Design For Six Sigma
An Enabler for Global Engineering Teams

By Garron K. Morris

In the last few years, more companies are creating engineering teams in China, India, and Eastern Europe to take advantage of lower wages, leverage local intellect, and build a regional presence in order to remain competitive. This globalization of engineering has enabled companies to partition designs and delegate sub-system design ownership to the engineering team that has the best mix of experience, skills, and proximity to research and development, key suppliers, and manufacturing. Eventually, the sub-systems must be integrated into a product – which is likely the responsibility of another engineering team located in a different country. The biggest challenge faced by these global engineering teams is communication. There is a need for a common language that global engineering teams can use to communicate requirements and performance, as well as a common design method to ensure that the system will perform as designed when the sub-systems are integrated. Design for Six Sigma (DFSS) provides this common language and design methodology.

Six Sigma grew out of a successful initiative at Motorola in the late 1980s where quality was achieved by focusing on manufacturing defect-free products. As manufacturing quality improved, Motorola had to change their quality measurement from defects per thousand to defects per *million*. The term *Six Sigma* refers to a level of quality where no more than 3.4 defects per million occur, as well as a structured methodology for defining, measuring, analyzing, improving, and controlling variation. Motorola's success with Six Sigma in manufacturing was formally recognized in 1988 with the Malcolm Baldridge National Quality Award; however, they were only able to achieve about a four sigma level (6,210 defects per million).

DFSS emerged in the early 1990's as the focus quickly turned upstream to engineering. Companies like Lockheed Martin, Texas Instruments, General Electric as well as Motorola saw the need to apply Six Sigma techniques earlier in the design cycle and began to design in quality and manufacturability. Since early 2000, hundreds of companies have adopted Six Sigma and DFSS in engineering and manufacturing.

Engineers at companies that have adopted DFSS design statistically – that is, they analyze sources of variation, allocate acceptable levels of variation to sub-systems and components, and optimize designs to reduce variation. This Six Sigma approach to engineering has led to a common vocabulary where critical engineering requirements and performance are communicated as targets, upper and lower specification limits (USL, LSL), and an acceptable amounts of variation (DPMO or PNC). Common DFSS terms include:

- **CTQ:** Critical to Quality – a requirement that is key to creating a quality part or process.
- **Target:** The desired dimension or performance (a.k.a. design goal).
- **LSL:** Lower Specification Limit – the minimum acceptable dimension or performance.
- **USL:** Upper Specification Limit – the maximum acceptable dimension or performance.
- **DPMO:** Defects per Million Opportunities – the number of defects per million opportunities.
- **PNC:** Probability of Non-Compliance – the probability that a part or process will perform outside of the specified limits (a defect).

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A Global Example

A Critical to Quality (CTQ) requirement for an electrical engineer in India is DC voltage output from a power supply sub-system. An electrical engineer working on a different sub-system in China will use the output voltage to drive a circuit and communicates that for this CTQ, she has a lower specification limit (LSL) of 11V, an upper specification limit (USL) of 13V and has a target of 12V. The electrical engineer in India measures the output voltage on a number of samples of an existing power supply and plots the distribution shown in Figure 1. The number of defects was calculated to be PNC = 0.148 or 148,000 defects per million opportunities (DPMO), which was deemed unacceptable by the electrical engineer in China. She communicates that the circuit can tolerate a probability of non-compliance (PNC) no higher than 0.001.

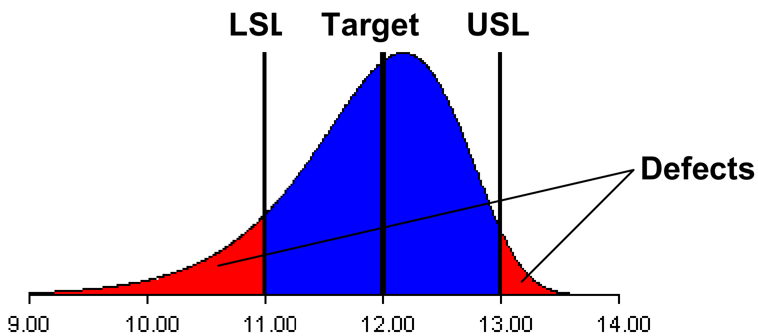

Figure 1. Distribution of voltage in the existing power supply.

Sources of variation in the existing power supply sub-system were identified and the power supply was redesigned. The new design was found to have a PNC of 0.0005 or 500 defects per million power opportunities (see Figure 2), which is half the allocated PNC of 0.001.

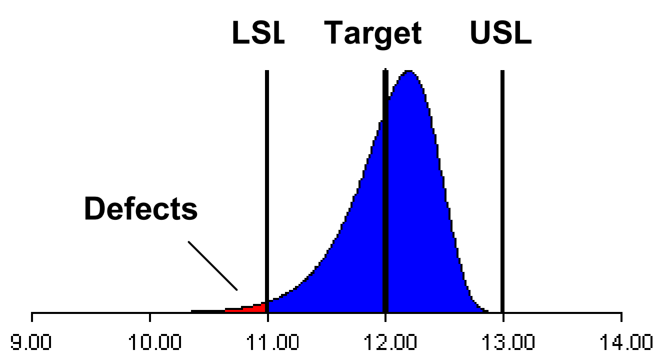

Figure 2. Distribution of voltage in the new power supply.

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Conclusion

DFSS provides a common language that allows global engineering teams to clearly communicate engineering requirements and performance. The focus of the DFSS methodology on analyzing variation, allocating variation, and optimizing designs to reduce variation also allows companies to have engineering teams all over the world design pieces of a system, knowing that the system will work when integrated. In years to come, more companies will see DFSS as an enabler for global engineering teams.

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