Figure 11.13a. PROCESS IMPROVEMENT STRATEGIES: Setting Standards

EM9104: The Globe and Mail, January 17, 1991, page B8

SIX SIGMA / *U.S. firms are embracing a defect-reduction strategy that will help them lower their costs*

Setting standards for product quality

BY GLENN RIFKIN
New York Times Service

WHEN Motorola Inc.'s fiscal year ended in December, the pay-off from improving the quality of the company's manufacturing operations suddenly became evident: $500-million (U.S.) saved during the year by reducing defects.

Digital Equipment Corp. of Maynard, Mass., benefited from improving its quality as well. Its storage division cut its product-defect rates by 60 per cent in one year, which meant a 25-per-cent reduction in overall product costs.

What these success stories have in common is that they were accomplished under the banner of "Six Sigma," a three-year-old defect-reduction strategy. Six Sigma was first used by Motorola of Schaumburg, Ill., and is now being embraced by a growing number of American companies seeking to improve quality.

"If you control your processes very tightly, you don't produce defects and therefore you don't have to refine and repair defects," said Richard Buetow, senior vice-president and director of quality at Motorola. "You don't need the extra people and equipment."

Six Sigma is a statistical term attached to the concept of achieving approximately zero defects – actually 3.4 – per million opportunities. Sigma – the 18th letter of the Greek alphabet – refers to the number of standard deviations from the mean in any given statistically measurable process. The mean is the arithmetic average; the standard deviation is a measure of variation from that average.

Six Sigma requires no new manufacturing equipment, but it does require rethinking the manufacturing process. It is, therefore, very difficult to take an existing product line and bring it all the way up to Six Sigma. "You can't take an old product and move it to Six Sigma," Mr. Buetow said. "You need to start with a clean sheet of paper."

According to John Early, vice-president of research and development for the Juran Institute, a quality-consulting firm in Hilton, Conn., every process has a measure of variability to it, whether it is soldering a chip on to a silicon wafer or delivering a package. "A key thing in quality is to keep the variation as close to the mean target as you can," Mr. Early said.

If Six Sigma were used at home in the kitchen for baking bread – which would never be the case – the process might work like this: First, the recipe would be analyzed to see whether there were ways to reduce the number of ingredients.

Next, the measuring process would be assessed to see which were the more difficult tasks. Goals would be established for the number of acceptable measuring errors.

Technologists would assess whether the rising time of the dough could be shortened and they would refit the oven controls to make them more accurate. In the end, the bread would be sampled by the group that wrote the recipe to see whether it conformed to expectations.

THE quality of most manufacturing processes in the United States is plus or minus three sigma, which means there are 66,810 defects per million opportunities for error. Motorola saw a clear potential to achieve better results.

"There's no great secret to all this," Mr. Buetow said. "You simply look at a process, centre the mean and reduce the variation; do it the same way every time." In other words, with Six Sigma, the company sets a target for the number of permissible errors for each series of operations and holds to that goal. Six Sigma was conceived at Motorola in early 1987. Motorola's chairman Robert Galvin, tired of hearing customer complaints about quality, sent out a company-wide directive. In it, he urged all employees to be relentless in improving quality.

"We could be doing from 5 per cent to 20 per cent more business and providing a steadier base of products and services, if we would but rise to the challenge and provide our customers the perfection that they expect," Mr. Galvin wrote.

Motorola's five-year quality plan, which began with Mr. Galvin's 1987 memo, called for the company to achieve Six Sigma capability by 1992. That meant a 10-fold reduction in defects by 1989 and a 100-fold reduction by 1991 from the 1987 rate.

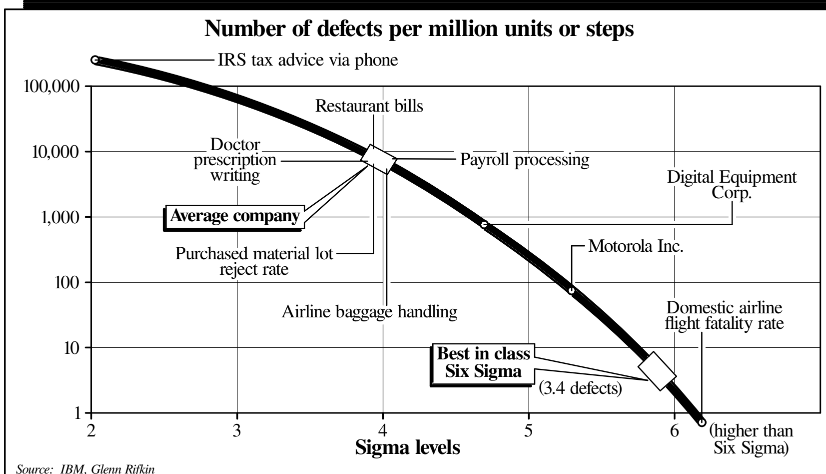
Mr. Buetow says Motorola is well on its way to Six Sigma. "We will be close. The evolutionary process is already paying off. We realized a savings of $500-million in manufacturing costs this year. The target is to reach $1-billion in savings in 1992."

As a winner of the Malcolm Baldrige Award for Quality in 1988, Motorola was required by the U.S. Commerce Department, which awards the prize, to open its doors and let other American companies see how it has achieved its quality goals.

