic way to create competitive advantage for the value network, as well as individual companies within the network. Inherent in these tools will be the creation and enforcement of business terms and relationships among the partners.

Managing multiple production facilities is a critical aspect of collaborative manufacturing. CMM systems must provide real-time visibility and business process control across distributed manufacturing facilities, share real-time production data with major suppliers and business partners, and provide customers with real-time manufacturing information visibility as needed. In addition, they provide for centrally managing manufacturing processes that may be distributed among physically remote plants.

In an efficient supply network, companies must implement shared business processes and data across organizational boundaries. This is, in many ways, the essence of the virtual supply chain or virtual manufacturing. Conventionally, outsourcing a standalone production operation increases risk. If the integration problem is 'solved' only at the business systems level, the plant manager rightly feels that he has no control over this portion of production. But establishing a credible, reliable infrastructure integrating such an outsourced group brings the risk level back to neutral.

Supply-Side Materials Management

A critical function for any manufacturer is ensuring that raw materials, parts, components, and/or subassemblies are sourced, delivered, and moved to manufacturing in a cost effective and timely way. In practice, this is commonly addressed today using a host of applications, people, and departments that interact in some way with inbound goods and services. Collaborative manufacturers use a variety of strategies to move beyond optimizing their internal processes to embracing suppliers as part of the process. They also try to simplify managing the many-to-many relationships that characterize this enterprise boundary. Manufacturers benefit by having a high-performance supply network, and from being able to more easily offer different levels of support to different classes of suppliers. Suppliers benefit from immediate access to such information as demand forecasts or payments that they can use to reduce costs, improve performance accuracy, and do more business. Using information sharing and business process management, the buyer-supplier relationship can grow beyond the basic notion of driving down the cost of inbound goods to something closer to finding the optimal cost and profit structure for the collaborative network – for the benefit of all participants.



Collaboration Today: Supply-Side Materials Management

- Sun gets Solectron deliveries within 4 hours of placing an order.
- Solectron gives customers like Sun role-based access to info.
- Real-time status, quality, cycle time, ECOs, etc.
- Factory floor information is available to global development and product teams using Solectron's portal and Teradyne CPM software.
- Result: Nimble, high confidence, outsourced manufacturing.

Customers and Order Fulfillment

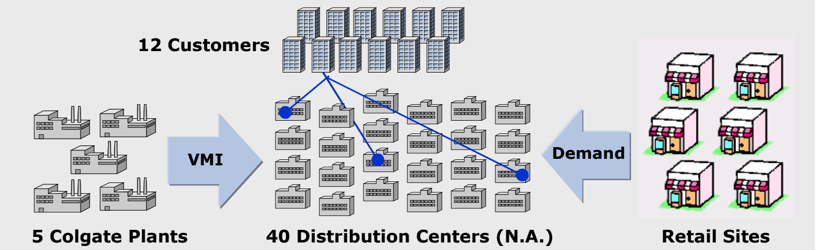
Customers and their orders are the lifeblood of any manufacturer, and this functional area addresses the need to serve the customer. It includes managing customer interaction channels, such as customer-centric portals, call centers and direct sales, maintaining links to production, and distribution and logistics.

Customers and Order Fulfillment:

- Identify the Customer
- Negotiate the Order
- Coordinate the Production
- Arrange the Delivery
- Measure the Satisfaction

The concept of collaborating with intermediaries or customers has been around for a long time – witness the establishment of EDI, Vendor Managed Inventory (VMI), and Collaborative Planning, Forecasting, and

Replenishment (CPFR). In the emerging collaborative environment, close collaboration among nodal manufacturers raises cooperation and interaction to a new level. It now becomes not only possible, but also necessary to transmit real-time information in two directions among these nodes. Production information on quality, materials availability, and production status must flow downstream to customers, while information on orders, inventory levels, specifications, and change orders flows upstream.



Collaboration Today: Customers and Order Fulfillment

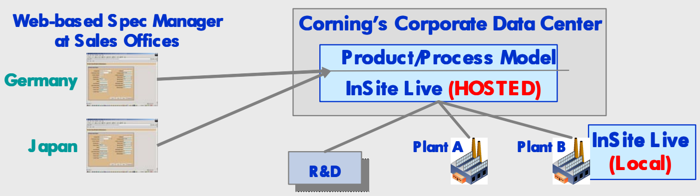
- Colgate does VMI replenishment of DC's using SAP APO.
- Replenishment orders are calculated from daily inventory levels and demand from DCs.
- Production requirements are then driven back into plants.
- Results: 98% on-time, complete orders.

The essence of collaboration is the ability for individual plants to synchronize their work in real-time based on accepted orders and to coordinate the production and delivery of component materials at the production level in a highly distributed manner. Orders must be scheduled, produced, and delivered from a tightly integrated and coordinated value chain. This requires sharing of detailed, current production information throughout the value chain, as well as throughout the enterprise. For example, brand managers armed with better information about production can begin their marketing campaigns before the inventory appears in the warehouse. Demand for components and services for the implementation of a customer order is sent to other plants or companies within the value network and then handled appropriately. At each node in the value chain, the work can be done in-house, outsourced to another node in the network, or purchased outside the network. This approach adds a high degree of confidence to Available-To-Promise (ATP) quotations because it reflects the actual committed production schedule based on real orders.

Product and Process Design, New Product Introduction (NPI)

Designing new products and their manufacturing processes is collaborative in nature, and new Internet-based tools are emerging to support these activities. As manufacturers react to the broader emerging collaborative environment, these systems will support their ability to compete by providing quick and effective responses to demand and accelerate time to market for new products.

