Figure 11.15. PROCESS IMPROVEMENT STRATEGIES: Six Sigma

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It sounds like Greek to some, but the latest in quality management is attracting an impressive following. Corporate visionary Jack Welch is so enthralled, he's betting his legacy on it. ***Ann Walmsley*** *investigates.*

Six Sigma Enigma

It is called Six Sigma and its practitioners are known as Black Belts. It may sound like a mystical art, but it is in fact a data-driven method for achieving near-perfect quality. And it is the latest mantra of Jack Welch, the brilliant, obsessive chairman and CEO of General Electric Co. (GE). In 16 years, Welch has built the Fairfield, Conn.-based conglomerate into the most highly valued company in the world, with a stock market capitalization of $200-billion (U.S.) [even though it ranks only 12th in the world in terms of revenues]. This is particularly remarkable, given that conglomerates usually trade at a discount and GE's operations are a confusing mix ranging from credit-card services to aircraft engine plants like the one in Bromont, Que., and from light bulbs, produced in Oakville, Ont., to NBC-TV.

♦ As a result, Welch's enthusiasms are closely followed by executives, as was seen when Welch's brutal restructuring at GE in the early '80s was emulated by CEOs globally. Now, the scrappy 61-year-old leader is counting on Six Sigma to be the grand finale of his career at GE, before his scheduled retirement in the year 2000. An in case you are wondering what that will mean in financial terms, the prediction is that Six Sigma will contribute an extra $10 billion to $15 billion annually in revenue and cost savings by the end of the century – just three years away.

Welch is tackling Six Sigma with the single-mindedness that characterizes everything he does: the GE restructuring, his devotion to Catholicism earlier in his life, even his successful effort to control his stuttering. Shortly after becoming CEO in 1981, he embarked on a massive program of closing and selling GE businesses with the aim of unloading any companies that were not No. 1 or 2 in the world. His methods prompted *Newsweek* to nickmame him Neutron Jack – a reference to the bomb that leaves buildings intact while obliterating the people inside. And when he was done, tens of thousands of ousted GEers veiwed him as the enemy. But his successful shakeup of the sluggish company, best known for its toasters and irons, became the bellwether of corporate re-engineering around the world. And Welch himself became the CEO to watch – the yardstick by which many other business leaders measure their own performance.

Now, he's breaking all the rules again by applying Six Sigma, which Motorola pioneered in the 1980s strictly for manufacturing quality, to everything that GE does: loan booking, credit-card processing, satellite time leasing, legal contract design – you name it. Confused survivors of previous Welch edicts wonder whether this is Welch's control tendency run amok or a sea change that will be copied throughout the corporate world. "There is a lot of eye-rolling. There still is," says one GE intern. And while customers will certainly be happier, a key question is, how will Welch substantiate his claims about Six Sigma savings?

Adopting Six Sigma is similar to retrainng your entire workforce, including marketers and janitors, to think and act like engineers. Sigma is a statistical unit of measurement that means a standard deviation from a mean. All processes – including returning phone calls promptly or assembling an aircraft engine – deviate because of human error or other circumstances. A Six Sigma process reduces that deviation to no more than 3.4 defects per million operations. Think of it as 99.9997% perfection. Mikel Harry, a former Motorola Inc. engineer and statistician based near Phoenix, Ariz., has mapped out a method for companies seeking to achieve Six Sigma that has made him the *de facto* guru of the discipline (see Data Buster, page 11.91).

Unlike other quality programs, such as total quality management, best practices and *kaizen*, Harry's method is a disciplined system of using extremely rigorous data-gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them. Instead of the fuzzy goal of continuous improvement, quality projects are chosen based on customer feedback. Improvements that have a significant customer impact are given top prioprity. Also unique to Six Sigma is the practice of training and deploying foot soldiers known as Black Belts throughout the company to work full-time on projects to dive out defects. (The term Black Belt, borrowed from the martial arts, in this case is meant to underline the mental discipline and intensive training involved).

It takes four months to train Black Belts, and two years for them to become expert in such heady statistical tools as Pareto charts, Chi^2 charts, time plots and fractional factorial designs, as well as to familiarize themselves with a software program called Minitab that handles statistical graphing. To become certified, Master Black Belts must have overseen 20 Six Sigma projects that achieved prescribed savings. In GE's case, there is also an expanding corps of Green Belts who work part-time on quality projects and devote the other half of their time to their regular jobs. Not surprisingly, these people are putting in longer hours.

The training costs are astronomical. In 1997, GE will spend $400 million on training. But it is counting on $600 million in savings from Six Sigma improvements – for a net benefit of $200 million. "TQM sounds like fluff and we had seen lots of companies pursue TQM and get nowhere," says GE senior vice-president Gary Reiner, the point man on Welch's latest craze and, at 42, one of the youngest GE executives rumoured as a possible successor to Welch. "Six Sigma is attractive because you know whether you are making progress or not. It isn't anecdotal, it is quantitative."

