The Adaptive Manufacturing Enterprise

New Directions in Manufacturing
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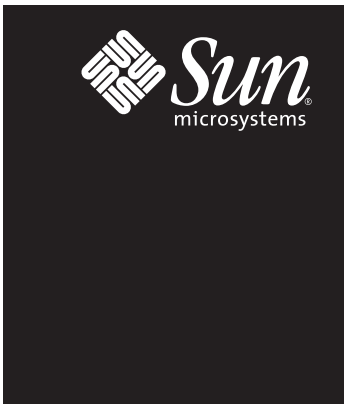


Introduction

Durable goods manufacturing has undergone almost constant change over the past two decades. Today's survivors hardly resemble the discrete manufacturing behemoths of the 1970s. Over the past 20 years, globalization of markets have driven durable goods players to shed the security of mass production in favor of lean and flexible manufacturing models. As we look towards the future, these changes may be just the tip of the iceberg.

On the supply side, manufacturers are continuing to shed peripheral operations to concentrate on their core value add. For instance, several automakers have in the past few years spun off their electronics components operations, in an effort to improve their flexibility in meeting customer demand, and leverage the technological innovation within the components industries.

On the demand side, OEMs are challenged by the reality that, in mature markets, most manufacturers are capable of making similar products, whether that involves high-end audio systems, PCs, dishwashers, or midsize sedans. They are struggling to differentiate. For instance, the recent Detroit International Automotive Show introduced over 700 new light-vehicle products/concepts. Significantly, in many cases, those concepts involved blending products or services outside the core vehicle, such as entertainment packages, to differentiate those products.

Meeting the challenges of mature markets could drive manufacturers to sharpen their focus even further. For instance, if a company's reputation to the consumer is for aftermarket service, does it need to continue owning the assembly line or the manufacture of subcomponents? If the company needs to react to changing customer demands faster to continue differentiating its products, wouldn't it be easier if the company was smaller with a flatter organizational structure? Wouldn't it be easier to react if the company could find partners with the right capabilities to manufacture, assemble, and deliver the product to market?

This paper discusses *Adaptive Manufacturing*, a new competitive strategy centered around virtual product coalitions that applies the lessons from lean and flexible manufacturing to the realities of the 21st century durable goods marketplace. This paper explores the road ahead for durable goods manufacturers, and the critical role that Sun can play to supply the technology to support the transition.

Historical Background

Traditionally, the durable goods manufacturing business has been driven by supply and demand levels. The huge accumulation of assets, capped by more sophisticated market expectations for consumer goods, has changed the equation drastically. This has come about through the interplay of several factors, including:

- *Manufacturing operational proficiency:* This is the increased output/unit of fixed-asset labor and energy input.
- *Asset accumulation:* As companies grow too asset rich, this could become a drag on productivity. Furthermore, if they are not efficiently situated to satisfy market demand, the drag on productivity increases.
- *Regulatory climate changes:* Shifts in government regulation and deregulation alter the competitive playing field.
- *Market maturity:* As various product categories are no longer "new" or innovative, it becomes more difficult to differentiate products. In some cases, this could lead to a decline in product loyalty.
- *Emergence of "Soft" differentiators:* Companies often compete on the quality of their reputations. Once lost, this is very difficult to regain.

Operational Proficiency

Manufacturers have become extremely proficient at the operational level. When offshore competition threatened the livelihoods of many durable good manufacturers, they responded with process improvements that declared war on waste, product defects, and idle inventory. Manufacturers applied continuous improvement principles, growing lean to attack waste, then adding flexibility to better respond to changes in consumer tastes. Further improvements have come through:

- Workforce strategic thinking and training at every level
- Superior mechanical technology innovations, and
- Improved information management, enabling improved supply chain visibility.

Manufacturing processes themselves have benefited from improvements in productivity. According to The Harbour Report North America 2002, "Today, lean manufacturing, and emphasis on quality, safety, and product and process engineering are key elements in almost every manufacturer's continuous improvement efforts."

Yet, in spite of all the operational gains, automotive OEMs still perceive the need for new capacity, having invested billions of dollars in plants in the southeast U.S. over the past decade.

Assets

The ideal goal is to have the right amount of assets (or capacity) in the right place, at the right time to satisfy demand. If it lacks assets, the manufacturer will have trouble satisfying demand. At the other end of the scale, excess assets can soak up capital that could easily be diverted more profitably elsewhere.

