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Eight Steps to Simultaneous Engineering
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A solid game plan can help you avoid pitfalls when you radically change the way you do business

Even though simultaneous engineering (SE) is one of the most effective ways to improve manufacturing operations, it cannot be bought or sold. SE means simultaneously designing a product and defining the best way to make it. Companies must, therefore, develop an SE plan from within to exploit their business and organizational strengths.

Although startup costs for training, coordinating efforts, and computer hardware and software are high, long-run costs are lower because product designs are simpler and faster to make. Justification for an SE program comes from reducing direct labor costs, cycle time, inventory, scrap and rework, warranty, and engineering changes. SE improves overall competitiveness.

In attacking manufacturability-related problems, management must use all applicable technologies and operating philosophies. Two vital areas are computer-aided design (CAD) and manufacturability assessment. Management must apply support technologies to use time and resources effectively, and it must monitor them regularly to ensure their usefulness to the organization.

Without adequate leadership from management and a general understanding throughout the company, however, SE will fail. To ensure success, create a clear-cut written plan as the primary reference for launching the program and providing ongoing support. The plan must state the objectives and describe how to accomplish them. Its elements should apply to the appropriate levels within the organization and name key players by position and, if possible, by name. The plan should also

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identify the key resources for support, including personnel, computer systems, and operating budget.

Before implementing an SE program, check your firm’s capabilities and resources. Outside sources can help ensure an objective and accurate appraisal, which should include the following:

- **Operating environment.** This means the company’s culture, quality programs, continuous improvement programs, customer and supplier involvement, and training and recruiting practices.
- **Current practices.** Engineering and manufacturing standards and other company policies and procedures make up current practices.
- **Design reviews.** Appraise them according to their purpose, frequency, and perceived effectiveness. Many companies know SE by another name, “design for manufacturability” (DFM), and tend to think of it as reviewing a product design to evaluate manufacturability in a particular factory. Manufacturability then tends to mean “degree of difficulty” rather than “simpler design.”
- **Computer systems.** Key computer systems applicable to SE include computer-aided engineering, CAD, and computer-aided process planning.
- **Manufacturability technologies.** Such technologies support assessing manufacturability, standardizing product, reducing part count, simplifying designs, identifying physically and functionally interchangeable parts, establishing robust manufacturing processes and product designs, increasing reliability, and shortening design time.

Since every business has its own unique combination of market, product mix, and manufacturing environment, customize the plan—one size does not fit all. Here are eight ways in which manufacturing-oriented businesses can achieve their SE goals.

**Step 1: Involve Manufacturing**

Early involvement means providing a formal mechanism for manufacturing to work with marketing and design from the start. It fosters a proactive rather than reactive atti-

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**Machine Builders — A Critical Addition to SE Teams**

“By some estimates, changes currently consume 45% of all product design time, suggesting companies design parts twice,” observes Robert Eitzinger, president, Mid-West Automation Systems Inc. (Buffalo Grove, IL), an automated assembly machine builder. In an era when some US firms must compress product development cycles by as much as 70%, manufacturers must rely on techniques like simultaneous engineering to boost design efficiency.

While most manufacturers acknowledge that SE can recover much of that lost time, they often overlook an important contributor: the outside supplier. “Perhaps the most intricate outside relationship to establish,” Eitzinger continues, “is one with builders of automated assembly machinery. They must deal with all the pieces—including those from other suppliers—to devise the best way to put them together.”

Assembly machine builders offer a different perspective than other SE team members. “For example,” Eitzinger offers, “they are likely to be the only ones to look for reference dimensions—those measurements and surfaces that make little difference to the product’s performance or appearance but are critical to feeding, tracking, orienting, and fixturing for automated assembly.” Experienced machine builders can also help streamline missing part detection and in-process testing.

If design considerations like these are overlooked or omitted for economy’s sake, they are very likely to be added later. That, however, only raises cost and slows new product introduction. By raising these concerns early in the product design process, the machine builder can help avoid such oversights.

Including machine builders in the SE team pays dividends in other ways too. Seemingly minor alterations in part configuration or assembly sequence sometimes result in fewer and simpler machine stations, thus reducing complex and costly fixtures, floor space, maintenance, tool wear, and spare parts inventories. Early alterations might even help the machine hold closer tolerances. The machine builder can also shorten production timetables by refining interim tooling, hand fixtures, and assembly procedures while turning out preliminary product samples for testing.

Saving this time is possible only when manufacturers forgo traditional multivendor bidding in favor of long-term joint venture relationships with builders. “Eliminating the bidding process alone can shorten machine development time by six to eight weeks (the time typically required to develop the conventional machine proposal and bid),” Eitzinger explains. “What’s more significant, by allowing machine development to begin earlier and evolve with product development, the no-bid relationship can shave four to six months off delivery lead times.”