For discrete manufacturers, this must include the management and collaboration of specification and product development information (PDM), as well as the design and collaboration on manufacturing processes across multiple specialized contract manufacturers. Collaborative systems must support a number of processes, including assembly sequence planning, constraint-based design, distributed process planning, and layout. In addition, they must be integrated with plant business systems.



Collaboration Today: Product Design and NPI

- Corning manages Specifications and the Product/Process Model centrally using Camstar's Virtual Factory Suite.
- Product Specs captured and maintained centrally with controlled release to local sites.
- Product/Process Model developed in R&D phase with knowledge of individual plant peculiarities and constraints.
- Same Product/Process Model is used for R&D, small lot testing, and volume production.

After the initial product and process design and documentation, collaborative systems must support ramp to volume, local process optimization, change management, and manufacturing improvement projects such as throughput reduction, cost reduction, and automation. Hybrid and process manufacturers have an analogous situation in the development and deployment of recipes and manufacturing processes. Collaborative solutions for these chemical, food, and pharmaceutical plants should support recipe-related business processes in R&D, manufacturing, and marketing. They must ensure consistent recipe maintenance across enterprise boundaries.

Product and Process Support

Manufacturers compete by making production and delivery commitments to their collaborating network partners and customers. In order to allow for the possibility of production equipment failures or downtime, they can either push out the delivery schedule to provide a margin for error, or implement a service strategy based on an EAM system that is closely integrated with production management and Plant Asset Management systems. By using the latter approach, equipment health can be factored into the initial production commitment and can help ensure customer satisfaction.

Another important collaboration area is with plant equipment suppliers. They may offer remote monitoring and maintenance of plant equipment via the Internet. It can take the form of a Remote Maintenance Portal or monitoring of provided equipment with embedded Internet access. When production equipment is connected to the Internet in this way, the embedded intelligence can be gathered, published, and visualized over the Web. With the right interface, remote users can then monitor the equipment, supply consumables, and support or provide diagnostics and maintenance.

While full service outsourcing may develop slowly, the future clearly involves a closer integration of in-house and OEM service organizations. Rather than managing staffs of technicians and stores of spare parts, modern service managers will have to learn to manage "service networks" that include multiple sources for service personnel, parts, and information. Service activities are always considered time- and cost-critical since they involve assets being unavailable for use. Even when the focus is on a single machine, the entire production line is often affected. Manufacturing improvement initiatives, like lean manufacturing, are further aggravating this situation by tightly coupling all manufacturing stages. Managing even the most basic service activities today requires sophisticated planning and flawless execution. At the same time, supplier and customer relationships must be continuously nurtured. While site support for installed assets is the most pressing responsibility of any service organization, close management of spares and off-site repair operations can be equally important to maintaining overall effectiveness and achieving service cost/profit goals.

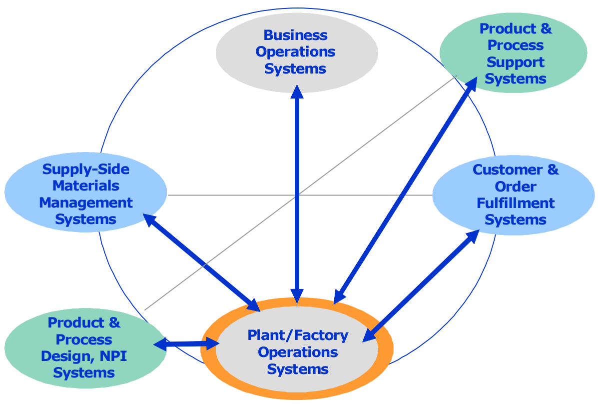
Managing service networks will be quite different from managing isolated service organizations. In-house service managers must become expert in the capabilities of their OEMs and develop relationships that can ensure seamless execution, particularly during emergency situations. OEM service managers must become more intimate with each customer's asset configurations and service histories to ensure that regional parts inventories and service personnel will support the agreed service levels. A partnership is required to insure that assets are maintained to meet expected demands.

Service networks will have many characteristics of product supply chains. For example, asset-owners will become part of many different service networks according to the assets they own and the OEMs who supply those assets. Third Party Service (3PS) providers will also play an increasing role as service is increasingly outsourced.

Delivering high quality service across a complex network requires synchronizing partner strategies, plans, and execution activities. A company committed to a flexible, rapid response strategy cannot be supported by a partner focused on least cost, next-day delivery of parts. While emergency service is hard to predict, managing planned outages improves if all partners work off the same page. Minimizing asset downtime is important whether the outage is an un-planned failure or a planned event, and visibility across the service network is vital to efficiently locating parts, expediting transfer of people and parts to the site, and managing impatient customers.

Plant/Factory Operations and Automation

The two collaboration imperatives for the plant floor: surface more information for sharing with other audiences, and make production systems more responsive and flexible. To be competitive, manufacturers must raise the visibility of manufacturing information in order to optimize performance, enhance responsiveness, and manage costs. Increasingly, purchasing decisions are influenced by the quality of available information about orders in production. The winners will be those who leverage manufacturing data not only to continuously improve their own operations, but also to enhance their information sharing with customers and suppliers.



Production Side View of Connectivity

Multi-Dimensional Collaboration

Collaboration must be embraced on the plant floor in five key dimensions: with Enterprise systems, with suppliers, with customers and channels, with product design partners, and with production equipment support providers. Look to suppliers to increasingly provide Web-enabled, collaborative software and production equipment to support each dimension. Over time, manufacturing systems will be able to participate in an environment where they operate collaboratively with markets.

Surface and Share Information

The concurrent trends toward increasingly sophisticated plant floor devices and more demands for both manufacturing flexibility and competition-driven information visibility are driving an approach to collaborative manufacturing where the collection, dissemination, and analysis of information about production operations is recognized to be strategically as important, if not more important, than the physical products produced.

