AME's Vision of *Total Enterprise Manufacturing*

Or "Gazoombah from Three Miles Up"

The fifth in a series on manufacturing future visions.

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Judging by the outpouring of courses, videos, and books on world class performance, Americans should have arrived some time ago. "World class" acronyms like TQM are losing emotional oomph, and "world class" itself has become a sportscasting cliche. Same old games, new stupendous adjectives. No one can keep up with the buzzword blizzard. About the time one is beginning to get a handle on the actual practice of JIT, QFD, or whatever, along come "virtual" organizations, "agile" manufacturing, and "holonic" systems, all with overlapping definitions.

"Virtual" suggests teams and teamwork across the boundaries of functional departments within companies, and across established companies besides. "Agile" is the ability to respond to all kinds of changes very quickly, or turbo JIT. "Holonic" refers to autonomous, distributed systems, whether they are computer networks or human systems. The Association for Manufacturing Excellence has elected to label the collage of concepts signified by these three new phrases as Total Enterprise Manufacturing. (We'll try to avoid the acronym TEM.)

Total Enterprise Manufacturing is an envisioned state beyond TQM, JIT, and employee empowerment. It is made possible by advances from many directions. A one-line definition does not encompass the scope of the vision, nor has any enterprise yet achieved everything that is suggested by Total Enterprise Manufacturing. As good a definition as any is a list of major objectives:

- Minimum time between recognition of a customer need and satisfaction of the need (much more comprehensive than a definition of JIT).
- Giving each customer products and services tailored to his needs at prices competitive with mass-produced, standard products, which is sometimes called "mass customization."
- Fail-safe quality processes in every function and in all operations.
- Environmentally sound products and processes.
- Robust financial margins that permit all stakeholders in the business to improve their quality of life.

To those jaded with "world class," these objectives might appear only to elevate the objectives of today's leading corporations by a notch or two. That's deceptive. The objectives are achievable by combining "excellence" concepts with the potential of advanced telecomputing technology. That the technology to achieve Total Enterprise Manufacturing will arrive in some form is a blue chip bet. Much more doubtful is the human ability to function differently. We cannot foresee all the challenges, but nine are worth review.

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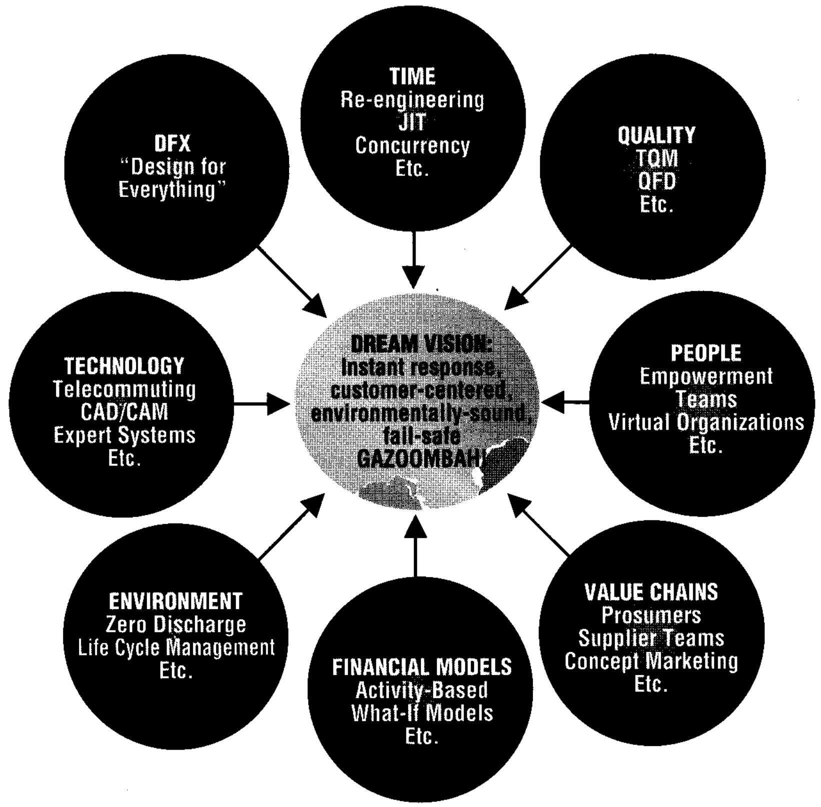

Figure 1.