Beginning with the volume issue, in many durable goods sectors, the answer is that there is too much capacity out there. The latter is currently the case in the automotive industry. According to the Automotive News Market Data Book for year 2002, there are over 600 final assembly plants serving an annual market estimated at 54 million units. Based on the fact that the average assembly plant has an annual capacity of 250,000 vehicles, that means that OEMs are currently saddled with twice as many assembly plants as they need. In a desperate race to keep their assets utilized, some OEMs are sacrificing their margins, with consumer incentives as generous as no money down with zero percent financing.

As to the location issue, the questions to ask are whether the facilities are close enough so products can be delivered within a timeframe and cost that the market will bear, and whether the supply lines are reasonably efficient.

The traditional practice in durable goods manufacturing has been for OEMs to own their final assembly facilities and dedicate those facilities to their own product nameplates. For instance, one OEM might own a sports utility assembly plant in Ft. Wayne, Indiana, while another may have a competing facility a few hundred miles away in Louisville, Kentucky. The result is that both have overlapping supply lines and delivery "lanes."

Using brute economics, it would make sense to reduce the sheer number of facilities and abandon the direct ownership model. In a "rightsized" market, for instance, a Ft. Wayne facility would assemble light trucks for the upper Midwest market for any OEM via contract, while the Louisville could service the southeast. In fact, such contract manufacturing models are already in place in the high technology sector, where OEMs often subcontract the assembly of personal computers at the same group of Asian plants.

Regulatory Climate Changes

Regulatory changes are transforming industry and commerce. Global deregulation and the need to gain economies of scale to address a proliferation of world and regional market niches are driving vast consolidation across virtually every industry.

Meanwhile, with the pressures of environmental mitigation and the reality of a more crowded planet with less available land area for disposal, pressures are mounting to add new regulations. For instance, the EU requires manufacturers to assume responsibility for disposing or recycling products at the end of their operating lifespans.

Market Maturity

As industries grow entrenched, there is the risk that product differentiation could blur. For instance, most consumer electronics manufacturers are capable of making similar audio and video equipment. In many cases, it may be difficult if not impossible to distinguish one manufacturer's brand of color TVs or dishwashers from another's.

In many cases, the answers may lie, not in differentiating the core product itself, but with the features or services that surround it.

Emergence of "Soft" Differentiators

A long established "soft" differentiator is the company's reputation or image. Some OEMs are known for economy models while others cater to upscale demographics, while some companies are known for their attractive product designs, while others are known for their customer service. In mature markets, factors such as these stand out.

Consequently, in the future, manufacturers may have to literally "think outside the box" to differentiate their wares with "soft" factors that are not necessarily intrinsic to the product itself. Examples could include features such as longer warranties, content subscriptions, travel assistance, or custom design of products by companies noted for high fashion. A more extreme case—the minivan aimed at young families that is equipped with children's video entertainment packages from Hollywood studios—demonstrates the types of unorthodox product/service partnerships that are beginning to surface.

Impact on Value Chain

Overview

The Harbour report documents what has become common knowledge: that automotive manufacturers have largely improved their manufacturing efficiency. However, that doesn't necessarily mean that the overall durable goods value chain in automotives or other sectors has necessarily grown more efficient at making goods.

Productivity is a key component of overall market efficiency. In essence, productivity is a ratio of value-added divided by resources, such as time and materials or other factors. In durable goods manufacturing, value is added when something is actually done to the product itself, such as conversion of raw material, assembly, packaging, and in some cases, the level or type of service accorded to final delivery. In many cases, products in varying stages of completeness may spend time as stalled work in process or in transit. This is a major issue for durable goods manufacturers today.

Challenges

The obvious problems are the length and pattern of transit spokes, and the relative efficiency of production lines.

For instance, as manufacturers either migrated portions of their operations to lower-wage regions, or chose suppliers with unique capabilities that are thousands of miles away in other states or world regions, supply lines get stretched long enough to make transit times a major hurdle to overall productivity.

However, supply lines are not the sole culprits. Even if durable goods manufacturing were to revert to older models of totally vertically integrated production, such as Detroit's famed River Rouge automotive complex, inefficiencies would still arise because process flows at the foundry could never synchronize in lockstep with the final assembly line, or any of the component manufacturing processes in between. Similarly, practices, such as the adjacent or "collocation" of supplier plants near, or inside facilities operated by final assemblers, can never solve all of the hurdles to keep all phases of production perfectly in sync, at zero inventory levels.