A prime example of Six Sigma in action comes from GE's 51%-owned Canadian appliance company, Camco Inc. For a year, the company had attempted to use conventional approaches to solve a problem with a lack of rigidity in some of its cooktops, which had been leading to high scrap rates. "We tried [a number of things] during assembly, [that] seemed logical, but they made the problem worse and cost us money," says Chris Mitchell, a Master Black Belt at Camco.

Then Green Belt Doug Martin tackled the problem with Six Sigma methodology over a period of eight months. Using Design of Experiments, Martin and his team tested 10 possible causes in various combinations, in 14 versions of an experiment. After a computer had crunched the results, Martin used Main Effects Plot Analysis and Graphical Analysis to pinpoint the source of variation: the pattern of hanging the parts in the oven during the enamel-baking process and the ratio of enamel on the top and underside of the cooktop. By tightly controlling these processes, the team was able to reduce costs by more than $500,000 annually and improve yields.

Even the most acid critics of management trend turnover are finding it hard to argue with Six Sigma philosophy, despite its arcane mathematics and its martial arts pretensions. Adrian Wooldridge, co-author of *The Witch Doctors: Making Sense of Man-*

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agement Gurus, observes: "Six Sigma is a very serious theory with hard-core sensible ideas that have done a lot to improve productivity." Bombardier Inc., which describes itself as averse to fads, unveiled its Six Sigma program in April and is using Harry as its consultant (see Six Sigma, Bombardier Style, on the lower half of page 11.90).

Wall Street also loves Six Sigma. Jennifer Pokrzywinski, an analyst with Morgan Stanley, Dean Witter, Discover & Co. in New York writes in a recent report on GE: "Six Sigma companies typically achieve faster working capital turns; lower capital spending as capacity is freed up; more productive R & D spending; faster new product development; greater customer satisfaction ... Six Sigma is like that old Wella Balsam shampoo commercial: 'She told two friends, and they told two friends,' and so on .... As Black Belt project leaders multiply and train people, and those people get involved in projects, the financial impact is exponential, in our view."

Most companies operate at roughly Three or Four Sigma (66,800 to 6,210 defects per million). Each Sigma increase requires an exponential reduction of defects. The cost of that quality is typically 10% to 15% of lost revenues, which in GE's case, according to Welch, "amounts to some $7 billion to $10 billion annually, mostly in scrap, reworking of parts and rectifying mistakes in transactions." Motorola Inc., which was the birthing place of Six Sigma more than a decade ago, now averages about 5.6 Sigma (20 defects per million) and has saved $11 billion to date and tripled worldwide productivity as a result. Most commercial airlines' safety procedures operate at a Six Sigma level. Reiner estimates that GE averaged Three Sigma when it introduced its Six Sigma program. In the first 22 months, it improved to about 3.5 Sigma (22,700 defects per million). To reach Six Sigma by the year 2000, it will have to improve by more than 90% per year.

Analysts predict that GE is unlikely to achieve this goal in so little time. And Welch himself admitted in a speech to shareholders, at the annual meeting in April, that Six Sigma by 2000 was "a 'stretch' goal, a target so far beyond seeming capabilities as to appear at first impossible," but a target that would force GE people to deliver "performances greater than we ever thought were in us."

Six Sigma has been around since the 1980s, when Motorola Inc. of Schaumburg, Ill., developed the techniques in-house to improve its production of pagers, cellular phones and other products. But it was former GE vice-chairman Lawrence Bossidy who formally introduced the idea to Welch. Bossidy left GE to become CEO of AlliedSignal Inc. in 1991, where Six Sigma got started in 1994 and began attracting enthusiastic attention from analysts. Allied claims that this year alone it has achieved $300 million to $400 million of Six Sigma savings on revenues of $14 billion, but that the cumulative impact to date is in excess of $800 million.

Speculation is that Bossidy and Welch were either golfing at Welch's country club in Fairfield, Conn., which is just across the road from his 3.2-million, 10,000-sq.-ft. Georgian-style brick house, or at his summer home in Nantucket, Mass., when the subject first came up. Welch invited Bossidy to speak to GE executives on Six Sigma in May, 1995. By October, 1995, it was policy. "Larry has a lot of credibility with the people here and he was swearing by it," says Reiner.

