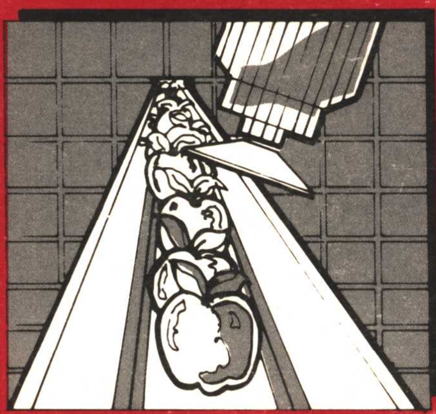
Food Processing Automation

Proceedings of the 1990 Conference



MAY 6-8, 1990
HYATT REGENCY, LEXINGTON
LEXINGTON, KENTUCKY

American Society of Agricultural Engineers

ASAE Publication 02-90

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Published by
American Society of Agricultural Engineers
2950 Niles Road • St. Joseph, Michigan 49085-9659 USA

Library of Congress Card Number (LCCN) 90-81324
International Standard Book Number (ISBN) 0-929355-06-7

PREFACE

The Food and Process Engineering Institute (FPEI) was formed in June 1985 by the American Society of Agricultural Engineers to serve worldwide technical personnel involved with the application of engineering principles to the processing, handling, packaging, storing, and distribution of food, feed, fiber and other biological materials. The FPEI organized this national Food Processing Automation conference for the technical and management personnel in the food industry with the objective of improving information transfer between food processors, food equipment manufactures, food handlers, and university/government personnel. The conference focused on three areas of automation technology: sensor technologies, automated inspection systems, and computer-operated controls.

The conference goal of improving information transfer was accomplished through four formats: twenty-eight speakers working on the forefront of new technologies were invited to make formal presentations during the two-day meeting; twenty-five university and government research and development personnel were invited through a call for papers to present recent developments which have potential applications in the food industry; selected industrial developments of automation equipment, software, etc. from vendors were exhibited; and lastly, the technical program was packaged into these proceedings (available at the conference), which includes papers from speaker presentations, poster session papers, and a listing of exhibitors.

The conference focus on sensors technologies, automated inspection systems, and computer operated controls was based on a survey of technical personnel in the food industry. Recent advances in integrated circuit technology has led to the development of sophisticated sensing systems for use in the food industry; machine vision has expanded its applications in the food industry, particularly in quality control; and advances in automation and control of continuous and batch processes, both in hardware and software, has progressed rapidly. The conference covered these areas and concluded with a session on future technologies.

The co-program chairmen, B.L. Upchurch and D.P. Bresnahan deserve special recognition for organizing the program and soliciting qualified speakers.

Fred A. Payne
Conference Chairman
Associate Professor
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Table of Contents

INDUSTRIAL AUTOMATION IN THE 1990s
A VIEW FROM TEXAS INSTRUMENTS

Jodie N. Ray
Executive Vice President
Information Technology Group
Texas Instruments Incorporated

The 1980s have been very challenging for Texas Instruments. Our dramatic growth, which derived from silicon transistors and our subsequent invention of the integrated circuit, has slowed. The competition became so tough, that we are the only surviving major supplier of dynamic random access memories in the U.S. competing with Far East suppliers.

But if you thought all of us faced many changes during the Eighties, just wait for the Nineties. The rate of change in all aspects of manufacturing is accelerating. Accommodating dynamic changes and learning to continuously respond to those changes with customer-perceived improvements is the greatest business challenge for the Nineties.

Plot the rate of change in almost any technology in the past three decades, and you will see the acceleration: whether computers, automobiles, consumer electronics, or even food processing. Add to these the rate of changes in the broader environment of world economic conditions, political positions of countries, regional competitive advantage, regional markets, etc. Change is inescapable. It impacts the U.S. manufacturing and process industries in new and unexpected ways each day.

The challenge is to adjust our business process to accommodate and leverage these changes as they occur. At Texas Instruments, we are addressing the next decade in a very proactive way. We are challenging our business processes in every major part of the corporation. We are re-evaluating market dynamics, competitive advantage, and a range of potential industrial automation strategies.

