THE ROLE OF CONTROL SYSTEMS IN CUSTOMER-DRIVEN MANUFACTURING

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"The industrial era dominated by mass production manufacturing is drawing to a close. It is giving way to a new era, to be dominated by agile manufacturing enterprises."

- 21st Century Manufacturing Enterprise Strategy The Iacocca Institute, Lehigh University

The past decade wrought dramatic changes in the way we all do business. As competition went global, companies decentralized. As customers demanded faster response, new technologies emerged.

In the computer world, systems managers began shifting from mainframe computers to highly distributed networks of desktop computers and file servers. Likewise, in the control world, more powerful microprocessors and smart devices launched control logic on a migration to the far reaches of the plant floor. Both trends were moves to give business greater flexibility.

It's no surprise that as we draw closer to the year 2000, many industry observers are touting "flexibility" — a key component of agile manufacturing — as business' newest process driver, joining quality, cost and delivery requirements.

Recently, the Japan Machinery Federation looked at the coming century's manufacturing requirements and issued its widely circulated *Manufacturing 21 Report.* It called for a new production paradigm: "post-Just-In-Time" manufacturing with great flexibility for change.

Likewise, the Iacocca Institute's *21st Century Manufacturing Enterprise Strategy* concluded that "those nations that focus now on speeding the transition to agile manufacturing will become the strongest competitors in the global marketplace."

Both reports envision the concept of a customer-driven enterprise — a real-time linking of business systems, concurrent engineering, concurrent development and flexible production — as the way to better meet changing customer needs.

Changing Customer Needs

Today we're witnessing the dawn of a new era — the new age of customized products. Consumers want finished goods tailored to regional, ethnic and personal tastes. For manufacturers that means producing a high mix at low volumes. The catch is, today's customers want these products at the speed, quality and cost of traditional mass production.

That was unheard of only a few short years ago, but some producers have already achieved it. Snack food manufacturers are producing potato chips in a variety of flavors: plain, barbecued, mesquite, sour cream and onion. In low-salt, no-salt, or regular versions. Often on the same production line.

Another food producer, a leading cereal maker, develops and introduces adventure-hero breakfast cereals within a few days of Hollywood movie premieres.

In these and other circumstances, flexibility has become a new competitive imperative. It's forcing companies to re-think how they organize, how they design, produce and deliver products. It's also forcing a re-examination of automation control technology.

Once upon a time, choosing an automation supplier was easy. You selected the vendor whose products matched your requirements. But today, no single supplier has everything you need to build an automation system. And chances are, no one company ever will.

Future System Requirements

Customer-driven manufacturing requires many things. It requires engineering to bring products to market faster and manufacturing to perform more rapid changeovers. It requires reusable processes and machines, versatile controls to empower operators, advanced sensors to let you know in real-time what's going on in your processes and advanced control algorithms to give you a sustainable, proprietary, competitive edge.

Allen-Bradley has identified four technologies it sees as crucial to tomorrow's customer-driven manufacturing systems (Fig. 1). But as these sensors, intelligent devices, I/O points and control logic move deeper into the manufacturing operation, as they push decision-making down to individual processes, the need for enterprise-wide integration becomes more and more real.

That raises important issues concerning how automation systems are governed, how devices are configured, how fault management is handled and how information is distributed. Looking at systems in this light, automation components become less and less critical, while the automation *architecture* that supports those components takes on dramatic new importance.

Automation Components of the Future

Allen-Bradley has identified four crucial technologies for the future:

- **Control Logic, such as logic processors, input/output modules (I/O), communications and supporting software**
- **Sensors, indicating attributes such as presence, position or condition (temperature, pressure, etc.)**
- **Man Machine Interfaces (MMI), from simple push buttons to smart displays and computer workstations**
- **Power Devices, including motor controls, motors, actuators and power distribution.**

Overlaying this is the application software that allows an automation system to be physically distributed, but still act as a coordinated whole.