It's no surprise that Six Sigma would strike a chord with Welch. A chemical engineer by profession, he has long been familiar with the techniques of measuring process variation. His PhD thesis for the University of Illinois investigated the role of condensation in nuclear stream supply systems. Moreover, Six Sigma offered him a way to differentiate GE from other quality poseurs in short order. According to associates, Welch is mindful of his retirement deadline in the year 2000, and seemingly gripped hy a new sense of urgency following his successful heart bypass surgery in May, 1995. Just before heading out on summer vacation this year, he could be heard exploding over the slow progress of one business in getting on-time delivery (higher Sigma) from a key supplier. "What the f— is going on in this business?" he ranted.

Even the gurus have tried to talk Welch out of his breakneck pace. He wants to accomplish in five years what Motorola did in 10. And unlike other Six Sigma old hands, who applied it strictly to manufacturing, Welch is also applying it to commercial transactions, which are trickier to measure. He is looking to GE Capital, which accounts for the largest chunk of GE revenue – $32 billion in 1996 – to deliver at least 40% of the Six Sigma savings this year. That means driving out defects from mortgage applications, credit card transactions, customer service call centres and truck leasing. The person in charge of delivering that at GE Capital is vice-president and chief quality officer Ruth Fattori, a mechanical engineer and quality expert hired from Asea Brown Boveri Ltd. for her experience with Six Sigma. Fattori says that Welch is all over her for results. "He's relentless," says Fattori, who seems to thrive on his intensity. "There's no patience for what's not done. He asks me and everybody all the time pointed questions: 'How many Master Black Belts do you have trained? What kinds of projects are they working on? What are the results? What have *you* learned? How are *you* leading the effort?'"

GE Capital has attracted growing attention in Canada in recent months because of two major deals by its Canadian subsidiary, General Electric Capital Canada Inc. It led the syndicate providing T. Eaton Co. Ltd. with financing after the retailer sought creditors' court protection. And last fall, in a joint venture with Oxford Properties Group Inc., it bought Marathon Realty Co. Ltd., for $952 million (Canadian) from Canadian Pacific Ltd., one of Canada's most legendary real estate portfolios.

Gary Reiner's favourite example of Six Sigma at work comes from a GE Capital business. The business's customers told the company that a critical quality issue for them was how often a salesperson could answer their questions directly without having to look into it and get back to them. Adhering to the the Six Sigma data-gathering discipline, each salesperson kept a meticulous diary for a week, noting each time a customer asked them a question and whether they were able to answer it immediately. The conclusion was only 50% of the time. Breaking down the data further, the team will be able to deduce the types of questions salespeople are unprepared for and what training would fill the gap, and, oh yes, which salespeople were best suited to the job. Likewise, GE Capital Mortgage Corp. Six Sigmaed the branch that best handled the flow of customer calls and used that model to redesign the other branches. Says Welch: "Customers who once found us [the mortgage corporation] inaccessible nearly 24% of the time now have a 99% chance of speaking to a GE person on the first try; and since 40% of their calls result in business, the return for us is already mounting into the millions."

The mathematics of the bottom line is not lost on the Master Black Belt trainees at GE Capital. In a Six Sigma training session in Stamford, Conn., last summer, every one of the 25 employees in the room knew that daydreaming through class was not an option. "GE Capital has to deliver $250 million [U.S.] of savings in 1997," said one participant. "And there are 250 Master Black Belts. So – work it out – each of us has to come up with $1 million in savings." Said another: "This is all about Wall Street." But some are still struggling with the mechanics of measuring their processes. "If we ask our clients what the perfect reinsurer might look like, they say, one that is flexible and creative," says one participant from Munich. "But it is very difficult to measure creativity."

Welch's Six Sigma push met two waves of skepticism from GEers. According to Reiner, some non-manufacturing and non-operational employees griped: "This doesn't apply to me – you can't measure my function," while others grumbled: "GE will never devote enough resources to this." Leading the "This doesn't apply to me" contingent was NBC, the one GE shop heavily dependent on creative output. Mikel Harry took on the NBC doubters directly, according to Greg

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Figure 11.15. PROCESS IMPROVEMENT STRATEGIES: Six Sigma (continued 1)

EM9706: (cont.) Brue, a Six Sigma implementer. "Mike said, ‘Okay, let’s talk *Steinfeld* for a minute’," recalls Brue. "‘How many laughs are you supposed to get from one of his jokes?’ The answer was 20. ‘So if you don’t get 20 laughs, it is a defect’." Brue also points to television ratings and technical functions as measurable. "Maybe the rating company’s sample size was wrong. Or there’s a defect in lighting, or the setup time for a set varies." Welch put an end to the resistance in July when NBC installed its first chief quality officer, John Eck, a long-time GE employee and resident of Fairfield, Conn., along with both Welch and NBC chairman Bob Wright. Eck claims that one Six Sigma project has already improved cash flow at NBC by $9.5 million in the first quarter by revising the processing of payments to suppliers. But a call to the *Today* show offices later in August indicated that Six Sigma is still an unknown term to some in the television company. "There’s nothing Black Belt about anything around here," said the staff member who answered the phone. "Six Sigma? You’re talking Greek to me." One hates to think of what David Letterman would do with it, if he were still at NBC.