We have discovered consistent agreement between the requirements of our own plants and those of our major customers. Competitive pressures demand that we address the following customer-driven needs with our industrial automation approach:

1) Quality and consistency in the production process as well as the product,
2) Response time in bringing new products to market and in meeting on-time delivery commitments,
3) Flexibility in product changeover and in balancing variations in mix among product families,
4) Total productivity including indirect costs over the process life-cycle not just recurring direct cost,
5) And continuous improvement since benchmark world-class performance for each of the above needs is a moving target.

We have come to realize, particularly in the past decade, the importance of a quality culture to complement the quest for these attributes. Total quality is interwoven with these competitive issues, and it is the proper foundation on which to build advanced automation strategies.

In the past decade we have been very aggressive in pursuing a Total Quality Culture (TQC). It has helped us greatly in dealing with competitive pressures and dynamic change.
As we have evolved our businesses and their processes, we are striving for TQC using three principals:

1) Customer Focus - Understanding what the customer needs and wants, then translating that into every job that can add value for the customer in both product and service, and, therefore meeting, or even exceeding, his expectations,
2) People Involvement and Development - Never underestimating people involvement and interorganizational team activities, as well as education and development of our people,
3) And Continuous Improvement - Never being content with any level of achievement; understanding and anticipating our best competition; always reaching for a higher goal against a tougher benchmark.

More and more we are sharing our experiences in this approach with our key customers to complement their automation strategies and to help accelerate their competitive advantage. We are fortunate to be recognized for our progress through many awards in recent years. Some of them include:

1) In 1985, recognition as the first U.S. company whose subsidiary in Japan was awarded the coveted Deming Prize,
2) In 1987, selection by the Society of Manufacturing Engineers for their annual LEAD Award for best application of Computer Integrated Manufacturing,
3) And in 1989, selection by Electronic Business magazine for their Electronics Factory of the Year Award.

But where we go from here is a more important issue. We believe a combination of our TQC thrust with some new ideas about automation and information management can greatly enhance competitive advantage across the total life cycle use of production systems.

We believe that real-time control and information management will become more comingled as business processes are made more competitive. To respond to this trend, we have formed a new Information Technology Group (equivalent to our Semiconductor and Defense businesses) to address exactly that. It includes, not only Industrial Automation, but also our other computer related businesses in Computer Aided Software Engineering (CASE), commercial applications of networked mini-computers, symbolic processing software, printers and hand-held terminals, etc.

Our concept includes a very broad definition of Computer Integrated Manufacturing (CIM). Its impact spans horizontally from our suppliers through to our customers while touching all aspects of the process in between including engineering, product design and order entry systems. It comprehends the vertical dimensions of information and control from corporate or plant systems through operations down to area or cell supervision to real time control on the plant floor that tie our machines and material flows into integrated production operations.

The progress being made in Electronic Data Interchange (EDI) is one example of the increasing importance of integrated information. TI was recognized in 1989 by Yankee Group as EDI User of the Year for our work in this area. Our current status is:

1) 10% of our customer orders are electronic ($3M/day)
2) 50% of orders to suppliers are electronic ($4M/day)
3) 72% of our incoming freight bills are electronic (900/day)

In addition, our concept addresses the life cycle aspect of a major production capability. This cycle typically includes product and process definition, implementation on the plant floor and production support from commissioning through upgrades across the production system's total life.

This concept supports concurrent design of the process, along with the product, using Computer Aided Software Engineering (CASE) tools. After commissioning, it not only addresses stabilizing the manufacturing process, but also optimizing it using Statistical Quality Control (SQC), Statistical Process Control (SPC), and expert systems. Further, this concept extends through the critical production support issues of diagnostics, maintenance and training over the useful life of the production systems.

We have now had two years experience with using a CASE tool to define production processes using graphical icons. This tool documents the design automatically and has a backend compiler to automatically generate the machine code required and download it into the Programmable Logic Controller (PLC). It has dramatically reduced application software cost and cycle time through commissioning while improving the software quality and support.

Improvements in the core production process are being achieved using expert systems and new intelligent control concepts. The Calgon Corporation has embedded their expertise on chemically balancing industrial cooling water systems in a special co-processor we offer in our standard PLCs. Thousands of rules covering hundreds of diagnostic situations are addressed. We have effectively demonstrated an expert system inside the control loop.

In other examples, we have progressed beyond SQC control of the product and SPC control of the process capability to discovering new knowledge about the process which can be used to optimize it. In an internal TI wave solder process for electronic board assembly, we used Taguchi methodology to harvest 97% of the remaining yield loss after the process was stabilized by traditional control methods.