Fig. 1

"The required production technologies are either already here, in embryonic form, or are foreseeable . . . the rapid creation, development, and manufacture of new products requires linking these technologies to organizational structures that can fully exploit their power."

- 21st Century Manufacturing Enterprise Strategy

The Growing Importance of Architecture

Successful management of distributed control depends on architecture, something we define at Allen-Bradley as "a cohesive framework of highly configurable elements, interfaces and services that allow the creation of highly integrated solutions." Architecture knits together the essence of an automation system, both hardware and software.

Why is architecture so important? Because properly planned and configured, automation architecture can help a manufacturer make more efficient use of capital. That's significant because, increasingly, today's financial constraints are no longer being viewed as temporary phenomena. Few companies will be replenishing the ranks they've thinned over the past decade. All businesses are seeking to use and reuse resources — including engineering.

Chances are, two years from now your company will have no more engineers than it has today. In fact, it may have less. And those who remain in your organization should be focused on activities that add value to your product and your business.

What role does architecture play in all this? Consider the hours your people now devote to integrating multiple platforms, multiple operating systems and communications networks. Those hours represent time that's not being spent on your core business. If your engineers are struggling to make one supplier's drive talk to another's man-machine interface; if they're toiling to connect programmable controllers to your mainframe computer, they're not adding any value to your product. That may sound simplistic, but it represents a growing and costly problem.

Engineering Time

NON-ARCHITECTURE APPROACH

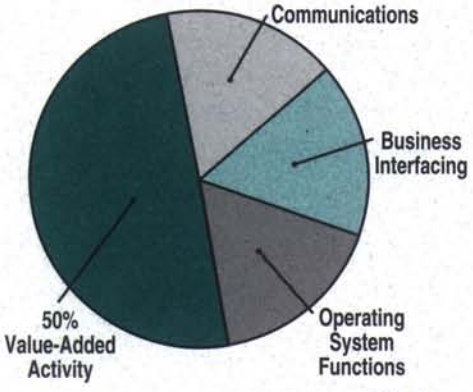

Fig. 2

Increasing the Value-Added Activity

Studies indicate that half of a typical engineer's time may be wasted on this kind of non-value-added work (Fig. 2). But a properly planned architecture, consisting of software tools for programming and configuration, with communications software embedded in all devices, with interfaces for application-specific software — that kind of architecture could minimize integration issues, effectively eliminating them as problems for users.

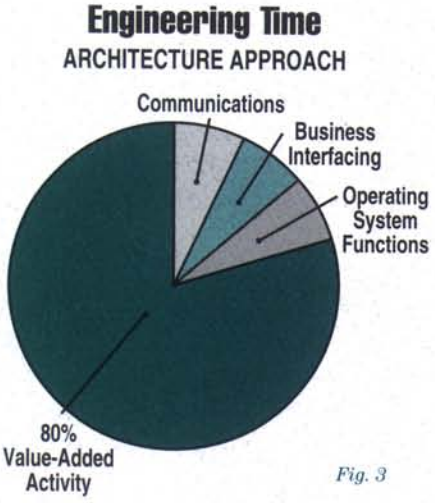

Fig. 3

In fact, some industry observers think a well-planned architecture could boost an internal engineering staff's value-added activity to eighty per cent of its time (Fig. 3).

As competition grows more and more intense, and customer demands for quality, flexibility and customization increase, control architecture must be designed to eliminate integration problems. This would allow engineering staffs to focus on what they do best: adding value to products — creating better cars, better cheese, better chemicals.

That's where Allen-Bradley is headed. We're working on several fronts, diligently exploring the future of automation systems, pursuing new technologies to make control architecture work *for* you.

With our parent company, Rockwell International, we're conducting joint research into technologies crucial to the future of industrial automation: highly distributed architectures, object-oriented systems, intelligent factory control employing artificial intelligence and adaptive control encompassing fuzzy logic and artificial neural networks. Much of this activity is carried out at the Rockwell Science Center, one of the world's premiere research facilities. Its ties to the military and aerospace industries give Allen-Bradley access to the most sophisticated research and development in the world.