The result is that the durable goods manufacturing value chain can never be 100% efficient. There will always be periods when the item is sitting in process or in transit. Furthermore, post-9/11 security concerns that add more non-value added disruption in the form of cross-border customs delays will only compound the problem.

Another potential constraint on the efficiency of the value chain is whether the *right* capacity is in place at the right location, and available at the right time. Admittedly, flexible manufacturing innovations of the past several decades have improved the ability of many plants to turn out more varied products. The operable question is whether yesterday's generation of "flexible" plants are flexible enough to continue keeping pace with changes in the market.

For instance, over the past decade, large recreational trucks and vans have grown far more popular in the North American market. According to figures from Ward's AutoInfoBank, published in the *New York Times* on June 18, 2002, SUVs, vans, and other light trucks have increased their market share over the past decade by 10% at the expense of compact car sales. The operable question remains: Can facilities designed for turning out a variety of midsize and compact vehicles make the switch to SUVs?

Results

Advances in plant productivity are only part of the challenge. The real issue for manufacturers to consider is whether their facilities can efficiently respond to demand.

Facilities must be flexible enough to make the right product mix, yet be located in the right place to satisfy the demand. This operating ideal may drive manufacturers, not only to relocate or build new capacity, but to consider deeper issues regarding what capacity they should own, whether the processes involved are best performed internally or by outside suppliers. If the answer is to divest and partner, they must identify what types of companies they should align with to meet demand.

The Restructuring Begins

Downsizing is nothing new to durable goods manufacturing. For instance, Ford's River Rouge complex, which originally included everything from the steel plants that processed raw iron through final assembly, today only performs the latter. Divestment trends are continuing, with the latest example being the spinoffs of automotive electronics components subsidiaries.

Newer industries, such as high technology computing and electronics equipment, have set the mold. For instance, the industry relies on contract assemblers in nations such as Taiwan, Malaysia, and China. The sector, which largely avoided vertical integration, has operated through long-term strategic partnerships for outsourcing fabrication, assembly, and supply chain management processes. These companies differentiated themselves, not on components like circuit boards, but on the degree of service, speed of delivery, and final configuration of hardware features and software images.

The driver has been the realization that what's good for manufacturing and assembly is not always the case for other operations upstream or downstream. For instance, a silicon foundry relies on semi-continuous processing because of the physical nature of chip fabrication and because of the huge capital costs of the facilities. Yet, at the component manufacture and final assembly stages, market demands for products may force them to slow down or speed up processing to match inventories with demand spikes.

Asset Utilization and Return

Which Assets are Worthwhile?

Manufacturers have several major categories of sunk costs including labor, materials, and fixed assets. As manufacturers adopted lean manufacturing principles, many have significantly reduced their inventory carrying costs. That state of affairs became apparent in the days following 9/11, when cross-border delays idled portions of the nation's manufacturing capacity.

The result is that asset accounting is hardly black and white. While the upheavals of the 1980s placed the onus on consumable assets, such as inventory, the market dislocations and demand spikes of today's environment are also driving manufacturers to train their eyes on sunken assets. The $64 billion question has become: what assets are absolutely necessary for a company to continue differentiating itself in an increasingly glutted, commodity marketplace?

As recent scandals in fields such as energy trading have revealed, there are limits to the effectiveness of strategies where companies operate *without* assets. But, if assets are necessary to maintain presence and control over one's destiny in the marketplace, what are the *right* assets to have in place?

Emergence of Virtual Manufacturing Coalitions

A solution could involve sober analysis of the company's own business directed at identifying where the enterprise adds the most value, and how its customers differentiate the company in their own perceptions. For many durable goods manufacturers, the answer to this question could shake their basic identity as manufacturers. The question for them is, do their customers buy their products because of their proficient assembly lines, or the styling or customer service that they deliver? A similar question is whether customers buy their products because they value the nameplate, and the reputation that goes with it.

The answers to these questions could drive what the company actually "does." In a market where product differentiations have blurred and competition is intense, the answer may involve further divestment of facilities and businesses that are no longer considered core to the mission. In a market where segmentation is getting more pronounced, the answer to keeping pace with delivering all the necessary innovations to the right market slices may lie in a new form of virtual corporate structure, where brand owners contract, or federate with partners that can collaborate on fulfilling an identified market need.