Control is the foundation for collaborative manufacturing and is a critical component of an effective collaborative manufacturing infrastructure. The key here is making the right information available, along with the appropriate management tools, throughout all levels of the organization, as well as customers and suppliers in such a way as to reinforce, enhance, and optimize business processes.

Internal Collaboration

Each functional area can and increasingly needs to collaborate with entities external to the enterprise. It is critical that all functions also "collaborate" internally. This means directly managing business processes that span multiple departments. It also means that manufacturers should explicitly consider the interrelationships among each of the main functional areas. For example, in certain manufacturing segments, there is a link between Product & Process Support and each of the other functional areas. If a pattern of failure develops in an aircraft part in use, fixing the problem could impact factory operations, outsourced manufacturing, upstream parts suppliers, and engineering. It also potentially impacts schedules and orders in progress. Each manufacturer will have unique interrelationships among all of the functional areas, depending on industry, manufacturing model, size, and degree of verticalization.

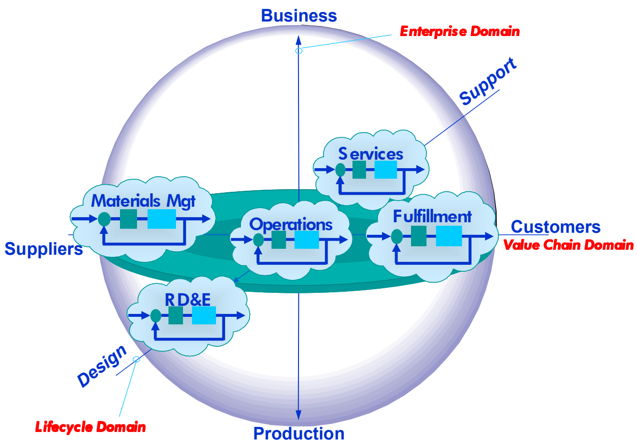
There are a number of approaches to systemizing internal collaboration requirements. One approach is to collect all of the data in a single database or repository. Another is to model the problem as an integration problem, and to then to identify, connect, move, and transform all of the data as required. A third is to identify the business processes involved, and let the business process requirements drive the underlying connectivity.

Process View

There are four fundamental Collaborative Business Process Loops, all of which must be synchronized with manufacturing and business operations:

- Customers, Order / Fulfillment Process
- Supply-Side Materials Management Process
- Product/Process Design, NPI Process
- Product/Process Support Process

Internal collaboration needs are determined by these fundamental processes, which vary by industry, tier, manufacturing model, etc.

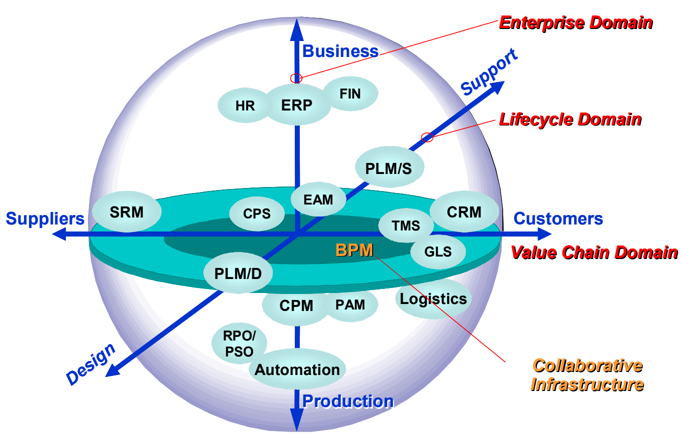


For any Manufacturer, Four Fundamental Business Process Loops Must be Synchronized with Manufacturing and Business Operations

These four main areas must be addressed when considering an infrastructure to support CMM. The infrastructure must support connectivity within the enterprise and among various sites, departments, and locations. It must support external connectivity to partners and customers, equipment connectivity, and visibility of necessary information to users throughout all levels of the enterprise. Internal connectivity may be implemented with Application Servers, Messaging, Host Integration, and Web Services. External connectivity may be implemented with private exchanges, public exchanges, portals, and traditional technologies. And portals can provide visibility.

Applications View

Evolving collaborative value networks requires that manufacturers visualize the relationships among plant and enterprise applications, markets, value chains, and manufacturing nodes in order to understand the context for planning and implementing collaborative manufacturing systems. A collaborative manufacturing network consists of spheres or manufacturing nodes connected by material, information, and process flows. The nodal sphere encompasses three axes: Enterprise, Value Chain, and Lifecycle. Above the central plane or disc are business functions. Below it, are production functions, now performed using a number of manual processes and legacy applications. These will be supported by collaborative components capable of orchestrating the designated functions in concert with the business goals of the node and the competitive dynamics of the value chains in which the node or enterprise participates.

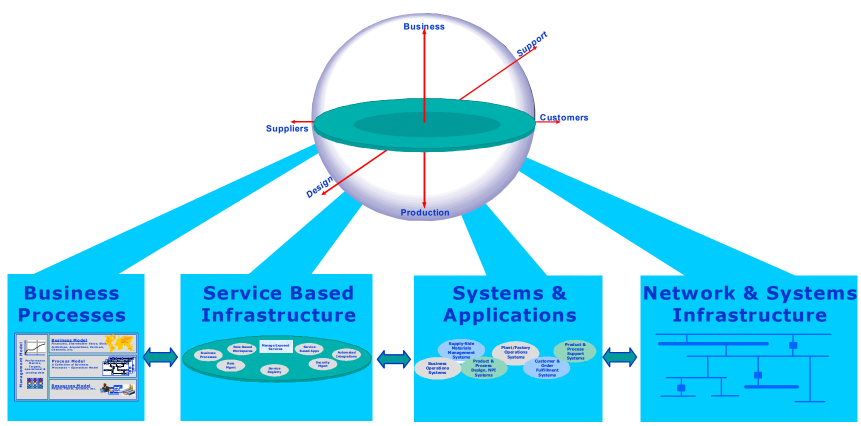


CMM Model: Applications View

Today, this globe is populated with standalone applications. These new and legacy systems can be knit together by BPM, messaging, and integration systems to optimize enterprise performance. Outside of the nodal manufacturing sphere, Internet-based collaboration options are growing in power and functionality. Exchanges and portals provide new channels for connecting with suppliers as well as customers along the value chain, while product lifecycle support options emerge for collaborative product design and support via the Web.