Thanks to this relationship, we've embedded fuzzy logic algorithms in a number of motion control products. We've used computer modeling and simulation to design an advanced printed circuit board manufacturing facility. We've employed computational fluid dynamics to predict the flow of plastics in injection-molded manufacturing. We've utilized object-oriented programming to design software. And we've introduced power monitoring products and interactive training and trouble-shooting software — all developed with Rockwell.

Additionally we're a partner in leading technology consortia. Our president serves on the board of the National Center for Manufacturing Sciences, and we actively participate in Sematech and the Microelectronics and Computer Technology Corporation.

These and other activities keep us in the forefront of the latest engineering and technological developments. Developments that can make our customers more aggressive competitors.

But What About Today?

Today's global competition requires organizations that can respond rapidly to changing customer requirements — organizations with more sophisticated manufacturing facilities, and more sophisticated work forces. At Allen-Bradley we've seen this trend reflected in orders for highly interactive man-machine interfaces. Companies need operators to make decisions on the production line, and they want them equipped to do just that. Hence, the wide range of sophisticated operator interface products we now supply to users: intelligent panel systems, user configurable operator interface software, touch screens for real-time graphic monitoring, and more — in addition to simple, reliable ubiquitous push buttons.

Human interface is just one component in the seamless flow of information necessary for agile manufacturing. In the big picture, customer-driven manufacturing requires total information integration, both horizontal and vertical. Horizontally (Fig. 4), programmable controls must integrate with other intelligent devices to distribute control where it's needed. Likewise, vendors' architectures must achieve interoperability so various production systems can communicate with one another. Vertically (Fig. 5), the control and information worlds must also be integrated, so business systems and plant floor control systems have a rapid response link.

This move toward enterprisewide information integration is breeding flatter organizations. One noted consulting firm has

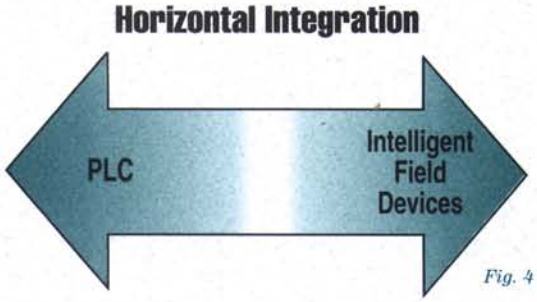

Fig. 4

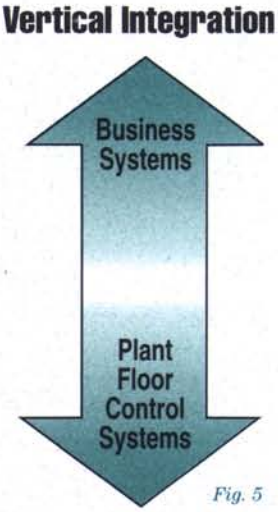

Fig. 5

already replaced industry's five-level pyramid with an operational model containing just three levels: Manufacturing Management, Manufacturing Execution, and Control Management (Fig. 6).

Flattening of the Enterprise

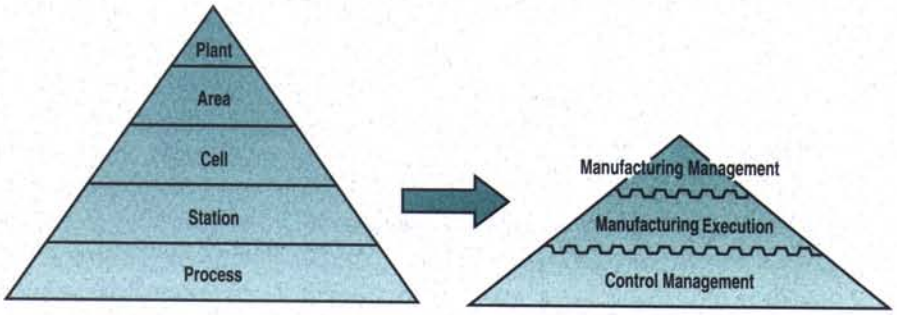

Fig. 6

Whatever shape the future takes, the worlds of control and information can no longer stand apart. Control and information systems must continue to merge into a unified whole for the enterprise to be as agile as possible, as flexible as it can be. Only then, can customer-driven information flow seamlessly throughout the organization, empowering the right people with the right data to make smarter, faster decisions.