But Welch has a foolproof method for ensuring enthusiasm for Six Sigma. Last May, he and his two vice-chairmen delivered an edict to all senior management: As of January, 1988, employees will not be considered for promotion to any management job, no matter how junior, unless they have begun Green Belt or Black Belt training. By July, 1988, they must have completed that training to be promoted. Moreover, 40% of the annual bonus for managers in the top two tiers at GE will be tied to their success in achieving Six Sigma goals. That means that 85,000 people, or 35% of the GE employees, will be Six Sigma acolytes by the millennium. Analysts are now predicting that anyone hoping to succeed Welch when he steps down in 2000 will have to be a Six Sigma whiz. "The methodologies of Six Sigma we learned from other companies," says Welch, "but the cultural obsessiveness and all-encompassing passion for it is pure GE."

The proclamation has successfully turned up the heat. Anne Louise Aboud, a former engineer who is responsible for General Electric Canada Inc.’s Six Sigma training, says, "Suddenly I have people popping out of the woodwork wanting training." GE Canada, which has been a wholly-owned subsidiary of GE since 1989, anticipated at the beginning of the year that it would have 617 Green Belts, Black Belts and Master Black Belts among its workforce of 9,500, generating net savings of more than $4 million in 1997. "But that was before the memo," says GE Canada CEO Robert Gillespie, who in his 44-year career at GE has survived all the company’s upheavals.

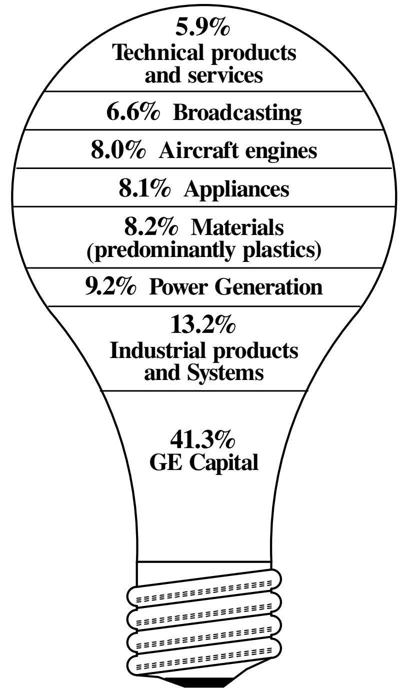
Welch’s brand of Six Sigma strikes some other companies practising the technique as extreme. Says a quality director at one of those companies: "It’s disproportionate. GE is 2.5 times bigger than us [in terms of employees] but is going to have 50 times the number of Black Belts. I don’t think we need 1,000 Black Belts running around our company by the end of the decade. Other things need to go on."

But according to Reiner, Welch recognized by the third quarter of 1996 that GE wasn’t getting the hit it needed from Six Sigma. In 1996, Six Sigma was a net expense: $200 million in training for $170 million in savings. "We discoved that we would never have enough full-time Black Belts to have a tangible effect on the company," says Reiner. "We needed a concept called Green Belts and we needed to grow it like crazy."

One of the GE companies that is ahead of its target in delivering savings by using Six Sigma is Electrical Distribution and Control (ED & C), based in Plainville, Conn. ED & C’s Markham, Ont., plant makes electronic motor protection relays for industrial and electrical utility customers. Under its previous owner, Derlan Industries Ltd., the plant had already improved many processes by implementing a continuous improvement program that adhered to Japanese *kanban* principles and the idea of assembling in work cells. But GE’s discipline of Six Sigma (the rubric is emblazoned on the walls throughout the plant) diagnosed a more profound quality problem that was interfering with on-time delivery.

At first pass, Black Belt Cary Correia and Master Black Belt Lisa Salley suspected that the plant’s problem was insufficient inventory from its circuit board suppliers, which could be remedied by advance ordering. But on investigation, the team discovered that suppliers were having difficulty inserting the diodes, resistors and capacitors in the boards without shattering them. Correia reached into the Six Sigma toolbox to measure the supplier’s manufacturing process for variation. Using stratified-run charts, time plots and other Six Sigma statistical tools, he discoverd that the problem was that the holes in the circuit boards were too small and that the cause of the problem was the original hole-size spec from GE. "This problem has been going on for as long as we’ve been in business," says Correia. "The supplier was just too embarrassed to tell us how much they were scrapping and reworking."