CMM Architecture

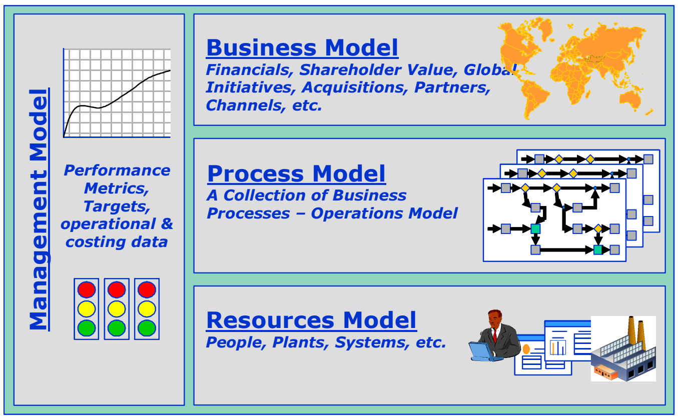
Underlying the CMM Model is an architecture which consists of multiple views. The Business Process view depicts the interplay of people, processes, systems, organizations, locations, and business goals. The business needs drive and determine the software and infrastructure requirements. The Service-Based Architecture (SBA) view depicts the relationships among applications, frameworks, Web services, standards, and integration techniques. SBA consists of Systems & Applications, together with a Service-Based Infrastructure. The Network and Systems Architecture considers networks, computing platforms, and equipment, as well as physical and geographical considerations.



CMM Architecture

Business Processes

Business Process and Operations Models represent the way the enterprise runs. The Business Model addresses the core values, strategies, and relationships of the enterprise. The Process Model is about how the business runs. It can be thought of as a collection of business processes. The Resources Model supports and is driven by the Process Model. It addresses all of the resources which need to be in place in order to operate effectively. The Management Model touches all of the others, and represents control, performance metrics, and the leveraging of operating data to ensure optimal performance.



Business Process / Operations Model

Using this approach has a number of benefits. Examining the business model can reveal operating anomalies. Separating out the Process Model encourages a fresh look at business processes and operations. Identifying boundary-spanning processes sets the stage for the whole enterprise to begin moving to a business process orientation. It highlights the processes that are embedded within applications. It raises awareness that some of these processes may be less than optimal for overall operations. The Resources Model reinforces the idea that the only reason for resources is to support the Process requirements, which in turn support the business model. Separating out the Management Model makes explicit the performance metrics, which should be tied to the processes, resources, and goals. More importantly, this organizational approach directly drives the System and Network architectural direction for the whole enterprise.

Service-Based Architecture

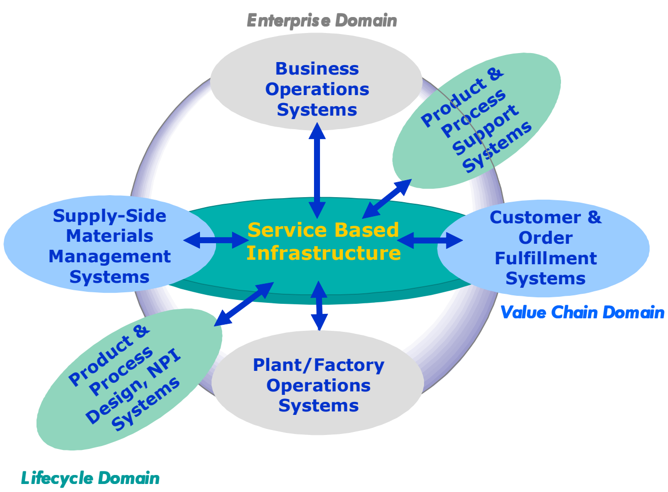
Collaborative Manufacturing can be accomplished with a variety of technologies. A certain degree of collaboration has been accomplished with paper, fax, email, and phone. But collaborative enterprises require an environment where business processes are automated, optimized, and managed dynamically to reach operational excellence faster, responding quickly to changing business needs along the way.

ARC believes that in the near future, Service-Based Architectures will be the norm for manufacturing and are at the heart of CMM. Many of the technologies are available today. In fact, many manufacturers have implemented some of the technologies in a portion of their operations, and new technologies are maturing that reduce the cost of SBA. What has been missing is a clear statement of the architectural principles manufacturers should follow when moving to a Service Based Architecture.

The culmination of a long evolution, Service-Based Architecture (SBA) allows manufacturers, for the first time, to have the best of all worlds. "Open," "Standards-Based," "Best of Breed," and "Legacy" all apply in SBA. It no longer makes sense to model the enterprise as a hierarchical stack of applications. New technologies – Portals, Internet, BPM, and more – don't fit easily into this conventional approach. The emerging landscape will still be complex, but it will be more manageable.