Reacting dynamically to inevitable production schedule changes is also an optimization issue and an important competitive advantage. By running continuous simulations of our worldwide semiconductor production flow, we can confirm most purchase orders with a commitment date within two seconds (using EDI or while the customer is on the telephone). Moreover, this commitment date is typically well inside our standard production lead time.

In the area of production support, we are working on concepts using emerging technologies to improve diagnostics, maintenance and training. Knowledge based expert systems can be very effective in troubleshooting complex systems. Portable, hand held, real time information-access at the point of need will greatly enhance maintenance. The combination of both can deliver repair, maintenance and calibration procedures to refresh training at the time of need. We call this Just-In-Time training.

What does all this life cycle optimization and support really mean to our bottom line? One can argue at length about the absolute numbers. The important point is that most of us realize the true life-cycle cost of a manufacturing process is much greater than the cost of the automation equipment itself. And there are significant potential savings in this area in addition to the normal productivity and yield savings associated with ongoing production.

The up-front manufacturing process planning and requirements analysis in the definition phase is the most crucial step. A good job here will allow the operation to be commissioned in a highly productive state and avoid costly iterations throughout the life cycle. But the cost of design, documentation and implementation of the manufacturing process can be even larger during this definition phase. These costs combined can be double the purchase price of the production systems, or more. We think they can be greatly reduced through use of computer-aided development systems. In early applications in the batch-hybrid process segment, for example, our Applications Productivity Tool (TM) CASE product has saved more than the cost of the automation equipment.

However, our largest opportunity is the area where expert systems were first applied. Over the life of the installation, the production support costs can be three times the equipment cost or more. The challenge is to make production support systems more on-line and usable by our larger population of operators and technicians. The idea of electronic access to schematics wiring diagrams, pneumatic diagrams, process flow charts, control code lists, repair manuals, etc., is realizable today. This area of production support is where TQC and continuous improvement can bear the greatest ongoing dividends.

In summary, we are entering the 1990s at TI with major resources focused on advanced automation as a major competitive advantage. We have a rather unique range of products and services from industrial controls at the plant floor with embedded processors up through more complex distributed control systems and supervisory control and data acquisition systems serving the process industries as well as the discrete manufacturing industries. But what we are most excited about are the emerging technologies of Computer Aided Software Engineering, expert systems, dynamic scheduling, hypermedia and other information technology and decision support tools. These will have dramatic impact on exceeding customer expectations in the 1990s.

We feel the major challenges of the 1990s for our own plants, as well as those of our customers, are:

1) To assimilate new concepts and technologies across the complete product life cycle,
2) And to achieve and maintain a "best value" position in the customer's mind on a continuing basis.

Our Industrial Automation Division and our Information Technology Group are dedicated to these objectives for ourselves and our customers. We feel these will be instrumental in helping us meet our TI corporate goal of achieving "customer satisfaction through total quality."

NEW TECHNOLOGY:

ITS STRATEGIC ADVANTAGES AND JUSTIFICATION

Thomas D. Archer
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Worldwide, the most profitable, aggressive manufacturing organizations develop clear operational strategies to exploit technology, and optimize their use of capital. Traditional manufacturing organizations tend to invest, at levels based on historical precedent, in technologies that largely replicate current operations and are not linked to operationally strategic opportunities.

It is common to see manufacturing companies operating at twenty-five to forty percent of the productivity of their world class competition. Inefficient plants have two to as much as twelve times the floor space and equipment of their best competitors. This is common, even in highly automated, state of the technology, operations. These organizations tend to isolate their investments from their corporate strategies, using mechanistic methods for justifying those investments. Conversely, successful companies develop, sometimes unconsciously, operational strategies that tightly link their investments in technology and people to their corporate strategy and markets.

For these purposes, technology is defined simply as materials or recursively applied tools. The tools can be hardware or methods, including those implemented through computers. New technology is technology that is new to the users. "New" is not intended to either preclude or imply "high-tech." For example, statistical process control (SPC) and Computer Numerical Control (CNC) machine tools have been around for well over twenty years, but have penetrated less than twenty percent of the domestic market. To many companies, these would represent "new" technology.