Challenge 1: Difficulty Integrating a Foggy Vision

Call this a Tower-of-Babel syndrome, the blind-men-describing-the-elephant problem, or simply being awash in a sea of acronyms — we lack a consistent language to describe a big foggy vision and have difficulty grasping it all at once.

The radical nature of the change is best appreciated through case scenarios like the Application Specific Integrated Circuit, the three-day house, or the three-day car.[1] Cases or scenarios integrate different concepts and perspectives into one story. Trying to understand the concepts in the abstract is tough.

Most of us learn a new idea by comparing it with something familiar. Otherwise we experience not paradigm shift, but paradigm lurch — inability to recognize either language or landmarks. It's a matter of perspective: Starting from known territory, we describe the new vision in terms of an old one, which depends on our personal experience. Someone familiar with TQM will describe the foggy vision as an extension of TQM. Someone with a technology and computing background will describe the technical processes and networks, and so on. The environmentalist sees it still differently. Figure 1 attempts to illustrate this condition.

Someone with a limited perspective may be unable to pull in a vision that contains elements from many other directions. One of today's stereotypical persons with this problem is the financial controller who cannot see the value of streamlining processes (an integrative change) unless it can be translated into results projected by today's financial models.

Working toward a different long-term vision of products, processes, markets, and reward systems is different from a continuous improvement process — a series of incremental changes from current status. For example, an electric car might be developed as a "three-day" product made available as a service, rather than sold as product. By technology feasible today, it is expensive even if produced in volume, but it would be very durable. The things might last for half a million to a million miles. So the design could use more durable materials, designed to be re-configurable and remanufacturable. Then "luxury-grade" electric cars can be leased at a cost per mile comparable to gasoline vehicles.

This scenario suggests a different kind of automotive industry with a different technology and service system, and a very different approach to the customer as well. Implementation would break from the current industry — probably a different total industry organization having a different mind set, suggesting innovative entrepreneurship more than an incremental shift in the way car companies now function.

Challenge 2: Concept Marketing and "Prosumerism"

The first sense of concept marketing is developing a radically different concept of how an industry might function and marketing it both to those who might implement the vision — and to those who might finance it. Without a scenario-type vision created in many minds, any specific industry implementation is apt to founder.

The second sense of concept marketing is inducing a customer to participate in the design and refinement of their product. And customers fall into two classes: 1) professional and commercial, and 2) consumer.

In this sense, concept marketing is a two-way street. First one must convince customers to define what they want. Having convinced them, one must then be prepared to adapt. Customers' participation also consumes their time and energy, both of which may be in limited supply. Without concept marketing, a vision for a "virtual" or "agile" product is incomplete, or perhaps dead wrong.

Ross/Flex: A Current Example

Take Ross Operating Valve as an example of working with a commercial customer. This company already uses a process called Ross/Flex to design prototype pneumatic valves with the customers' engineers; the hardware is delivered within days. In this case the interaction is heavily engineer-to-engineer. The major value to customers is finding, with help, a solution to their design problems, which really means that Ross Valve's business is evolving toward participation in their customers' improvement processes. This change is a major shift in how Ross markets — and in the overall strategy of the company.

Consumers' desires for quick fulfillment of orders or their inclinations to participate in defining their own needs are more questionable. For example, the possibility of having a car in three days or a customized Motorola pager shipped in two hours is so exciting that visionaries overlook the equal possibility that most customers really don't much care about that capability. As we know, drastically reducing leadtimes is an indicator that processes have been rid of considerable waste, a benefit indirectly appreciated by customers; but instant delivery may not be a high priority to many of them.