Under this model, the company whose nameplate is a key differentiator would retain ownership of the brand and product creation and rely on contract manufacturers. High technology mass market electronics products, such as PCs, cell phones, and components (such as disk drives or memory) already utilize this model. Brand owners contract with manufacturing companies situated in the right places, which make plant floor workflows, quality track records, and production expertise their core competence.

Under this model, factories are no longer captive operations to individual brand nameplates. They can sell their manufacturing services to any sector that needs it, without having to be captive to the ups and downs of individual product sectors or company nameplates.

A refinement of this model is the emergence of "virtual manufacturing coalitions," communities of companies that band together to maker and deliver to market specific products or product families. With a coalition of partners dividing up the labors, companies could act without the need to sub-optimize all of their conflicting operations. For instance, computer makers would only work with silicon foundries on their own schedule, not the foundry's. Appliance manufacturers could assemble refrigerators without having to balance loads with their compressor plants.

Shorn of the baggage of peripheral operations, manufacturers could become freer to respond to market fluctuations. In short, they could become *adaptive*.

Adaptive Manufacturing: How Could It Work?

Responding to a market need invokes a complex set of interlocking processes that have significant differences in life cycles, business rules, and lead times, that must be choreographed together to devise an effective response.

In the classical, vertically integrated manufacturing enterprise, tradeoffs would have been necessary to sync the various components of the value chain. In adaptive manufacturing, the formation of virtual coalitions could reduce many of the inefficiencies that would otherwise come from these tradeoffs for one basic reason-each spoke in the chain would be free to work with other spokes. In the long run, competition could winnow out the least efficient spokes.

In essence, virtual manufacturing communities would be mobilized to meet a specifically defined market need, comprised of players that act as "service utilities" for each part of the value chain.

The Value Chains

Each of the value chains in manufacturing operates according to different objectives. Throughout the entire life cycle of a product, from conception to manufacture, purchase, use, and final disposal, these value chains must be effectively networked.

The different components of the value chain for durable goods manufacturing enterprises include:

- *Product Chain* — Covering product development, the goal is to reduce timeframe that begins with conception to the point where manufacturing is launched.
- *Supply Chain* — Covering the movement of materials, the supply chain focuses on the flow of material as they are converted from raw stock to subcomponents that are eventually assembled into final products. The goal of supply chain management is to accelerate the flow to the point where material is converted to final product with minimal delay.
- *Production Chain* — Covering the manufacturing stage, the goals have changed in recent years. When lean manufacturing practices emerged, the objective was to reduce the amount of inventory clogging the system, soaking up scarce capital, and masking defects. Although inventory reduction remains important, it is tempered with considerations such as cross-border security and the need ensure maximum utilization of assets. Consequently, plants that are more flexible are likely to be better utilized, even as demand or inventory flows fluctuate.
- *Customer Chain* — This is where the product actually reaches the buyer. The goal is to increase customer satisfaction, and thereby improve customer retention.
- *Support Chain* — Creating revenue opportunities in the aftermarket, this portion of the value chain includes conventional post-sales warranty and repair services, and could also include a new array of "lifestyle" or convenience services that make the product more valuable to the customer.

The Service Utilities

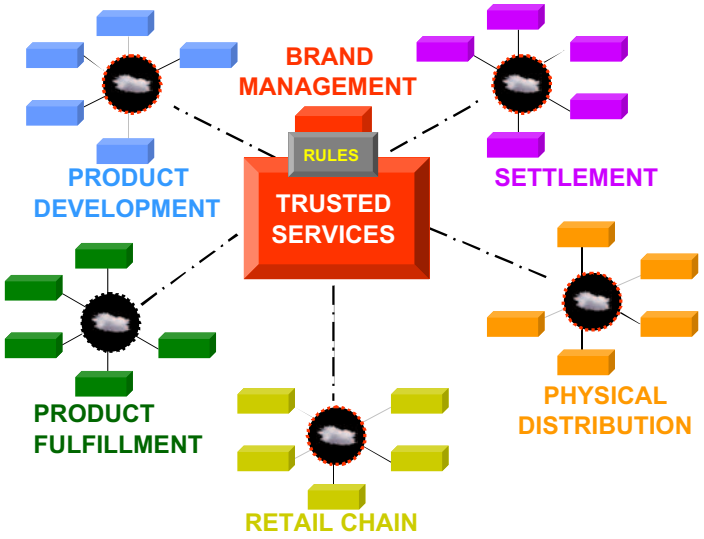
In Adaptive Manufacturing, service utilities based on each of these "chains" could be mobilized to deliver a product, from conception to aftermarket, to the end customer.

