# The fewer engineers per project, the better

To help U.S. industrial competitiveness, large engineering organizations need to be restructured, downsized, and redeployed. Engineers must take the lead, because we are part of the problem—and the only hope for its resolution.

U.S. manufacturing environments have become a barren wasteland. The design and improvement of products and particular processes are treated as engineering afterthoughts that disturb the *status quo* of an assembly line. Manufacturers in other countries take another approach, and the difference shows on every encounter between Nikon and Kodak, or Mercedes-Benz and Cadillac. We simply lack creativity and detailing. The U.S. engineers who could have solved the problem are now held mostly in the aerospace industry orbit.

In order to survive, General Electric Co., one of our oldest manufacturing companies, is becoming a conglomerate—in effect a supermarket of industrial goods. Jack Welch, president of both GE and the National Academy of Engineering, has promoted strategic alliances that allow the company to ignore manufacturing problems by simply importing the products instead.

Recently GE stopped manufacturing televisions altogether, selling to France's Thomson CSF its several-billion-dollar, low-margin TV business for some $750 million, so that GE could maintain its high market share (and high prices) in the medical electronics business. The United States now has few domestically owned suppliers of consumer electronics, and few trained engineers or other elements of the labor force needed to feed our nation's addiction to TVs, radios, videocassette recorders, and so on.

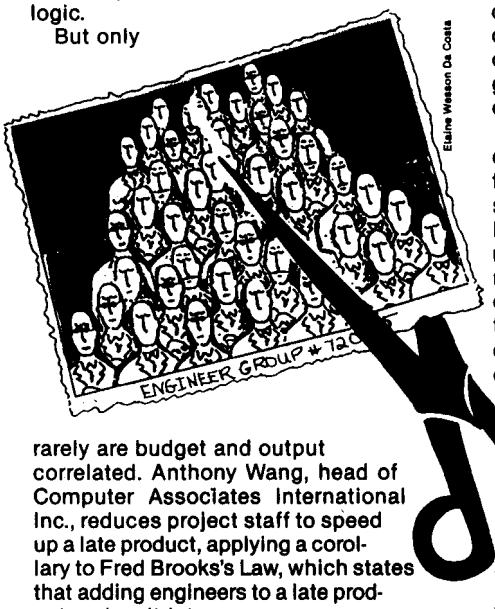
The formalization of the manager as an entity by business schools has probably had the single most deleterious effect on U.S. competitiveness. By focusing a discipline on general business management, we have created a nation of process people, devoid of content. Ken Oshman, founder of Rolm Corp., feels so strongly that a two-year MBA program is a waste of engineering talent that he instituted a one-quarter course at the University of California, Berkeley, and Stanford University, to alleviate the perception that engineers need MBAs.

The processes needed to manufacture complex products can only be managed by technologists, not by the production bosses of a bygone labor-intensive manufacturing era. But the ultimate manager is not a technologist. He delegates thinking, learning, writing, planning, analyzing, synthesizing, designing, and testing to technologists. The process, not the product, becomes what is managed.

The focus on products should never take second place to the focus on process. Continual evolution of existing products and the introduction of radically new products and new ways to build them are needed to sustain a high-technology manufacturing organization. The inertia of old product lines, organizational traditions, and conservative customers all work against technical and managerial innovation of any kind.

Engineering organizations are perhaps the most fertile breeding grounds for rampant managerial incompetence. As engineers, we excel at designing and building oversized organizations, endless processes, and an almost unbounded succession of rules—the foundations of bureaucracy and the bane of productivity and creativity. We have evolved to the point of being totally rewarded on the basis of input (budget and organizational size) and not of output. Increasing the budget to raise output is the most timid bureaucrat's logic.

But only




rarely are budget and output correlated. Anthony Wang, head of Computer Associates International Inc., reduces project staff to speed up a late product, applying a corollary to Fred Brooks's Law, which states that adding engineers to a late product makes it later.

Large staffs are required because the heads don't understand the technology. Just after Seymour Cray produced the CDC 6600 in 1965, Thomas J. Watson Jr., president of IBM Corp., wrote a memorandum to his staff in which he said:

"Contrasting this modest effort [of Cray in his laboratory] with 34 people including the janitor with our vast development activities, I fail to understand why we have lost our industry leadership position by letting someone else offer the world's most powerful computer."

Cray's comment was simply: "It seems Mr. Watson has answered his own question."

Here, as with many of the ideas in computing, I'm stealing from Cray. Based on personal experience at Ardent Computer Corp. and other startup companies, I have found that in order to get the number of staff on a project down below 50 (six teams, say, of six or seven), we must have exceptional, and very broad engineers—something most large engineering organizations discourage. The product quality and performance that results is usually outstanding. Furthermore, productivity is more than an order of magnitude greater than that found in the typical large organization.

The vast array of new computer-aided design tools provides exceptional productivity gains and allows a small, bright staff to design very complex products in a very short time. By allowing us to simulate nearly all physical phenomena at almost any level of detail, for example, supercomputers enable us to adequately model reality. They let us do away with actual breadboards, early prototypes, and even early production runs.

Modern CAD tools permit the modeling of a wide class of digital systems, from a chip to a large system. In this fashion, we can "build" virtual systems and processes of all types, reducing the time and size of group needed to create the final product or manufacturing process.

A few areas of engineering, including computer design, have adopted this practice, but others—and other disciplines, such as mechanical engineering—are at least a decade behind. The academic community's greatest challenge (especially in mechanical engineering) must be to encode its entire knowledge for computer interpretation, so that a few engineers can design a simple mechanical artifact—a car, for instance—within a year or two.

To cut the size of engineering organizations by a factor of four or five, one part should move into manufacturing, another into marketing and sales to learn and solve real user problems, and another should go back into the educational stream as either producers or consumers. The rest should be encouraged to leave the company and start up new ventures based on the company's technology—but for various reasons this is usually irrelevant to, incompatible with, or too creative for, the company's business objectives.

Removing the nonproductive cancer that has spread through engineering and manufacturing will hurt, but it is the only way to survive competitively. By migrating into brand new divisions or startups, engineers might reestablish some of the industries, such as consumer electronics, that have been lost in the past decade of industrial decay.

Productivity would increase dramatically if engineering teams consisted of fewer, higher-quality members with more responsibility. Engineers would become broader, too, which would also improve product designs. And perhaps, like their salesmen counterparts who get commissions on every unit sold, the engineer could be rewarded according to the profitability of the product.

*—C. Gordon Bell*

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