There seems to be little doubt that Welch will achieve remarkable things with Six Sigma at GE. For one thing, major competitors in a number of GE businesses have been slow to follow suit. The only notable



exception is Whirlpool Corp., the biggest major appliance manufacturer in the United States, which quietly began investing in Six Sigma six months after GE. And Camco is already well into the nirvana stage of Six Sigma – designing products to meet Six Sigma standards, not just fixing processes. Based on the trajectory of results that Alllied Signal achieved by introducing Six Sigma, Morgan Stanley’s Pokrzywinski predicts that GE will enter "the ‘sweet spot’ of Six Sigma benefits in 1998 to 2000," which would see as much as 15% earnings per share growth anually, of which 5% could be attributed to Six Sigma. Between July, 1995 and July, 1997, Allied Signal’s stock had climbed 103%, compared with the S & P 500’s 74% rise. "As impressive as his 16-year tenure has been," says Pokrzywinski, "we believe Welch views Six Sigma as his ultimate legacy to GE."

Welch’s love affair with Six Sigma is tempered by an understanding of its weak points. The system relies on customers being able to articulate what they want and need. Yet, as GE Capital’s Fattori notes, customers are not always reliable. For example, business travellers will cite frequent-flier programs and convenience as the reasons why they choose a specific airline on a given day, until there is news of an airline disaster, which completely alters their priorities. Black Belt trainees from GE Canada’s Aircraft Engines operations told their classmates during a training session last summer that engine customers were fed up with being asked what they want: "They told us, ‘Why don’t you fix the problems we told you about five years ago first?’" As well, it takes a sizeable

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corporation to finance the massive investment in training required for Six Sigma to work. Even in large corporations, gathering data and analyzing them can take weeks. Then there's the question of who is minding the shop if the best and brightest are becoming Black Belts. Ironically, coming full circle from the restructuring days, Welch has had to embark on a significant hiring campaign to backfill the jobs of people who have moved into Black Belt positions. Finally, analysts admit that the market has to take Welch's Six Sigma balance sheet of training expenditures and cost savings on faith. "There is no way I can verify their internal numbers," says James Samuels, an analyst at the New York office of securities firm Smith Barney Inc. "[However,] we might try with some difficulty to think of how GE can grow at this above-average rate of 13% to 15% [if not for Six Sigma]." Even Reiner admits to stress on the subject. "If you wonder whether I sleep at night – not very well," he says. "I can usually tell you what shade the moon is."

But a good measure of Welch's success at inculcating his latest craze is the way in which GEers have applied the principles to their personal lives. Correia, at GE's electronic motor protection relay plant in Markham, Ont., confides that he has used Six Sigma measurements to carve 50 strokes off his golf game. A rookie golfer, he can be found at the modest five-hole course near the plant, scribbling Pareto diagrams on pin location and wind direction into a little black book attached to his golf cart. Welch, who golfs with an impressive handicap of 6, will not say whether he is doing the same. But when he walks out the door of his executive office for the last time in 2000, past the luminous painting of the front porch of a white clapboard house, the rest of GE will know what to do. "First, Six Sigma," says Reiner. "Then Seven. And then ... Eight." ■

Six Sigma **Speak**

Sigma: A statistical term measuring the extent to which a process varies from perfection. To calculate the Sigma of a process, Black Belts multiply the number of units processed by the number of potential defects per unit, divide that into the number of actually made and multiply the whole thing by one million. This produces the number of defects per million operations. A conversion table translates that number into Sigma.

6 Sigma = 3.4 defects per million;
5 Sigma = 230 defects per million;
4 Sigma = 6,210 defects per million;
3 Sigma = 66,800 defects per million;
2 Sigma = 308,000 defects per million;
1 Sigma = 690,000 defects per million.

Pareto Chart: This simple bar chart is the most widely used data display tool in Six Sigma because it identifies which problems occur with the greatest frequency or incur the highest cost and therefore should be attacked first. A typical chart might feature reasons for the problem along the horizontal axis and frequency or location along the vertical axis. Italian economist Vilfredo Pareto theorized that 20% of possible causes are responsible for 80% of any problem.

Chi^2: An analytical table that tests the relationship between two possible causes of variation to see if the relationship is statistically important.

Dashboard: A scoreboard on GE progress for the customer. It resembles a car's instrument panel and replaces the oil, mileage and temperature gauges with such gauges as order fill rate, billing accuracy and percentage of defective parts. One arrow on each dial indicates the level of quality that the customer is seeking. The other arrow measures how far the company is from meeting that requirement. Welch has said that he wanted a dashboard on every customer updated every week, but insiders say that the goal placed unrealistic demands on the existing workforce. Instead, businesses are aiming for monthly or quarterly dashboards on the most strategic customers.