THE ROLE OF TECHNOLOGY

Technology is part of the package of tools used to iteratively formulate and implement an operational strategy. Far too often technology becomes an objective. When the focus is exclusively on the technology, the technology will fail. Perhaps it will not fail in a technical sense, but it will fail to contribute at maximum effectiveness and efficiency to the organization's operations and profitability.Indeed, in some cases, when the focus is only on the technology, when technology becomes the apparent objective, the technology does, in fact, fail completely.

The emphasis, the point of concentration, and management's unwavering attention must be on the *benefits* of the technology, on the contribution of the technology. Do not just *buy* technology, *invest* in what it does for the business. In the typical scenario an opportunity or problem is recognized. Then, a technical solution is identified. Too frequently, that solution quickly becomes *the* solution without serious evaluation of alternatives or even an in depth understanding of the problem, the opportunity, or the implementation issues. The technical solution becomes the objective as the implementation is delegated to remote parts of the organization. Finally, with technology as the objective, the project gets out of hand, over budget, and behind schedule; it may never serve its original purpose. We saw this in the late 70's and early 80's with the rush to robots, then to flexible manufacturing systems (FMS), and currently in the charge toward Computer Integrated Manufacturing (CIM).

The leverage, and benefits of these technologies, is unquestioned, but only to the successful companies that focus on the value derived from the technology. They drive for the strategic advantages and constantly evaluate their implementation against strategic and operational objectives.

It is important to recognize a difference between *corporate* strategy and what is fair to call *operational* strategy. From an operations perspective, the management assumptions about a company's ability to exploit technology are rarely realistic. Management's view of technology tends toward the extremes being either technophobic in its pessimism and apathy, or technophillic in its optimism. Sweeping decisions, pro and con, are often based on invalid, usually unstated, assumptions.

Developing a successful operational strategy is an iterative task, particularly with respect to technology. Recognition and formulation of opportunities requires a thorough understanding of the business environment and an intuitive grasp of the feasibility and benefits of a wide range of technology based tools. Ideally, the technical perspectives will be driven by staff with experience in developing, implementing and operating "new" technology, not just purchasing it.

STRATEGIC ADVANTAGES OF TECHNOLOGY

The benefits of technology are its justification. These are inseparable issues. From an operating perspective, there are five broad categories of technology benefits:

- Increased resource utilization
- Improved product quality
- Risk reductions
- Faster transformation velocity improvements
- Compliance and arbitrary objectives

As each of these categories is briefly explored, consider them not only as a benefit of the technology, but as a point of justification in light of the technology's potential to contribute to achieving strategic objectives.

<u>Increased resource utilization</u>

- Lower direct and indirect labor costs
- Increased machine capacity and availability
- Smaller facilities (i.e., bricks and mortar)
- Reduced inventories
- Reduced management requirements
- Reduced overhead expenses
- Reduced capital equipment/facilities
- Reduced "engineered" scrap
- Increased flexibility.

Improved product quality

- Improved product consistency
- Higher net process yields
- Reduced field failure/service costs
- Increased product reliability
- Reduced inspection/test requirements
- Reduced operational "firefighting"

Risk reductions

- Reduced "artisan" dependency (both direct and overhead)
- Improved plant safety
- Improved assurance of feasible schedules and resource availability (no surprises).
- Reduced/eliminated environmental problems
- Reduced market risks
- Reduced materials risks

Faster transformation velocity

- Shorter product development cycles
- Faster order entry and processing
- Shorter production lead times
- Shorter production cycles
- Smaller economic production lot sizes
- Improved exception and contingency handling.

Compliance and arbitrary objectives

- Meeting regulatory requirements
- "Wish List" satisfaction

These strategic advantages are precisely the justification for technology. Every proposed technology should be evaluated against its total contribution to operations. Typical organizations focus only on identifiable savings in direct costs, without serious attention to the other advantages, including revenue enhancement. The larger the company, the less likely it is that projects will be considered that do not meet certain financial goals--frequently a twenty to thirty-five percent rate of return, again usually based only on direct cost savings. At least two Fortune 100 companies frequently limit analysis to direct labor savings. Companies that are willing to address other benefits rarely are even moderately thorough. Justifying technology on the basis of these strategic advantages is a management issue, not an accounting problem. When decisions are made on such a mechanistic basis, the tool has become the manager.

Our current operating, accounting and marketing practices make many of the strategic benefits of technology difficult to quantify, but that does not change the underlying reality of the benefits. The benefits are real and they have economic value to the markets. Frequently the value is not recognized until a competitor demonstrates it. The management issue becomes one of recognizing value and not assuming that it is not real. Twenty to thirty-five percent return on capital assets is not impractical unless limited to direct costs.