Service-Based Infrastructure

The Service Based Architecture highlights critical solution elements, rather than products. SBA consists of a Service-Based Infrastructure (SBI) that provides and manages services, and other Application Systems that expose functionality as services. The SBI corresponds to the Collaborative Infrastructure, (portrayed as a central disk in the CMM model). In addition to Active Service Management, the SBI provides seven core functions: Security Management, Service Registry, Role Management, Role-Based Workspaces, Service-Based Applications, Business Processes, and Automated Integrations. The first three are necessary functions for creating and maintaining the SBI. The remainder are critical for creating and managing business operations.

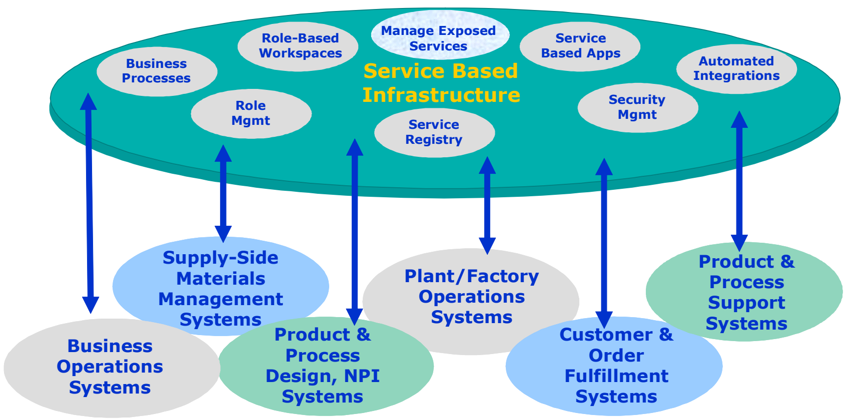


The Service Based Infrastructure Supports Functionality Throughout the Organization

SBA's value is in providing an enterprise-wide strategy and structured environment for managing enterprise business processes. This includes the set of re-useable services that are assembled to create collaborative processes. A "service" in this context is any re-useable function that an enterprise wants to expose to a select community of users through a well defined interface. Almost all application systems (enterprise or automation), have information or processes that have value outside the scope of that application, to other applications or people. For a true SBA to work, the organization must consciously devote resources to supporting, maintaining, refining, and building processes and services.

SBA does not degrade or make obsolete application systems, but increases the value of these assets by defining consistent methods for managing their use and relationships through end-to-end business processes and information sharing. Accordingly, the creation of services from application systems, such as ERP, SCM, CPM, PAS, and HMI, is a necessary part of any SBA. Several suppliers are "building in" to their products support for services, and some are adopting SBA to pull together broad product lines.

A fundamental concept of SBA is that only select information and processes should be exposed. The service interface and security elements of SBA limit the nature of that exposure. Also fundamental is the concept that exposure is always limited to a selected audience. These two concepts define requirements for the security, role management, and interface registry elements of an enterprises SBA.



A *Service Based Architecture* Consists of an SBI Interacting with All CMM Application Systems

Once the specifics of an SBI have been determined, fully deploying SBA throughout the enterprise can be an evolutionary process. This enables the enterprise to develop best practices and to optimize the management of services according to specific business and operational objectives. BPM, enterprise integration, and enterprise portal software have been moving toward SBA and forming the tools for modeling, implementing, deploying and optimizing enterprise-wide collaborative processes and providing effective visibility for increased productivity and better decision support.

SBAs are standardized, dynamic, real-time, secure, role-based, and reliable. They leverage legacy systems and applications, are scalable from small to large organizations, and are evolutionary; you can start small and grow when appropriate. In other words, SBA provides the enterprise with the means for solving today's collaboration and business process problems.

Plant Services Connector

Each CMM function has unique requirements when it comes to operating within an enterprise-wide SBA, but Plant/Factory Operations is a special case. A new group of solutions that ARC calls Plant Services Connector

(PSC) has emerged to provide for the real-time data collection and connectivity needs of the plant floor, in operational context, and expose them as services for the rest of the enterprise. Plant Services Connector may include functionality such as SBI interface, plant data model, object repository, application server(s) for data collection or interface to plant systems and OPC, historian, plant database(s), production workflow (business) processes, production document flow processes, and portal/role-based UI.

Systems and Applications

Manufacturers have invested a great deal in software and systems, and migrating to CMM does not require that they be replaced. Over time, suppliers will update their applications to expose more functionality as Web services, but at present, it is already usually possible to connect to critical functionality with existing APIs. Because they organize operations at a higher level, it is feasible to introduce BPM and SBI based on connecting to existing systems and applications and then make improvements as needs and as opportunities arise.

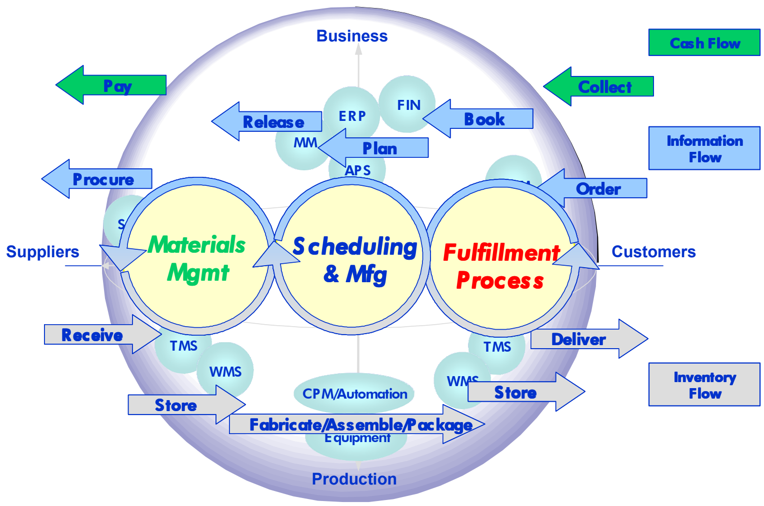
Network and Systems Infrastructure

The Network and Systems Infrastructure encompasses the Internet, enterprise and plant networks, communications infrastructure, firewalls and fault tolerance, computing platforms, plant equipment, and other physical requirements for deploying systems in support of the process model requirements. These systems are often necessarily complex and need to be robust enough to support the increasing real-time nature of business processes throughout the extended enterprise. Security and plant-level requirements of the Network and Systems architectural are examined in detail in other ARC publications.