Design of Experiments: A way of shifting or reducing variation in a process by carrying out a methodical sequence of experimenrts rather than attempting a scattershot trial-and-error approach. Each combination of adjustments becomes an equation that can either be solved as a matrix or entered into a computer for solution. DOE allows users to efficiently test a large number of variables. Black Belt trainees learn how to visualize this method by practising on an adjustable catapult that fires a table tennis ball at a coffee can on the floor. They must become so familiar with the mechanism that no matter where the can is placed, they can adjust the catapult to hit it on the first shot.

Six Sigma, **Bombardier** Style

Bombardier buys engines for its Learjets from AlliedSignal and engines for the Challenger and the Canadair Regional Jet from General Electric. So it wasn't long before those companies' enthusiasm for Six Sigma practices and Wall Street analysts' rhapsodic reports came to the attention of Bombardier Inc.'s strategic planners. In the first half of 1997, the company sent 15 employees from its aerospace group to Mikel Harry's Arizona ranch for Six Sigma training. Then, two months ago, Harry flew to Montreal to deliver an intensive two-day Six Sigma session to Bombardier chairman Laurent Beaudoin, his top aerospace management and the company's senior executives. Harry acquainted them with everything from the main Six Sigma processes to such advanced statistical tools as multivariate analysis, logistic regression and Monte Carlo simulations. By the end of the year, there will be more than 100 full-time Six Sigma-certified enployees dedicated to aerospace quality – making it the most high-profile Canadian company to adopt Six Sigma.

True to Bombardier's distinctive Canadian culture, however, certified employees will be known as Agents instead of Black Belts. "The label had to work in French and people had reservations about the *ceinture noire* translation," explains Yvan llaire, Bombardier executive vice-pesident. "Also, Black Belts had warlike connotations." Moreover, Bombardier is not copying the GE model of immediate Six Sigma immersion company-wide, but is instead rolling it out business by business: first in its aerospace group, followed by the train group, the Sea-Doo and Ski-Doo group, the capital group and services group. Allaire says that this will enable them to customize the training materials to Bombardier and create a corps of Master Agents in-house who can teach the other groups, incidentally saving money on consulting fees.

Also, unlike GE, Bombardier will not be hiring new people to perform the jobs of employees who were cherry-picked for Six Sigma training. Bombardier already has a corps of methods engineers and other personnel dedicated full time to quality. And those who have been seconded from other areas are expected to increase productivity so dramatically that there will be no need to hire replacements. Indeed, the greatest gains will not be in product quality, because its aircraft already meet Six Sigma quality, but in the rework on the assembly line, where processes hover at the Three to Four Sigma.

"There is a risk that this approach will turn into a fad and generate a large number of consultants with the usual cycle of disenchantment and criticism," says Allaire. "But we are a very unfaddish corporation. We think Six Sigma is a method of substance."

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Figure 11.15. PROCESS IMPROVEMENT STRATEGIES: Six Sigma (continued 2)

Data Buster

Six Sigma guru Mikel Harry's ranch is a magnet for CEOs

Mikel Harry's grammar is sometimes corn pone, his mustache is a shade too gunslinger and his presentation style has the fire of a Southern Baptist preacher. But there is something about the hard ridin', steer ropin' 46-year-old ranch owner and his business partner, Rich Schroeder, that mesmerizes CEOs. Harry talks data. Pure unassailable data. He's an engineer and statistician who has transformed the mushy goal of quality into a method of breathtaking precision, with concrete financial results. The duo's client list includes Polaroid Corp. and Lockheed Martin Corp. Which means Harry is very comfortable financially.

His wealth is evident in his steadily expanding spread, the Sigma Ranch, 140 kilometres north of Phoenix, Ariz., in the high desert of the Mongollon Rim. Only top executives, high-level Black Belt trainees and Wall Street analysts are invited to sessions at the ranch. Horsewhips decorate the walls of the log house. Picture windows afford a panoramic view of Harry's eight hectares, featuring scrub oak and juniper and populated by mountain lions, horses and deer. After dazzling and often confusing trainees and guests with Six Sigma statistics, Harry invites them outdoors to practise lassoing dummy metal steers, or to unwind at a cowboy biker bar at nearby Cave Creek. Harry and Schroeder relax by roping the real thing – wild steers. It's not unusual to see Harry at the front of the classroom the next day with bloodied arms and dusty cowboy boots. "Mike and I, we like to push the edge of the envelope," says Schroeder.