The chains could be assembled through a foundation agreement that begins with a brand owner: the OEM that maintains the brand awareness with the target market and acts as the

critical mass of the coalition. This agreement could cover the degree of investment that each player is obliged to place, along with the training, marketing, and post-sales support activities that are specified for the final product.

To promote the cross-fertilization of coalitions with different members, each vertical industry segment would set up its own generic business rules, or "ontologies" in the same manner that vertical industry groups developed basic standards for processes such as EDI. On the horizon, these business rules could be used for spawning standardized Web services frameworks for specific vertical industry sectors.

Adaptive Manufacturing Service Utilities
The Adaptive Manufacturing environment is comprised of a network of coalitions that each provide, in effect, "service utilities" that manage specific parts of the manufacturing value chain. They all revolve around the Brand Manager, the entity that owns the brand and acts as the central hub for all the coalitions.



Beyond that, the roles that each of the players would assume would vary, based on the needs of the product segment and the prevailing practices of the particular industry.

For instance, the roles that the brand owner may play could vary based on the owner's business rules or the dynamics of the particular market. For instance, in laptop PCs, contract manufacturers in Taiwan might actually "own" the product design decisions, with the brand owner distinguishing itself through external attributes, such as onsite customer service or MP3 entertainment packages. In other sectors such as automotives or appliances, the design initiative could remain with the OEM. In short, many different kinds of models are possible.

The group could be comprised of a series of subgroups responsible for specific parts of the value chain. In effect, they could function as "service utilities" covering:

- *Brand Management:* Acting as the product systems integrator, the brand manager defines the business rules, analyzes the market, manages orders, controls the workflows, and depending on the industry, owns the brand nameplate, end customer, or retail relationship.
- *Product Development:* Beginning with product conception and ending with product launch, this phase terminates when the design is complete. This covers product design, development, testing, pre-production, product launch, post-launch refinement, and engineering change management (including recalls). Multiple companies, from design studios to machine tool manufacturers, could be involved in this complex process. This engineering utility could operate according to unique rules that may transcend vertical industry lines.
- *Product (Order) Fulfillment:* Involving the physical production of all components required to complete the final product, this process integrates the workflow that schedules, notifies, and releases materials, parts, components, machines and labor necessary to produce the

customer's order, according to preset terms. They reflect the timeframe to delivery, technical and performance specifications, and other terms of the sales agreement. This utility may cross industry liners, operating according to rules that prevail in manufacturing plants.

- *Physical Distribution:* This encompasses the physical movement of material, parts, components, modules, and final salable units between value-added producers. Included in this routing are ports, rail hubs, trucking hubs, warehouses, distribution centers, freight forwarders, trucking firms (or "third party logistics providers," or 3PLs), barges, completion centers, inbound logistics centers, outbound logistics centers, and others. This distribution utility could operate based on the rules of the transport industry.
- *Retail Channels:* These channels are where consumer products are delivered or presented to the customer at a store site. This sub-network of customer-facing services could behave as a customer-centric "utility" operating based on common practices in retailing or wholesaling.
- *Settlement*: Financial settlement is the reconciliation of all monetary transactions and obligations. Besides monetary settlement, this could also encompass loss indemnification; tax or regulatory compliance; letters of credit; and other economic transactions. This sub-network of trusted services could behave as a settlement "utility" operating to a set of rules set by the financial, security and insurance industries.

Software as Services and Adaptive Manufacturing

Because the Adaptive Manufacturing environment is, by nature, loosely coupled, the software underlying the business processes must be similarly flexible. Each player in the adaptive manufacturing value chains would have to be prepared to deal with a changing mix of trading partners, depending on which virtual product coalition they are participating in.

That in turn would dictate a software architecture that is:

- Loosely coupled, reflecting the changeable, interlocking business processes that they support;
- Based on standards and open architectures, enabling virtual manufacturing coalition partners to seamlessly integrate with each other without regard to platform;
- Supports deployment of software as services, because of the B2B integration that is required of adaptive manufacturing coalitions.

Since day one, Sun has placed the network at the center of computing. As one of the first providers to prepackage industry standard IP network technologies into our products, we know what it takes to deploy applications that take advantage of networks. At the core of our strategy is support of industry standards, such as TCP/IP and XML.