Business Process Management

Making business processes the focus of management's attention can yield significant operational benefits. Managers can begin to think about new ways of doing business. A deeper understanding of a businesses' processes generally comes from implementing them in systems and invariably reveals hidden inefficiencies. The boundary-spanning nature of Business Process Management (BPM) systems allows managers to design process improvements that move beyond the limitations of standalone or legacy applications. Providing support for people as part of a controlled business process not only enhances their contributions, but also improves their job satisfaction. And because BPM systems can document and manage changes to the process themselves, it becomes relatively easy and predictable to make process changes in order to improve overall operational performance or respond to changing customer demands.

BPM solutions can help an enterprise in a variety of ways. Existing systems like ERP, WMS, and SCM can be integrated into higher-level processes. Wherever complex processes or workflows are employed, BPM solutions can orchestrate, manage, refine, and optimize them. For example, the processes for fulfilling a customer's order as promised can be systematized, with controls and alerts in place to ensure that each order stays on track. This process typically spans a number of departments and partners, and companies benefit from replacing unconnected, ad-hoc procedures with synchronized, rules-based business processes. Manufacturers should consider BPM solutions anywhere increased collaboration is likely to help reduce costs or inefficiencies.



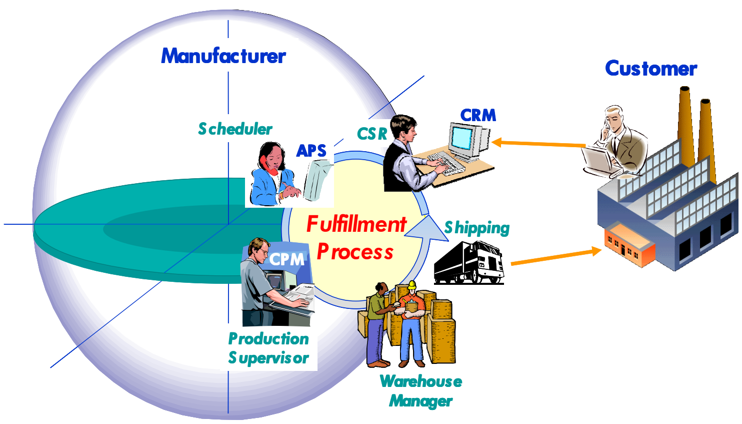
Manufacturers Can Use BPM to Drive Individual Business Processes in a Closed-loop Way

BPM also is important in moving and synchronizing data among disparate systems throughout an organization. Very often, there is a set of specific processes and transformations that must occur in order to use the data correctly in each application, and base-level BPM systems support and enable these transformations. This is often done in conjunction with the design and implementation of complex inter-application logic.

Examine the three interacting loops in the Value Chain. Order/Fulfillment is the process of reaching out to customers, accepting orders, and ensuring that goods are delivered as promised. Materials Management is the process of connecting with suppliers, procuring the materials, and ensuring that they arrive as needed by production. Scheduling/Production is a process that interacts with both the Fulfillment and the Materials Management process. All manufacturers have these basic processes, but the degree of interaction, the time dependencies, and the information flows all vary widely, depending on the size of the enterprise, the manufacturing model, the position within the supply chain, global manufacturing requirements, the degree of vertical integration, and other factors.

Order/Fulfillment Process

The customer-facing business loop consists of those processes for finding customers, accepting their orders, and ensuring that their goods are delivered as promised. This typically involves people in different departments using different standalone applications. For example, a customer service representative uses a CRM application to take orders. A scheduler uses a spreadsheet or a sophisticated Planning and Scheduling system to generate the work plan. A plant supervisor uses a Production Management System to direct and monitor the work. A warehouse manager uses a WMS application to track finished goods inventory and optimize stock movements. A shipping clerk and shipper use a 3PL system to arrange and track deliveries. Often, these applications are unconnected, and the business processes are ad-hoc and unsynchronized. Sometimes, things fall through the cracks.



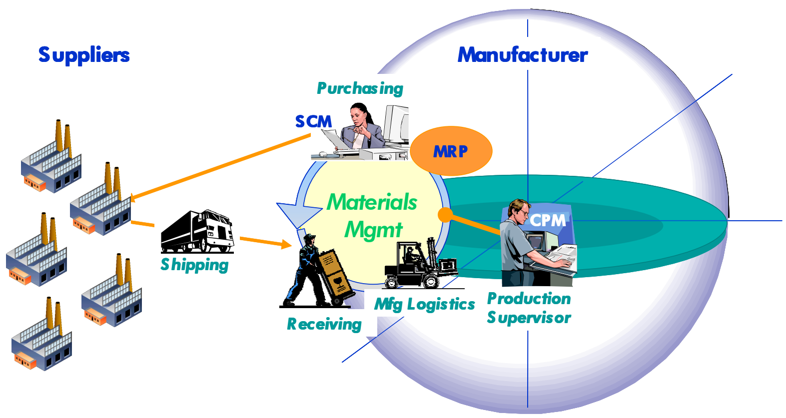
BPM Systems Can Link Independent Operations into a Controlled Customer-facing Process

BPM systems can link all these activities in order to orchestrate all of the disjointed processes and operations to better serve customers in the most efficient manner. BPM can ensure the timely execution of specific processes, streamline the extraction of data from various modules and applications, manage the procedures to transform and transport data between systems, and ensure that workers are effective.