A no-bid joint venture relationship, though, can be a frightening step for both sides because it requires a trust uncharacteristic in US user-vendor relationships. Both builder and user must work with “ballpark” projections—which can change weekly or even daily—rather than firm quotes. Both must delegate authority so that lower levels can make decisions, allow a common team objective to drive them, and commit time and money when the product design may amount to no more than freehand sketches.

Very often this approach will have a high initial cost but will provide time gains, quality improvements, and other operational benefits that are worth far more than any savings on initial machine costs from the conventional bidding process. “You might not save money on the machinery,” Eitzinger points out, “but you will save money by cutting engineering and administrative time normally lost in redesigning the product to solve production problems. And you’ll make more money by getting the machinery into production sooner. “Studies suggest that if a technology-based product comes to market four to six months late,”
tude toward manufacturability opportunities. When manufacturing works with design, marketing, and the customer from the beginning of the design cycle, the company can respond to customer needs better and make more orderly transitions in the prototype and design phases.

Some companies rely on design reviews to solve manufacturability problems. All too often, however, schedule conflicts delay or preclude them. And when marketing, design, manufacturing, quality, and management finally do get together, the emphasis is usually on whether the design meets customer expectations and whether manufacturing can make it. Manufacturability design improvements are often identified too late.

Step 2: Involve Employees

The more people aware of a problem, the more people available to solve it. Given the right information, design and manufacturing people will frequently devise unanticipated, novel solutions because they know their part of the business better than anyone else. And an employee participation program can boost morale and interpersonal communication throughout the company, which creates the environment necessary for SE to work.

One way to get employee feedback is to conduct an oral survey, in which an SE team member identifies relevant people and asks them about problems with past products. Machine operators, process planners, and field service personnel can be instrumental in pointing out problems often unknown to the rest of the company. Another way to get feedback is for the SE team to hold joint meetings with various departments to solicit their input. Once the team finds problems, it must then examine options for correcting them.

Employee participation often yields critical information and is financially helpful, but employees need to know that someone is really listening to and considering their ideas and suggestions. Management must be receptive to new ideas, must be flexible enough to implement them when justified, and must project a “can-do” attitude. It must also recognize that an employee involvement program

Bob Eitzinger inspects an assembly system module that monitors inner and outer diameters of a circular part, rejecting those that are out of tolerance.

he continues, “It will earn up to 33% less profit over five years.” By contrast, coming to market on schedule with a 50% cost overrun will cut its earnings by less than 5% across that five-year period.

Establishing a joint venture SE relationship with a machine builder is not easy, however. Many builders are reluctant to work without the protective structure of conventional bid contracts. “Many design engineers, especially the more experienced ones, have difficulty working without all details defined-including budget and timetables—before the engineering work begins,” Eitzinger notes.

When searching for potential builders, compare them on the basis of technical capability, “track record” with systems like the one you want, and financial strength. Track record and financial strength are easy to check, and the builder should be ready and willing to provide references. Technical capability is not as easily documented, but it often becomes apparent during the initial exchange of engineering data.

An important step is to designate a coordinator on each side of the project’s task force. “Obviously, both team leaders must be ‘on the same wavelength’ and have good personal chemistry,” Eitzinger says. “Clear communication, with ready access between companies, is possibly the most important element in the time-driven SE environment.” If your engineers work on a CAD system, link it with the vendor’s CAD system via phone lines.

It is helpful for the builder to have worked with accelerated development programs where small teams of innovative and experienced craftsmen develop machines on their own without the red tape of formal planning and committee approvals. Also desirable is a willingness to focus on components that need custom development or precise dimensioning. According to Eitzinger, most machines can rely on many standard components, and builders who use them whenever possible minimize both engineering and debugging time because such components are already refined and proven.

But before SE can work, it must have the full support of the builder’s and user’s top management. Make sure your builder partner shares your commitment. “In the last decade, US manufacturers learned that automation can dramatically improve product quality and profitability,” Eitzinger concludes. “The question for the ‘90s is not whether to automate but how quickly can we integrate automation into new product development.”

—James R. Koelsch
requires discipline, commitment, and daily attention.

Most employees want to improve the company's competitiveness and are very effective when given the chance. The program should credit not only those few whose ideas yielded the highest returns. There should be rewards at all levels and types of participation. The National Association of Suggestion Systems (230 N. Michigan Ave., Chicago, IL 60601) can help companies start employee involvement programs.

**Step 3: Increase Cost Awareness**

Involves both shop and office workers in the cost reduction program. Some people will know about cost problems or sources of manufacturing variability that are invisible to others. An initial Pareto analysis can help identify the most significant problems so the organization can focus its collective effort on them first. Ishikawa, sometimes called fish-bone, diagramming can help link cause to effect.