Defining your needs is not easy; it is a learning process. In the case of the three-day house, customers were willing to spend a couple of months off and on designing a house on a CAD system at the sales office to obtain exactly what they thought they wanted and could afford.

However, one of the problems is that the house as built may not always look the way they thought it would on the screen. Improving their visualization using virtual reality may help, but is not likely to eliminate this human problem, which is common in the custom-designed housing business. Many customers are limited in their ability to foresee how a design will look or how it will work out. They want changes later, which implies that flexibility to change a design after it is in use may have a higher added value than rapid delivery of the first version.

For less costly products, the same customers are not as likely to spend as much time and effort describing exactly what they want. For example, it should soon be technically possible for men to order a custom designed suit that is built to exact body measurements the next day. One unknown is how many men will want immediate delivery. Another is how many will actually prefer to design their own suit. A fraction of the market orders suits from catalogs rather than off the rack today. Will catalog buyers simply designate a standard suit to be built in their size? How many off-the-rack buyers will order a custom-fit version of something on the rack? In the end, will the technical capability induce many buyers to order suits with features special to them — unique styles or suits with a half-dozen pockets inside the coat?

Prosumerism — the participation of customers in tailoring their own products and services — is a large unknown. No one knows whether such a market will be limited to connoisseurs, or whether the vision will be shaped by a new movement in customer roles and tastes. In any case, it's wise to begin with a vision that allows for flexibility depending on customer preferences as they actually turn out.

Challenge 3: Rethinking the Basic Structure of Industry

The distinguishing feature of organizing for Total Enterprise Manufacturing is that all operations form as short a stream as possible that directly feeds the customer. In many cases, the stream consists of product design and re-design, not just a flow of material. It is a service network that centers on the end customer, often carrying streams of electronic information that result in the product or service. Another way to think of it is combining and directing the pertinent expertise (or core competence) from many sources on the customer's problems. We do not know how to do this very well because in traditional manufacturing, organization first developed around ownership of the capital equipment rather than exchanges of information.

Traditional organization grew by function, with separate operating companies split up into multiple function organizations, all with vertical control hierarchies. Boundaries between functions and between companies have been marked by transaction systems. It was satisfactory as long as optimizing separate machines and functions could crank out large-scale results.

Cutting across all this has long been necessary in developmental project work, from which matrix management originated. The nature of the problem is not totally new. As concentration on customers has assumed more importance in companies striving for excellence, organizing various kinds of teams to circumvent functional hierarchies has become a favorite exercise.

In industries having less complex supply chains, Total Enterprise Manufacturing processes may be possible by stretching partnership teams across established organizations. For example, Ross Valve's pneumatic valves do not require a long supply chain, nor are their customers today generally organized into huge cross-company project teams. However, Ross' practice of having the same engineer responsible for marketing, production, shipping, and follow-up customer satisfaction is far from common. The organization of Ross/Flex is a major step from business as usual, but if it were as complex as a three-day car, Ross Valve would have had much more difficulty starting it up.

Much of our discussion about "virtual companies" is patchwork to circumvent existing forms of business.

If organizing to concentrate expertise from various sources on customers becomes common, it will force us to push new forms of organization further and rethink the basic structure of industry. What forms of information-based organization allow us to add value to customers, and what is the source of that value? How can we retain the special expertise of functional groups while forming multi-functional teams to concentrate on customers?

The size of organizations is also an issue. If personal service is important, smaller units may be better. A team that is too large is no longer a team. The trend toward smaller, flatter operating organizations started long before Total Enterprise Manufacturing was ready to burst the scene. In time, the organization of an enterprise to concentrate expertise on a customer could well resemble that of consulting companies that cooperate with each other today. That is what they are organized to do.

The organizational revolution will go beyond teams and beyond the current trend toward "Japanese-like" relationships with suppliers. The Japanese companies are at present also stuck with structures and organizations that only promote a lean version of mass production. A customer-focused, "information organization" goes further.