BPM enables existing workflows to be supplemented with additional feedback loops. For example, the CSR can be automatically notified if work hasn't started on a particular order in the expected time frame, or if something causes it to be rescheduled after work has begun. This enables proactive intervention to address schedule issues or notify the customer in advance if the problem cannot be solved.

Materials Management

The supplier-facing business loop includes those processes for identifying suitable suppliers, placing orders, and ensuring that goods get to manufacturing when needed. Again, this typically involves people in different departments using different stand-alone applications. For example, an ERP/MRP system generates a required materials list. A purchasing agent uses a Supply Chain application to negotiate terms and issue purchase orders. At the receiving dock, goods are accepted and moved to the inbound storage area. Manufacturing withdraws the parts as needed.



A BPM System Can Link Independent Operations to Ensure that Materials Arrive in Time for Manufacturing

As with the Order/Fulfillment process, BPM systems can link all of these activities to ensure that materials arrive at the proper station on time. Where Kanban, VMI, Re-order Point, or other inventory management techniques are utilized, BPM can often enhance performance by introducing new feedback control opportunities. For example, the production supervisor can be automatically notified of delays for a particular particular order. Both the purchasing agent and the production supervisor can be automatically notified if received goods were damaged and possibly unusable. Again, the additional control enables a proactive intervention to address any schedule issues and to develop workarounds where needed.

Scheduling/Production

The scheduling/production business loop includes the processes to plan and execute plant floor operations. Details depend on the particulars of the manufacturing model involved. Production supervisors, equipment and transport operators, planners, expediters, ERP/MRP, lab managers, and others participate in the workflows involved in day-to-day operations. Most often, these processes run independently, and process boundaries are where things are likely to go awry. BPM systems can synchronize all of these processes and ensure that optimal production decisions are made, taking into account order (demand) and materials (supply) constraints and opportunities.

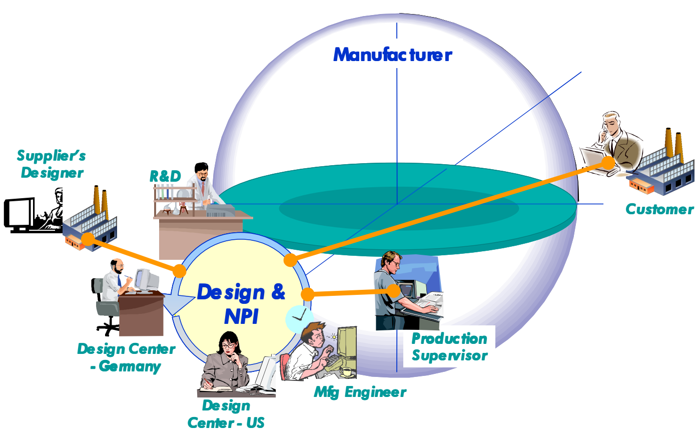
It should be noted that in addition to interacting with the customer-facing Order/Fulfillment process and the supplier-facing Materials Management process, the Scheduling/Production process must interface with the Product/Process Design process and the Product/Process support processes.

Design and NPI

The design and new product introduction process takes many forms. Sometimes, it starts with basic research and formulation, and proceeds through raw materials specification, recipe development, process design, and ramp to volume. Sometimes, Design Centers in different cities collaborate to produce a single design, in concert with outsourced manufacturers and suppliers who also contribute to the design.

Design

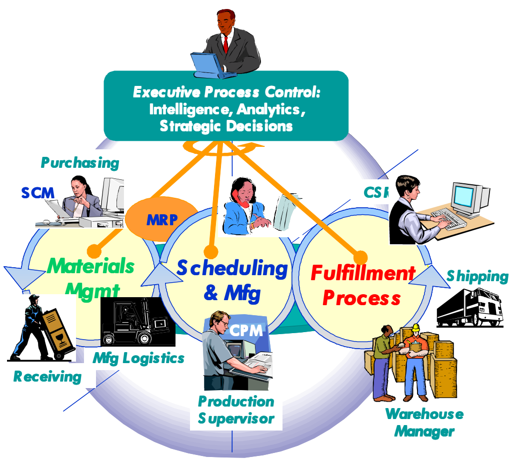
The design organization must collaborate with suppliers and customers, as well as with internal supplier-facing, customer-facing, manufacturing, support, and business operations. Design metrics should include time to market, product development cost, product manufacturing cost, and product performance. The real challenge is effectively managing processes and resources for multiple teams developing multiple products globally. New Supplier Total Quality Excellence programs can standardize a rigorous approach to supplier quality management across multiple product lines. This requires focusing on the processes and using technology to reduce geographical, organizational, physical design, and manufacturing constraints.



The Design and NPI Process Takes Many Forms - Focusing on the Overall Process Leads to Improvements

Collaboration with Production

An important aspect of collaboration on production involves making sure that the inevitable stream of ECOs and design changes is coordinated with manufacturing operations. It is difficult and time consuming to locate and view engineering data and specifications, and in many operations it is difficult for operators to be sure they have the latest drawings or specs. Operators must learn and use many systems, logons and screens, and usually deal with a lot of paper. This can lead to missed product and process changes, causing excessive rework and scrap. A business process that touches all appropriate systems and identifies "what's different" up front will improve performance.



Adaptive Real-time Collaboration

Collaborative systems can provide easy access to shop reference materials, lower the required skill level for users, facilitate moving employees between jobs and product lines, adding new jobs or changing rates to use less skilled employees, speed the hunt for information in time-critical situations, and cut dependency on job knowledge and informal information sources.