Often, companies already have the necessary information: it just needs packaging. Presentation is critical: providing raw data in long computer printouts makes the average worker's job harder. Pie charts and bar graphs make data much easier to use, and good data make questioning the status quo easier.

Instituting a parts standardization program is one way to embark on an SE-based cost reduction program. Upper management, accounting, and purchasing appreciate part standardization because it enhances profitability by exploiting economies of scale and reducing engineering and other costs associated with special projects. Of course, some customers will have unique problems, so strike a balance between custom and standard work.

**Step 4: Arrange Workers Properly**

Separating people by a hundred feet or more diminishes communication greatly. Communication improves with daily face-to-face interaction. Direct contact stimulates all the senses, not just hearing, as the telephone does. While the telephone has its place, it is often ineffective for discussing important matters or explaining new concepts. Likewise, some topics cannot be handled expeditiously or efficiently in scheduled formal meetings.

When NCR Corp. (Dayton) experimented with floor plans, for example, it found that a simple technique, such as having interacting groups share the same coffee areas, could improve communications. Floor plans supporting SE allow people working on the same projects to be close to each other.

**Step 5: Recruit Key Players**

Engineering generalists—people who can handle variety—are essential to support simultaneous engineering. An SE team must balance design, manufacturing, accounting, purchasing, human resources, and management. Therefore, team members must have a strong background in the product's design, manufacture, or support. They also need strong interpersonal, general problem-solving, and analytic skills, as well as an understanding of the business's goals and organizational dynamics.

A good way to assemble a team is to look for qualified workers in house. Welcome experience, but not at the expense of creative thinking. SE players must be able to influence others and tolerate significant changes in their job responsibility.

**Step 6: Offer Training**

Train key employees in recognizing and solving problems and in improving interpersonal skills. Some training is best done in house, but when internal training is impractical, consider programs from professional societies and academic institutions. Education groups can help if the class is large enough.

There are more seminars and conferences on SE today than there were five years ago. Unfortunately, however, some SE seminars are little more than restatements of good design practices. Useful SE seminars go beyond a "do's and don'ts" checklist and adopt the big-picture view of manufacturability. Good product designs come from tradeoffs between product performance and total cost (capital equipment, labor, inventory, and timely delivery). Seminars should include manufacturability measurement to justify manufacturability studies and analytic tools.

Related topics include quality philosophies (Deming, Crosby, etc.), problem solving (Kepner-Tregoe), Ishikawa diagramming, Pareto analysis, design of experiments (including Taguchi methods), group technology, design for assembly, value analysis and engineering, solids modeling, and Kaizen-type continuous improvement.

Because job rotation exposes people to the needs of other departments, it can supply considerable training to support SE. Let SE personnel work with marketing, quality, product engineering, manufacturing engineering, purchasing, and manufacturing. Many companies use some form of job rotation for employees with up to 15 years of experience.

**Step 7: Exploit CAD**

CAD solid modeling can support many communication and information needs during the proposal and development phases. It displays 3-D graphics and contains the master product files, giving more people access to the latest product design revision. It can rotate an image and display hidden sides, which is the least ambiguous and easiest way to understand drawings.

More advanced CAD systems recognize solid parts and can distinguish between the inside and outside of a part and define it as a bounded object. They can also display bills of material, routings, tooling, and reference information. Employee efficiency increases because the computer accurately tracks a project's progress and makes current information readily available.
SE Team Cuts Assembly Operations

When Ingersoll-Rand’s Portable Compressor Div. (Mocksville, NC) introduced design for manufacturability concepts, it dramatically increased productivity and reduced new product development time. “We reduced our new product development time from two years to 12 months, yet maintained high quality standards,” says Don J. Gerhardt, manager of engineering and development. DFM quickly became an important tool in uniting project teams from various departments into a cohesive SE group.

The impetus for the DFM program was a two-day training workshop conducted at Ingersoll-Rand. Using two assemblies from one of Ingersoll-Rand’s portable compressors, a representative from Munro and Associates (Troy, MI) trained 34 people from design, manufacturing, and marketing in Boothroyd-Dewhurst DFM techniques. He brought parts into the training room for analysis and divided the trainees into five teams with representatives from every department on each team.

The SE teams reduced the number of parts 64% (from 80 to 29), including a 47% reduction in fasteners (from 38 to 20). Also, assembly operations plummeted 75% (from 159 to 40 operations), reducing assembly time from 18.5 to 6.5 min/unit.

“The new designs from the June ’89 training session went into preproduction during the last quarter of ’89 and into full production last February,” Gerhardt recalls. They appeared in Ingersoll-Rand’s Prestige Series compressor line in time for the American Rental Show on February 12, an important show for the division.

