Origin of Six Sigma: Designing for Performance Excellence

The late Bill Smith, a reliability engineer at Motorola, is widely credited with originating Six Sigma and selling it to Motorola's legendary CEO, Robert Galvin. Smith noted that system failure rates were substantially higher than predicted by final product test. He suggested a number of possible causes for this phenomenon, including a dramatic increase in system complexity and the resulting opportunities for failure and a fundamental flaw in traditional quality thinking. He concluded that a much higher level of internal quality was required and convinced Galvin of the importance of setting Six Sigma as a quality goal. Smith's holistic view of reliability (as measured by mean time to failure) and quality (as measured by process variability and defect rates) was indeed new, as was the Six Sigma quality objective.

Prior to Smith's analysis, a number of gurus, including Joseph M. Juran, Dorian Shainin, Genichi Taguchi and Eliyahu Goldratt, had presented their programs for quality and productivity improvement at Motorola. Mikel Harry, president of the Six Sigma Academy and co-author of *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, attended some of these programs and developed a program for the Government Electronics Division of Motorola that included Juran's quality journey, statistical process control (SPC) and Shainin's advanced diagnostic tools (ADT) and planned experimentation (PE).

Harry later teamed with Smith on the Six Sigma initiative and created Motorola's Six Sigma Institute prior to forming his own firm. Smith and Harry's initial Six Sigma umbrella included SPC, ADT and PE. Later, they added design for manufacture (product capability and product complexity) and, as quality was linked to business performance, accomplishing quality through projects.

Motorola's design margin had been 25 percent (or 4σ or $Cp = 1.33$). When Smith noted that escaping and latent defects under this strategy were far too high, he reasoned that the disparity between actual reliability and the reliability expected at final test could be accounted for by increased product complexity and deviations of the process mean from the target value, arriving at a value of 1.5 sigma. The complexity phenomena had been noted previously by Wernher von Braun in the U.S. space program: If a large number of components must function for a system to accomplish its objective, the probability of system success diminishes rapidly as the number of components increases unless the reliability of each is essentially perfect. The 1.5-sigma deviation remains controversial, but it's not a fundamental issue. What is important is that Smith recognized that a process mean could not be maintained exactly on target, and when it deviated from target, the traditional three-sigma process produced large numbers of parts that exceeded specifications. Thus, this breaking with the three-sigma quality tradition was a major contribution, as was the recognition of the role of complexity, which dramatically increases the number of opportunities for (and thus, probability of) defects and the likelihood of subsequent system failure.

But what about the then-existing theory of optimal quality levels? Motorola observed that Japanese products were of much higher quality than was predicted by the traditional optimal quality level curves. Independently, Robert Cole investigated this issue and noted several reasons for this change in the quality viewpoint. Japanese quality professionals, he asserted, realized that the costs of poor quality were far larger than had been supposed; recognized that focusing on quality improvement as a companywide effort improved a wide range of performance measures; established a system that moved toward quality improvement and low-cost solutions simultaneously; shifted the focus of quality improvement from product attributes to operational procedures; developed a dynamic model in which customer demands for quality rise along with their willingness to pay for these improvements; and focused on preventing error at the source, thereby dramatically reducing appraisal costs.

As Motorola set out on its quality journey, Harry noted that the company ran into a five sigma wall. Motorola found that it could attain a three-sigma level by installing process improvement and control in its own installations, and improve this to the four- or five-sigma level through the education of its suppliers. However, Six Sigma only became possible once the company had attained a better understanding of the role of robust design—systems design, parameter design and tolerance design.

Not coincidentally, Motorola won the Malcolm Baldrige National Quality Award shortly after the rollout of Six Sigma. Receiving the Baldrige Award requires the winning company to present its concepts to the world. Thus, as Six Sigma was approaching adolescence, quality professionals at Motorola were describing their methods to their colleagues and learning how far Motorola had advanced in comparison to other companies. At this point Harry wrote a strategic vision for accelerating Six Sigma. This included a change in focus, anchoring quality by dollars and seeking a business transformation. It included a description of different competence levels in the Six Sigma methods, which, in the karate tradition, were designated by belts—Green Belt, Black Belt and Master Black Belt.

Elsewhere, GE's Jack Welch and AlliedSignal's Larry Bossidy (first at GE Financial) led their organizations' cultural change through Six Sigma initiatives. In 1998, *Business Week* reported that GE saved $330 million through Six Sigma, doubling its CEO's previous prediction. Welch has predicted a savings of $10 billion over five years. It's no wonder Six Sigma has gained industry's attention.