Too often we do not know our true operating costs, so identifying improvements becomes more or less a marginally successful effort. We make decisions based on cost accounting data as though it had absolute meaning.

We look at cost information and assume that it means what we think it means, but it usually does not. Usually such information is grossly incomplete and often misleading. Therefore, it is not surprising most profitable companies we have worked with make their management decisions based on unallocated costs.

Justification efforts frequently focus on changing the variables in discounted cash flow models. "We need longer payback periods," is one argument. "Why do we demand twenty-five percent return on capital equipment when the whole corporation only earns six percent on assets?" There are certainly cases where eighteen to twenty-four month equipment amortization periods are ridiculous, but generally, reasonable returns of twenty percent on operating investments should be recovered in under a three year horizon, frequently well within a conventional eighteen to twenty-four months.

We have found that when organizations know that their competitors have purchased, are developing, or are considering new technology, the justification and analysis process becomes dramatically more urgent. In some cases, the fact that their competitor has technology is sufficient without further analysis. In today's markets, the best assumption may be that our international competition has the technology. Frequently they do.

We have found no magic, mechanistic procedure to justify technology. It is not that conventional discounted cash flow models will not work if properly applied. But when artificially constrained to apply to only limited variables, such as traditional direct costs, it is not the model that is defective. Major investments in new technology tend to be irrational rather than analytical, but that is not necessary or recommended. Technology does not have to be risky. It has to be managed. Software does not have to be late, and it does not have to be over budget. We know how to manage technology but we frequently choose not to. But regardless of the management technique, if technology cannot be justified, *don't do it*.

Although we have not yet learned how to quantify many of the benefits stemming from technology, it is practical to make dramatic improvements in current practice. Consider an actual example: tooling procurement cycles for automotive stamping tooling is about half the time for some foreign based producers as for certain domestic car manufacturers. The foreign producers have worked in partnership, investing in technology with their tooling suppliers. The obvious benefits are shorter lead times, but how do you put a value on shorter lead time? The cost savings come first from dramatically reduced costs associated with tooling changes mandated by late product design changes. Although these costs, based on historical precedent, are straightforward to estimate, the more subtle, but far more dramatic savings are actually found in operations. Every tooling modification represents a compromise. Through the iterations of product and tooling changes, the tooling can become difficult to use in practice. It can be made to work, but the process is unforgiving, usually generating a lot of rework, sometimes on every part. In many cases costs might even justify completely replacing the tooling, but the procurement cycle is so long that the part is obsolete before the tooling can be ready. The result: rework has become institutionalized in most domestic plants and is not even tracked as a separate cost.

Shorter tooling procurement cycles have major impacts on productivity and plant capacity. The benefits are identifiable and have real, calculable costs associated with them. They do not automatically appear in our management cost reports as a line item "cost of long tooling procurement cycle," so they may not be recognized. Only after world class competitors have succeeded does it attract our attention, possibly too late.

The most frequent omission when we assess operations technology is marketing. The issue in marketing is not satisfying a customer's needs; the issue is and always has been: "what will motivate a customer to part with his money?" In the case of capital equipment, a customer may not be willing to pay more money for a faster delivery, but they may be willing to "sign the order" for faster delivery. That may translate into, say, a fifteen percent increase in sales over a year, which means more profit and reduced overhead allocation per machine, leading to lower prices followed by a further increase in orders. It is a classic cycle that simply serves as one small example of the leverage available from good marketing involvement.

Unfortunately, marketing usually is not involved in operating technology justification. In the previous example, marketing knows better than to ask for better delivery. They have done that in the past and been verbally castigated, abused and derided for being presumptuous and naive. Operations is afraid to ask marketing if there is any value to faster delivery because they know marketing will start making commitments immediately.

Justification is a management issue, not an accounting procedure; it frequently needs marketing involvement. Justification is a process that should be based on a view of the entire enterprise. All benefits and costs should be identified, with financial objectives treated as only one of many elements. In today's world markets it is best to assume your competition has the technology, because it does, and perform a technology reality check. Remember that the strategic advantages of technology are resource utilization, quality improvement, risk reduction, and increased transformation velocity. These strategic advantages must be the justification for implementing new technologies.