Much of our discussion about "virtual companies" is patchwork to circumvent existing forms of business. A business strategy other than "selling hardware" will hurry the thinking a bit. When we "advise people on solutions" we recognize that companies must start integrating organization with current suppliers and customers — form virtual companies. Then we must move on to tougher issues, such as whether these virtual companies should be more formally recognized, whether they should have a business plan, and whether they should have a single set of accounting books.

Challenge 4: Open System Communication Standards

None of this going to work well unless computer communications work like the telephone system where we simply expect that any telephone can communicate with any other in the world. Communication standards have progressed, but they remain far short of the telephone system standard (which itself is still rather patchy in spots).

The issues go much further than which low level networking code should be used, just as a telephone linkage does little good to two humans who speak no common language. We still have transmission of EDI data that must be rekeyed, transmission of CAD drawings that must be redone on the recipient's internal system, etc.

Some of the issues are human work protocols, like the old problem of engineering design configuration management. That is basically a system to assure that a drawing being used is really the applicable standard or latest revision. A number of persons working on a design in several locations need a system that assures that they are all taking off from the same reference points and that they are not working on two revisions that are going to conflict with each other. Having two people work on the same CAD drawing simultaneously at two remote terminals is a marvelous technical feat, but it does not resolve the problem of change coordination that occurs even if they were working side by side.

Challenge 5: Unique, Economic Designs Made in One Pass

Here we begin to bump into the technical problems of effectively giving the customer something unique. If the product can be machined from a common material using a CNC machine, then no special hard tooling is required. In a sense Ross Valve does this. A valve unique to the customer's requirement is built up around a combination of standard valve components. The unique parts are machined to fit it together.

If the same valve is made in large quantities, costs can be shaved by designing castings that avoid extensive machining of a plain aluminum block. But if the unique valve has a special purpose, or eliminates a messy combination of standard valves, the result is a great saving to the customer, and the incremental production cost is less significant than the ability to modify the product in the field later.

The basic concept of an Application Specific Integrated Circuit is to build it using standard circuitry combinations as much as possible. With a good catalog of such standard modules, an engineer could order some of the simpler cases by scrolling through an order entry menu and transmitting the request. It's a nice concept, but one that appears to be some distance from actualization.

In both these cases, the economy was in not making special tools or equipment before making the product. This concept is a stretch, but ideas have even been floated for designing an automobile that required no stamped body panels — therefore no expensive dies requiring a long time to build and try out. If no one has such an idea, no one will ever work on how it might be achieved.

In any case, if a product with uniquely engineered features is delivered quickly, a rapid prototype is the product itself. Here's where imaginative engineers earn their keep. It also changes the concept of the product and the business. The objective is customer satisfaction — a design or process so versatile that the customer receives a unique output from a fast flow process that has no special hitches in it.

Mass customization becomes much easier the closer one gets to merely manipulating data rather than tools and material. Uniqueness conveyed simply through printed images is deliverable using today's technology.

Challenge 6: Detailed, Flexible Process Modeling

Rapidly producing something unique depends on understanding exactly how to perform each step of the operation. For example, in the "next-day" suit a number of technical problems must be resolved. One is development of a new machine to cut a single layer of cloth at a rate economically comparable to cutting a hundred or more (which is the start of large lot sizes). The other is at each step to instruct the machine or cue the operator exactly what to do to meet the design at each step in the operations. Needed is a more precise understanding of the details of each process than was necessary in mass production, whether the understanding is conveyed by digitized models, or by the interpretation of skilled operators. The Textile/Clothing Technology Corporation in Cary, NC is wrestling with such problems.

Transferring directly from design to production is old hat in CNC machining. In many other operations, including assembly, it isn't. Being able to perform unique operations in a lot size of one in a flow process requires an understanding of the process generally beyond that previously thought necessary. However, this is not totally strange territory. Much of the objective of continuous improvement, however stimulated, causes people to greatly refine their understanding of a process.

The added step is codifying this so that something unique can be understood and performed the first time. And every process has its own quirks. For example, in making a suit, different types of cloth stretch differently.