Because of the first application’s success, Ingersoll-Rand invested in software and in an SME Design for Improved Manufacturability and Profitability clinic. The PC-based software package is “Design for Assembly Toolkit,” from Boothroyd-Dewhurst Inc. (Wakefield, RI). The firm then reduced the number of parts and assembly operations for one of its control and instrument panels 33% (see figure): the count fell from 36 to 24 parts and from 45 to 30 operations. The team eliminated 38% of the panel’s fasteners, and assembly time is now 6.1 minutes, down 28%.

“The training served as a catalyst for team building, which has stimulated our SE activity,” Gerhardt reports. “We currently have six active new-product development teams.” One has members from three foreign countries; two have representatives from four other Ingersoll-Rand divisions.

—James R. Koelsch
Step 8: Apply Analytical Tools

The need for timely manufacturability feedback poses major problems for product designers. First, maintaining a database relevant to the manufacturing environment can be difficult. Second, although product designers need the information, they usually have little manufacturing background. Finally, a manufacturability evaluation must provide feedback early enough to influence the design before it is too late to change it. So a short, manageable list of critical design and manufacturing factors can be an effective analytic tool.

Manufacturability guidelines range from color coding and identifying the purpose of fasteners to simplifying the product design. Boothroyd and Dewhurst developed the most widely used manufacturability technique to improve product design when assembly costs contribute significantly to total cost. This technique determines the minimum number of parts for an assembled unit and how to design them to improve assembly. We need new guidelines, however, to handle cases where a product’s assembly cost is low compared with total cost.

Another technique, variation modeling, determines the effect of stacked tolerances and helps balance them among several parts to reduce manufacturing cost.

Many expert system shells address the manufacturability issue. With the right knowledge base, a computer can evaluate manufacturability of conceptual product designs. Unfortunately, the software is expensive and typically needs dedicated workstations rather than PCs. Off-the-self software has minimal design value because it needs tailoring for specific applications.

The selection of manufacturability-related analytic tools will probably improve over the next few years. Look for those tools to merge with CAD systems. When that happens, CAD developments will greatly influence manufacturability evaluation tools. Product engineers will no longer have to deal with complex equations; they will concentrate on designing.

Launching a Program

If you are not careful in setting the tone for your program, people will resist the change. Before revealing specific objectives of the SE program, explain the benefits of SE to both key players and other people in the organization. What employees must understand is that the SE program represents a permanent change in the organization.

Explain the program’s goals at a formal launch meeting. Clarify weighted goals like shorter cycle time, lower manufacturing unit cost, and reduced manufacturing variability. And describe methods for quantifying and reporting improvements for current policies and practices.

SE programs must avoid pitfalls like these:

- **Unqualified management and other personnel justifying and controlling the program.** Unfortunately, some managers and executives interpret SE simply as a way to shorten lead time by hurrying product design and process specification.

The SE program manager and upper management must understand the workings of the primary and secondary functional departments. Those without design and manufacturing engineering experience will have problems communicating, monitoring the program’s success, and providing management support.

- **No one owning the program.** Program ownership comes from involvement in developing goals, resources, and a timetable. If key people wait to participate until others make major decisions, their sense of ownership will be minimal. Also, goals that are unclear, unrealistic, or too numerous can make implementation and monitoring impossible.

Programs falter without a consensus about their outcomes. A program must set specific priorities to avoid false starts and prevent diluting its effectiveness.

- **Complex coordination of the activities of many departments.** The organization should move toward program-driven responsibilities for the SE team and away from traditional job descriptions. Coordination includes dividing responsibilities into prototype development, prototype materials procurement, manufacturability, conformance testing, program scheduling, proposals to customers, and product supportability. This promotes flexibility in job assignments and often results in increased productivity.

- **Fear of reprimand if the program fails and absence of reward if it succeeds.** Employees will not take risks when there is no potential for reward.

The fear of reprimand is not addressable at the worker level because it is a function of the perceived company culture and management’s boldness and leadership. The best way for management to stimulate an SE team’s creativity and willingness to question the status quo
is to set the pace: show its boldness and support employees who are unafraid of breaking away from the pack.

- Failure to relate manufacturability improvements to job satisfaction and career advancement. At the initial meeting, stress how SE can simplify jobs and explain the program with specific references to career opportunities.

- Difficulty in placing numerical values on the many design and manufacturing operation factors involved. At least a few SE team members should understand cost accounting so they know where to begin attacking costs, lowering not only unit cost but also overhead. This knowledge works especially well when the same people understand design and manufacturing and how those activities establish a product’s base cost.

Results from an SE program are complex and far-reaching. Fortunately, most people understand the basic idea and are not afraid of the concept. Fear can spread, however, when people sense that their responsibilities and ways of thinking will change drastically. People will be less fearful when they regularly see examples of direct involvement, bold leadership, and risk-taking management.