Among the first visitors were International Business Machines Corp. and Digital Equipment Corp., and others such as Corning Glass Works, Northern Telecom Inc. of Nashville, Tenn., Boeing Co., Caterpillar Inc. and Raytheon Co. that have subsequently initiated Six Sigma programs.

According to Stephen Schwartz, IBM's senior vice-president of market-driven quality, Six Sigma is now a critical part of a

Quality in some everyday tasks



Source: IBM, Glenn Rifkin

New York Times Service

(continued overleaf)

company-wide initiative to improve quality.

At the end of this year, IBM expects to reduce defects by 10 times, by 1993, another 10 times, and by the end of 1994, the company says it should attain Six Sigma. "Six Sigma brings a common language to understanding defects and putting an action plan into place," Mr. Schwartz said.

IBM is hoping Six Sigma will help cut significantly into the $2.4-billion it paid in warranty costs in 1989. "People always gave lip service to quality," Mr. Schwartz said. "Ninety-nine-per-cent good sounded terrific."

But in fact, according to an IBM management report, a 99-per-cent defect-free rate translates nationally into 20,000 pieces of mail lost every hour; 5,000 incorrect surgical procedures every week; and, inside IBM, 10 defects out of every 1,000 solder joints on a computer motherboard.

IBM is using its Rochester, Minn., plant to set the standard for quality across the entire company. In 1990, that plant won a Baldrige Award for its work on the AS/400 midrange computer.

A specialist in the company's electronic card assembly group was able to show the Baldrige examiners weekly quality reports detailing a defect rate of seven parts per million – almost Six Sigma.

Digital is requiring its senior managers to take Six Sigma training, according to Frank McCabe, vice-president of corporate quality. Digital's Six Sigma plan is aimed at eliminating "non-value-added costs" such as warranty repair service which generally take 25 per cent from each sales dollar at most companies.

"Our focus is to eliminate 50 per cent of the defects per year in every part of the company until we get them all," Mr. McCabe said. He predicts the program can improve the entire company's financial picture by as much as 5 per cent of net sales – or about $650-million.

At IBM, Digital and Motorola, every process has been or is being re-evaluated to eliminate defects. "We've even reduced defects in the way we do our financial reporting," Mr. Buelow explains. "By reducing cycle times, we've cut $44-million out of the cost of our final audit."

1. Near the bottom of the left-hand column overleaf on page 11.79, Mr. Early is quoted as saying: *A key thing in quality is to keep the variation as close to the mean target as you can.* Explain briefly the *statistical* issues involved in this statement.
   - If necessary, rewrite the statement to make its meaning clearer.

2. It can be shown that, for the standard normal distribution, $\Pr[N(0, 1) \geq 4.5] = 0.000\,003\,398$. In light of this information, discuss critically the statement in the fifth paragraph of the left-hand column overleaf: *Six Sigma is a statistical term attached to the concept of achieving approximately zero defects – actually 3.4 – per million opportunities.*
   - In the second-last paragraph of the middle column overleaf, it is stated that: *The quality of most manufacturing processes in the United States is plus or minus three sigma, which means there are 66,810 defects per million opportunities for error.* Suggest the basis for the figure of 66,810 in this statement.
     - Comment on the wording of the statement in the article EM9104 in light of your suggestion.

3. Starting at the bottom of the middle column overleaf on page 11.79, Richard Buetow, senior vice-president and director of quality at Motorola Inc., is quoted as saying: *You simply look at process, centre the mean and reduce the variation; do it the same way every time.* Outline, in the context of quality improvement, the *statistical* issue(s) involved in *each* of the *four* phrases that make up this statement.

4. Comment briefly, from a *statistical* perspective, on the wording of the title of the article EM0009 reprinted below.

There is further discussion of Six Sigma in Figure 11.15.
The article EM0009 reprinted below also deals with quality standards and difficulties they may involve.

EM0009: The Record, Waterloo Region, October 14, 2000, page A12

WASHINGTON

Too many screws loose on American aircraft

Associated Press

U.S. aircraft may have too many screws loose, the U.S. Transportation Department's inspector-general said.

Investigators found more than one-quarter of screws and bolts tested at random didn't meet specifications, an inspector-general's report released yesterday said. The report included no reports of accidents resulting from sub-standard parts.

"We are not seeing a problem in service," Federal Aviation Administration spokesman Eliot Brenner said.

"Airplane parts are holding together. The figure they came up with is a surprise to us," he said, noting the FAA has launched an evaluation of screw and bolt manufacturers.

A 1990 law, the Fastener Quality Act, requires screws, bolts and other fasteners used in aircraft to meet strict specifications.

In an effort to check fastener quality, inspectors from the inspector-general's office randomly collected 176 fasteners from the inventories of airlines and repair stations. The items were selected from a list of critical parts used in Boeing, Pratt & Whitney, General Electric and Bombardier products.

These parts were sent to the Science and Engineering Laboratory at Hill Air Force Base for testing, and 48 screws and bolts – 27 per cent – were found without correct thread dimensions, the report said.

When the FAA was advised of this finding, it had the items re-tested by the manufacturers. When this was done, only three per cent were found not to comply, the report said.

The inspector-general's report said the differences raise serious questions about quality.