Acquiring this capability may or may not take a great deal of investment, depending upon how a company has invested previously. If a plant still looks like it did in 1948, it's a long haul.

Challenge 7: Fail-Safe Process Control of Unique Steps

The quality control builds on the ability to model the process so that the machine will stop before a defect is actually made. By using closed-loop feedback control in mass production, millions of parts can be made without a known defect. (Nypro, a plastic molder, is doing it.)[2] Accomplishing this for unique items on a first pass is an "order of magnitude or so" beyond Nypro's accomplishment in degree of difficulty.

Fail-safe control of unique production starts with fail-safe methods in the design process, which may include the customer. Today, it is too easy to download CAD/CAM instructions with errors in it to a machine. Working out the errors in these processes is akin to the now well-known problems of purifying data accuracy in inventory and bills of material in order to avoid having an MRP system belch nonsense. And just as with materials data, the improvement process starts with having a can-do attitude about it.

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Challenge 8: Environmentally Robust Processes

Most product and process designs have environmental implications. Wanting processes to be environmentally benign adds a significant load to the challenges. The ideal is processes that do not have significant effluents, emissions, or throw-away.

If a company has a number of existing environmental problems, they are not likely to go away. The best way to avoid environmental problems is to plan an environmentally sound strategy from the beginning. That is a major reason why much of the new world of Total Enterprise Manufacturing is apt to include re-manufacturing. Re-manufacturing generally consumes less energy than recycling the materials and incurs less long-run environmental risk than sending it to the dump. In addition, a customer-designed, easily-modified product is apt to be kept longer, and a long life cycle of materials use suggests that premium products can be made available at affordable costs.

The difficulty with long-life products is technical obsolescence. Even computers are now designed for upgrade rather than replacement, but at some point, the old machine must go. One objective may be to give customers what they desire as quickly as they want, but technological forecasting is no less important than ever. For example, an ingenious strategy for a long-term, upgradeable, gasoline-powered car could easily be upset by the need to switch to a different power source.

Throwing in the environmental challenge makes the entire package mind-boggling. If one only considers the problem of product design, it is apparent that this new world was closed to yesterday's manufacturers just because of the difficulty of managing competing demands. An engineer could not keep all the conflicting objectives in mind, much less balance them out. Only computer-assisted logic can enable some of the decisions. Unfortunately, addendums to design software that enable environmental assessment are probably some years away, but the time for taking this part of the vision seriously is now.

Challenge 9: Globalization of Total Enterprise Manufacturing

Proponents of agile manufacturing, virtual companies, and similar ideas (Total Enterprise Manufacturing) sometimes argue that this approach will help the United States to keep its manufacturing jobs. Unfortunately, many of the scenarios and actual cases so far belie this argument. Ross Valve has Ross/Flex capability in Germany and is adding it in Japan. Americans are not the only advanced manufacturing country to be working on these ideas.

An advanced capability plant can be operated anywhere the talent and market for it can be found. To the extent that telecomputing enables the approach to be feasible, it also allows it to be communicated with the speed of light. Total Enterprise Manufacturing will be an accomplishment depending more on us than our geographic location.

1. From prior articles in the series in *Target*:
   1) "The Challenges of the Three-Day Car," March-April, 1993, pp.21-29.
   2) "The Other Side of the Black Hole," May/June, 1993, pp. 29-35
   3) "Sekisui's Three-Day House," July/August, 1993, pp. 6-11.
   4) "Enterprise Manufacturing," September/ October, 1993,

2. Pearson, Jim; "Event Report: NYPRO People Deliver Effective Process Control with Seasoned Cpk 2 Measures," *Target*, V. 7, No. 1, spring 1991, pp. 51-53.

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Henry Duignan, Ross Operating Valve Company, was a keynote speaker at the AME 1993 annual conference in Nashville, TN. [TC]^2 also presented and offered a demonstration of JIT manufacturing at the conference. [TC]^2 will host an AME workshop January 20-21, 1994 in Cary, NC (Raleigh area).