Our vision of the services-driven network comes straight out of our original experience. It is the idea of deploying responsive networks that provides customers "dial tone" like reliability in delivering value-added services. Because Adaptive Manufacturing relies on loosely coupled, responsive coalitions, reliable network-driven services are essential to making the vision happen.

The Sun™ Open Net Environment (Sun ONE) provides the architecture and the products that support this vision. Sun ONE is the software vision, architecture, platform, and expertise to deliver Services on Demand. These services include everything from dedicated applications to Web-based applications to Web services, based on standards such as SOAP; Java™ 2 Platform, Enterprise edition (J2EE™); UDDI; WSDL; and LDAP. These solutions are designed to deploy atop Sun's

back-end server and storage infrastructure—systems that have been proven under the challenges of 24x7 Internet commerce.

Sun ONE supports the goals of Adaptive Manufacturing by providing the tools, applications, and frameworks for integrating diverse systems, data, networks, and legacy assets to create a collaborative environment supporting the interaction of virtual manufacturing coalitions.

We back our commitment to the Sun ONE architecture up with products that can help your company build the integration hub that it needs to easily connect with business partners, through a services-based architecture. That includes:

- *Sun ONE Internet Servers:* Sun offers robust, J2EE application servers that are used as the basis for deploying services that can integrate with your business partners. Based around Sun ONE Application servers, we offer an array of standards-based directory servers that can be used as part of a B2B security strategy; portal servers, that can provide personalized access to critical information for internal staff and external business partners; and commerce servers that address online procurement.
- *Sun ONE Commerce Servers:* The Sun ONE architecture offers a roadmap for building supplier portals and deploying applications components or services that can give those constituencies the power to buy, sell, bill, and trade products and services in ways that turn the supply chain into a value chain.
- *Sun ONE Application Integration and Messaging Servers:* Based around standards such as the Java Connector Architecture (JCA) and Java Messaging Services (JMS), the Sun ONE platform includes servers designed to integrate with the back end systems that you already operate. Sun ONE integration products help protect the investments in your existing infrastructure, providing a standards-based approach to seamlessly connecting your systems with each other, and with trading partners.
- *Sun ONE Application Development Tools:* Sun offers integrated development environments (IDEs) for Java technology and legacy languages such as C, C++, COBOL, and Fortran.
- *Solaris™ Operating Environment:* The Solaris Operating Environment is known for delivering availability, scalability, and security, providing a trustworthy platform to meet the needs of businesses—from small startups to large Fortune 1000 enterprises

And, thanks to our commitment to open systems and industry standards, Sun can provide access to one of the widest selections of best-of-breed third party solutions of any major platform vendor.

We back our commitment to best of breed with the iForce™ program. The iForce program includes a community of service and solution providers that are brought together at centers where customers, solution providers, and systems integrators can work with Sun professionals to build proof of concepts to pretest the integration of best-of-breed solutions. Sun iForce centers leverage Sun's worldwide alliances and bring together Sun and third-party expertise to help you with everything from brainstorming to pilot programs.

Sun provides the expertise, hardware, networking and industry standard software components necessary for project sizing, configuration, and tuning for a specific application as well as support for selecting the appropriate hardware required for a solution's stability and scalability needs. Thanks to the iForce program, manufacturers can take advantage of best practices to readily assemble the solutions they need to compete in the new, virtual world of manufacturing communities.

Conclusion

Durable goods manufacturing in the 21st century is evolving to the adaptive model, where groups of business partners assemble to produce, deliver, and support a product addressing a defined market need throughout its life cycle.

Adaptive Manufacturing is the latest evolution of a long-term trend in discrete manufacturing away from classic vertical integration. OEMs and suppliers assume new roles, focusing on their core competencies, and partnering for all other activities. This model, which has already become standard operating procedure in many high tech electronics sectors, is now spreading to other durable goods verticals as well.

Adaptive Manufacturing is a model that requires manufacturing and related companies to develop business processes that can easily interlock with business partners that may change from one product family or platform to the next. Consequently, the software and business processes must be flexible in order to support the partnering and re-partnering activities that are inevitable.

As a networked business model, Adaptive Manufacturing requires network-friendly processes. Since day one, Sun has dedicated itself to building open computing infrastructures that are designed around the network. In the Adaptive Manufacturing environment of the 21st century, Sun offers the platforms and software that can help manufacturers use the adaptive networks as the ties that bind.

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