Capturing process knowledge as part of a collaborative system supports OpX by reducing dependency on experienced senior employees while encouraging continuous improvement.

CMM Drives Operational Excellence

Companies striving for Operational Excellence (OpX) at any level must have a model for continuous improvement. The DMAIC model, which is generally used in Six Sigma, describes the sequential steps that should be taken in assessing and improving performance. DMAIC stands for Define, Measure, Analyze, and Improve and helps companies to identify problems and implement solutions. Control, which is the last part of DMAIC, makes sure that the process retains gains that have been made.

Six Sigma is a continuous improvement methodology that has gained considerable attention in recent years. It provides a rational approach for evaluating performance, identifying real problems, determining the causes of those problems and directing resources towards the best solutions. Six Sigma is a natural component of operational excellence, and has become the basis for many continuous improvement programs. But Six Sigma and operational excellence are not synonymous. Six Sigma focuses on improving current measures. OpX extends Six Sigma by directing improvement efforts towards those issues that are most important to the customer and to overall efficiency.

Manufacturing organizations can use Six Sigma to improve product quality and performance. Six Sigma principles can be also applied across the supply chain, to improve performance metrics such as on-time deliveries.

Solutions Solve Specific Performance Problems

OpX can be measured in terms of four key characteristics: average performance, variability in performance, synchronization, and responsiveness to change. Average performance includes factors such as cost, throughput, delivery times, and reflects the steady state behavior of the system. Planning solutions can be useful tools for addressing these problems by finding the optimal way to operate the process.

Issue	Solutions
Average Performance	Production Planning & Scheduling Distribution Planning Transportation Planning Supply Chain Planning
Variability	Production Management Warehouse Management Transportation Management Supply Chain Management Order Management
Synchronization	Business Process Management Enterprise Integration Collaborative Applications Supply Chain Collaboration Supply Chain Event Management
Responsiveness	Business Process Management Customer Relationship Management Production Management Supplier Relationship Management Product Lifecycle Management Service Network Management
Improvement	Strategic Enterprise Management Business Intelligence, Analytics Business Process Management Supply Chain Process Management

Operational Excellence Solution Map

Variability in performance includes factors such as unplanned stockouts, late deliveries, incorrect order-filling, etc. Variability generally reflects the lack of repeatable business processes. Applications such as Production Management or Warehouse Management systems can make significant improvements by optimizing performance in specific areas. These can make a major contribution to reducing variability by focusing on business processes that span multiple areas.

Synchronization and tuning of business processes, both internally and externally, is important for achieving OpX. Carefully optimize buffers, such as inventories, excess capacity, and excess resources that smooth the interactions between trading partners or internal groups. Collaborative solutions help to reduce buffers by keeping all parts of the value network working under common assumptions and plans, while providing for changes in the face of changing competitive and environmental requirements.

Responsiveness relates to the time it takes the organization or network to adjust to a change or an unexpected event. This is the most difficult aspect of supply chain performance to measure. Being responsive often means the entire value network must shift from one steady state operating point to another. In the process, each individual area must shift, stabilize, and re-synchronize with the rest of the supply chain. Responsiveness can improve with faster information flow across the supply chain, but OpX probably requires the introduction of Business Process Management solutions.

Recommendations

Embrace CMM. Manufacturers should not wait to begin migrating to CMM. Solutions are available. The technology and implementation road-maps are foreseeable. It is feasible to introduce BPM and SBI based on connecting to existing systems and applications and then make improvements as needs and opportunities arise.

Focus on Business Processes. Making business processes the focus of management's attention can yield significant operational benefits. Managers can begin to think about new ways of doing business.

Build your SBI. Create a collaborative infrastructure for an enterprise-wide strategy, and a structured environment for managing enterprise business processes. Establish the organization, and devote resources to supporting, maintaining, refining, and building processes and services.

Evolve to SBA. Once an SBA Infrastructure is delineated, deploying SBA throughout the enterprise can be evolutionary. This enables the enterprise to develop best practices and to optimize the management of services.

Strive for OpX. Adopt a continuous improvement approach to achieving Operational Excellence, such as ARC's DMAIC Model.

CMM can improve response to changing market conditions, streamline product introductions, improve asset utilization, increase or maintain market share, reduce inventory, and reduce cycle times. All these improvements are important contributors to profitability, competitive advantage, and shareholder value. Most suppliers will offer a hard dollar value proposition that manufacturers can factor into their assessments.

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Acronym Reference: For a complete list of industry acronyms, refer to our web page at www.arcweb.com/Community/terms/terms.htm

AMHS	Automated Material Handling System
APC	Advanced Process Control
APS	Advanced Planning & Scheduling
BPM	Business Process Management
CMM	Collaborative Manufacturing Management
CPAS	Collaborative Process Automation System
CPM	Collaborative Production Mgmt.
CPS	Collaborative Planning & Scheduling
CRM	Customer Relationship Mgmt.
CSR	Customer Service Representative
EAM	Enterprise Asset Management
EMS	Electronic Manufacturing Services
ERP	Enterprise Resource Planning
LIMS	Laboratory Information Management System
MRP	Materials Resources Planning
NPI	New Product Introduction
OpX	Operational Excellence
PAM	Plant Asset Management
PDM	Plant Data Management
PLM	Product Lifecycle Management (**/D** = Design; **/S** = Support)
PSC	Plant Services Connector
PSM	Product Service Management
SBA	Service-Based Architecture
SBI	Service-Based Infrastructure
SCM	Supply Chain Management
SCPM	Supply Chain Process Management
SEM	Strategic Enterprise Management
SFA	Sales Force Automation
SRM	Supplier Relationship Management
TMS	Transportation Mgmt. System
VMI	Vendor Managed Inventory
WMS	Warehouse Management System

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