No one questions Harry's brilliance, but his originality is sometimes at issue. He was employed at Motorola Inc.'s government electronics division in Phoenix when he and several colleagues developed the Six Sigma methodology in-house in the early 1980s, using well-known statistical tools. He did not actually coin the name Six Sigma. Another Motorola colleague did that. And it was a client at Unisys Corp. years later who first compared the discipline with that of a karate black belt, which inspired Harry to certify trainees as "Black Belts" in Six Sigma. But Harry's technical finesse and speaking skills earned him the job of establishing Motorola's Six Sigma Research Institute at Motorola University. And by developing advanced Six Sigma engineering methods and writing several books on the subject, he legitimately packaged the technique as his own, in a format that could be adopted by other companies. By the time he left Motorola in 1993, the company claimed to be operating at nearly Six Sigma in most of its manufacturing operations. Harry took his know-how to Asea Brown Boveri Ltd., along with Schroeder, another former Motorolan. Later he and Schroeder struck out on their own as consultants (or "gurus," as Schroeder likes to say), founding their Six Sigma Academy in Phoenix.

Harry does not come cheap. The fee to license his method and train a core group of Black Belts starts at $1 million (U.S.) and ramps up, based on the client company's gross revenues. Training each additional class of 25 Black Belts costs $150,000. He feeds subcontracts to nearly a dozen other former colleagues from Motorola who have set up two other Six Sigma consultancies, including Harry's neighbour, Mike Carnell, a former bull rider who is currently delivering Six Sigma training to Navistar International Corp. Canada employees at its truck plant in Chatham, Ont. Asked whether it is an accident of geography that so many Six Sigma consultants are cowboys, Carnell says: "No. It's just because we aren't smart enough to know when to quit. We want to reach Six Sigma in everything."

The Four Phases of Welch's GE

Restructuring 1981-1985

This is the program that shrank GE's workforce from 404,000 to 304,000 and earned Welch the nickname "Neutron Jack." Soon after taking office as CEO, Welch drew three intersecting circles on the back of an envelope and placed GE businesses that were No. 1 or No. 2 in their industries inside the circles. Any operations outside the circles, he said, would be "fixed, closed or sold." GE divested 125 businesses or pieces of business units, including its beloved housewares operation, which made GE toasters, irons and coffeemakers. It acquired entirely new businesses, including Employers Reinsurance Corp. And it laid off 170,000 employees from 1981 to 1991. Corporations around the world followed suit. GE earnings rose from $1.7 billion (U.S.) to $2.3 billion.

Work-Out 1988-1992

Welch's confrontational version of *kaizen* was one "one of the biggest planned efforts to alter people's behaviour since Mao's Cultural Revolution," according to GE consultant Len Schlesinger. GE employees at all levels from all different businesses gathered in town-hall meetings to air frustrations and forward new ideas for eliminating unproductive tasks, without fear of reprisals from their superiors.

Work-Out laid the groundwork for Six Sigma by hammering away at useless bureauocracy and teaching the skill of process mapping. But many employees remained suspicious that the process was really a way of eliminating more jobs. There was little copycatting by other corporations. Earnings rose from $3.4 billion to $4.7 billion.

Change Acceleration Process 1992-1995 Welch's idea for getting his 12 disparate businesses to talk to each other to speed up change. Touting the notion of a "boundaryless organization," a value that had been kicking around the company since the late '80s, he also sought to open dialogue with suppliers, customers and partners in global markets. Earnings rose from $4.7 billion to $6.6 billion.

Six Sigma 1995-2000

Welch's last stand. A program to train all salaried employees (roughly one-third of the company's employees) in high-level statistical analysis to drive out defects – not just in manufacturing but in commercial transactions as well. In 1995, GE was averaging 66,000 defects per million. Welch is pushing his managers to squeeze it down to 3.4 defects per million by 2000. As he said to a gathering of GE operating managers in Boca Raton, Fla., last January: "You've got to be lunatics on this subject. You've got to be passionate lunatics." But the ruthless message from the Restructuring phase was also there: "We want only A players. Shame on any of you who aren't. Don't spend all that time to work plans to make Cs into Bs. Move 'em out early." This writer's prediction: Companies around the world will be falling over themselves to adopt GE-style Six Sigma. Earnings to date have risen from $6.6 to $7.3 billion.

This discussion of the chronology of Welch's time as CEO of GE is notable for the idea (in the second paragraph of the middle column) that the groundwork for implementing Six Sigma was laid by inculcating company-wide *process thinking* (or even *statistical thinking*) [as defined on pages HL91.18 and HL91.21 in Statistical Highlight #91].

(*continued overleaf*)

Books by Mikel Harry:

The Great Discovery: A Process That Creates Breakthrough In Everything You Do. Harry, M.J. and Lawson, C. The Great Discovery LLC, Scottsdale, Arizona, February, 2010.

Practitioner's Guide to Statistics and Lean Six Sigma for Process Improvements. Harry, M.J., Mann, P. S., De Hodgins, O.C., Hulbert, R.L. and Lacke, C.J. John Wiley & Sons Inc., Hoboken, New Jersey, 2010.