Partnering — the Key to Customer-Driven Manufacturing

"The recent increase in the pace of formation of cooperative ventures among traditional competitors, as well as among companies with complementary resources, is symptomatic of the dynamism of agile manufacturing competition already at work."

- 21st Century Manufacturing Enterprise Strategy

Since no single company can offer users every solution, enlightened controls suppliers are turning to partnering. They're forming relationships with computer companies, distributed control system companies, hardware suppliers, software suppliers and system integrators. Sometimes these relationships take the form of "virtual" corporations — organizations which share resources, risks and costs, yet aren't actual physical entities. All are dedicated to bringing application knowledge to bear on customer needs, solving them as quickly and cost-effectively as possible.

Practically speaking, many of today's partnering relationships were inspired by customers who had to react faster to changes in demand. One major customer who brought Allen-Bradley and Hewlett-Packard together requested that we co-develop an easy way for our two systems to interoperate. So A-B worked with H-P to share information, technology and responsibility, and delivered a solution that was advantageous to

all three parties. Similar customers asked us to work with Digital Equipment and IBM. The resulting alliances have helped multiple users more easily integrate their Allen-Bradley control networks with their information systems.

If industry is to achieve greater customer-driven manufacturing, these multi-vendor solutions must become a bigger part of our business culture.

The Tough Issue of Standards

The need for partnering raises the issue of "open systems." Won't open systems permit interoperability and the free exchange of data between the plant floor and upper-level computer systems?

The truth is, none of today's controls suppliers have architectures that are "open" in the purest sense. That's because across-the-board, universally accepted open standards simply don't exist, primarily due to technical barriers.

This is illustrated by the matrix below (Fig. 7). Today, non-standard, proprietary technologies are linked to open standards via networks that are non-standard, yet open. Vendor-specific technologies which are non-standard and proprietary are shown at the lower right. At upper left are open standards such as OSI/MAP, UNIX in its several variations, VME, and others. Acting as the interface between these two groups is the upper-right block: non-standard, yet open networks.

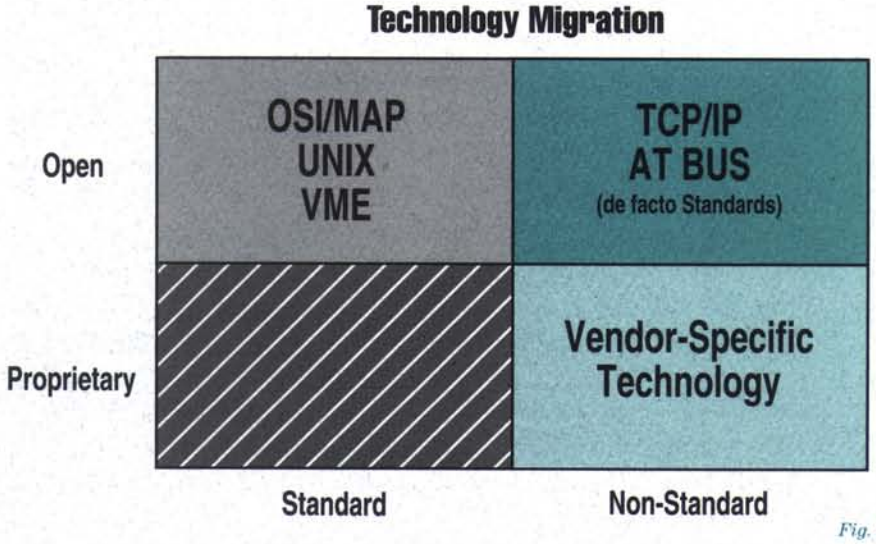

Fig. 7

While Allen-Bradley is committed to the concept of open systems, the customers, analysts and experts we've consulted agree: there's little chance these network options will soon evolve into a single universally accepted open standard. Therefore, controls companies must strive to meet their customers' needs by developing systems which can function on a variety of networks.