The Six Sigma Fieldbook: How to Successfully Implement the Six Sigma Breakthrough Management Strategy. Harry, M.J. and Linsemann, D. Doubleday Random House Inc., New York, March 15, 2005.

Demystifying the 1.5s Shift: Statistical Theory and Engineering Rationale. Harry, M.J. Palladyne Publishing. Phoenix, Arizona, 2003.

Six Sigma Knowledge Design: Illuminating the Path to Successful Deployment. Harry, M.J. Palladyne Publishing, Phoenix, Arizona, 2002.

Six Sigma: The Breakthrough Management Strategy: Revolutionizing the World's Top Corporations. Harry, M.J. and Schroeder, R. Doubleday, Random House Inc., New York, New York, 1999.

The Vision of Six Sigma. Harry, M.J. Volumes 1 through 8, Tri Star Publishing, Phoenix, Arizona, 1997.

The Vision of Six Sigma: The Tools of Breakthrough. Harry, M.J. Sigma Publishing Company, Phoenix, Arizona, 1994.

The Vision of Six Sigma: A Roadmap for Breakthrough. Harry, M.J. Sigma Publishing Company, Phoenix, Arizona, 1994.

One-Way Analysis of Variance. Harry, M.J. and Prins, J. Motorola University Press, Schaumberg, Illinois, 1991.

Six Sigma Producibility Analysis and Process Characterization. Harry, M.J. and Lawson, R. Publication 6s-3-03/88, Motorola University Press, Schaumberg, Illinois, Second Edition, 1990, pp. 1-125.

Six Sigma Mechanical Design Tolerancing. Harry, M.J. and Stewart, R. Publication 6s-2-10/88, Motorola University Press, Schaumberg, Illinois, Second Edition, 1988, pp. 1-60.

The Nature of Six Sigma. Harry, M.J. Government Electronics Group, Motorola Inc., Scottsdale, Arizona, First Edition, pp. 1-25, 1987.

Achieving Quality Excellence: The Management Perspective. Harry, M.J. Research Dynamics, Tempe, Arizona, Second Edition, Published by the Government Electronics Group, Motorola Inc., Scottsdale, Arizona, First Edition, 1986.

Achieving Quality Excellence: The Technical Perspective. Harry, M.J. Research Dynamics, Tempe, Arizona, Second Edition, Published by the Government Electronics Group, Motorola Inc., Scottsdale, Arizona, First Edition, 1986.

Achieving Quality Excellence: The Strategy, Tactics, and Tools. Harry, M.J. Research Dynamics, Tempe, Arizona, Second Edition, Published by the Government Electronics Group, Motorola Inc., Scottsdale, Arizona, First Edition, 1986

1. In the second paragraph of the middle column on page 11.87 of the article EM9706, it is stated: *Sigma is a statistical unit of measurement that means a standard deviation from a mean. All processes ... deviate because of human error or other circumstances. A Six Sigma process reduces that deviation to no more than 3.4 defects per million operations.* Rewrire this explanation in point form so as to make its meaning more accessible to a reader with*out* formal statistical training.
   - Discuss briefly the implications of this instance of explaining statistical ideas for the wider goal of making society more statistically informed.

2. In the second-last paragraph of the middle column on page 11.89, Six Sigma methods identified a long-standing wrong hole-size specification for circuit boards as the cause of a problem. Explain briefly how the discussion in this paragraph implies that this problem could have beed resolved much sooner and without Six Sigma.
   - Describe briefly how Deming's 14 points (on page 11.56 in Figure 11.10a) might have been useful in this situation.

3. In light of discussion in the article EM9706 of GE's adpotion of Six Sigma practices, commment critically on the following three statments from the middle paragraph of the right column in the Bombardier box on the lower half of page 11.90:
   - *Bombardier already has a corps of methods engineers and other personnel dedicated full time to quality.*
   - *... those who have been seconded from other areas are expected to increase productivity so dramatically that there will be no need to hire replacements.*
   - *... the greatest gains will not be in product quality, because its aircraft already meet Six Sigma quality, but in the rework on the assembly line, where processes hover at the Three to Four Sigma.*

4. Discussion overleaf in the middle column of the box on the upper half of page 11.91 refers to books about Six Sigma written by Harry. A Google search in December, 2025, yielded the 18 titles listed on the upper half of this page 11.92 (although there is some variation in title wording and authorship in related advertizing). From these titles and other information in the article EM9706, describe briefly what you infer about Harry's development and promulgation of Six Sigma.

5. In light of the information presented in this Figure 11.15, discuss critically the statement: *Creating a company culture where the overriding concern of every employee is quality, together with routine application of proceess (and statistical) thinking, is as important in achieving success as using the technical methodologies of Six Sigma.*