To that end, the philosophy of Allen-Bradley is to be open at the top, open at the bottom, and performance-based in between.

At the bottom of our controls network, technology licensing helps independent companies with application-specific expertise to develop products matched to our customers' needs. So far, more than 48 licensed companies are manufacturing robot controllers, welding controllers, vibration analysis systems, weigh scales and other technologies that are tightly linked to Allen-Bradley's architecture. As a matter of fact, we have more third-party companies tied into our architecture than any other automation controls supplier.

At the performance-based level, while many of our products were developed before open systems, and are, therefore, considered de facto standards, we treat them openly. For example, in the late 1970s, when we developed the first Data Highway™ local area network for a customer, no industrial communication standards existed. So we published access specifications to let other companies interface. This "openness" eventually benefited thousands of users in multiple industries.

At the top of control architectures, the newest interoperability strategies include standard Application Programming Interfaces (APIs), like Allen-Bradley's INTERCHANGE™ product. APIs make vertical integration available at a reasonable cost by offering software tool kits that greatly decrease development time when implementing connectivity between UNIX, DOS, VMS or Windows platforms and the control systems.

Bridging the Gap

These and other solutions are helping users bridge the gap between the present and the future. And if they are properly conceived and developed, these solutions can help customers pursue a path that delivers the maximum return from their current technology investments. In fact, during this transition period, protecting a user's current investment should be the key consideration for any controls company. Allen-Bradley is committed to developing the control technology of the future with this in mind.

How Can You Plan Your Future?

What can you do as a manufacturer — a user of automation technology — to plan your automation future? A few words of advice:

Envision what you need to succeed. Create a picture in your mind of your company's goals, projections and marketing strategies. Let this long-term view drive all your planning and decision-making.

Think in terms of architecture, not automation products. Don't evaluate an automation supplier on individual technologies — on hardware, software, or intelligent devices. Instead, concentrate on the system you need to achieve your goals. And select your partners accordingly.

Focus internal resources on enhancing the quality of your product. Prioritize your key value-added processes and allocate internal resources to them. Focus your engineers on making better products, not better connections. If others can supply some services better, purchase them on the outside.

Select an open-minded supplier. Choose a controls supplier that's open-minded, easy to partner with, responsive to your needs. A supplier that opens its architecture to multiple hardware and software vendors — even to competitors, if necessary, to meet your needs.

Plan a migration strategy. Work with your supplier to develop a road map for where you want to go, and how fast you want to get there. Make sure the resulting strategy reflects your needs, your requirements.

Customer-Driven Manufacturing — Responding Like the Human Body

The goal of customer-driven manufacturing is a company that makes decisions much like the human body. When you're driving on the freeway and find a semi-trailer truck coming at you, your reaction must be immediate and automatic. In other cases, your actions require thought, reflection and input from more knowledgeable, experienced sources. The same holds true for manufacturing. Some reactions must take place immediately, while others require higher-level input.

As a manufacturer, your immediate actions are dictated by your customers. Customers who are making more and more buying decisions based on "customized" needs. Your company's agility — the degree to which it can respond to these needs — will determine its success or failure.

Finding the Right Supplier

Automation control systems play a crucial role in this brave new world. That's why charting the best, most efficient route to customer-driven manufacturing should be a joint effort with your controls supplier.

The "right" supplier will be a true partner. Someone who looks out for your interests. Whose strategy protects your current investment. Who takes you to the future, by building on the past.