Six Sigma Innovation and Design

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INTRODUCTION

Six Sigma Innovation and Design theory, strategy and supporting methods have evolved along two primary pathways, A third path, referred to as *Lean Six Sigma*, has more recently emerged from integration of Six Sigma approaches with lean enterprise and manufacturing methods that leverage synergies between the two approaches (Bossert, 2003). The origin of Six Sigma theory and approaches at the end of the 1970s is ordinarily assigned to Motorola Corporation, but it is GE and its former CEO, Jack Welch, with which Six Sigma is most commonly associated. Its use in its many forms has proliferated due in large to its acknowledged contribution of multiple billions of dollars to the economic performance of many firms.

Six Sigma innovation applications typically seek to deliver significant stakeholder-driven improvements in key products, processes, systems or the enterprise itself using key levers of change that are referred to as critical to quality (CTQ) characteristics. The innovation algorithm applied in such applications is referred to as DMAIC and is a simple, yet logical scheme that demands the project in question to be carefully defined (D), with definition followed by measurement (M), analysis (A), improvement (I), and control (C) phases.

Six Sigma design projects may employ any from among a number of similar Design for Six Sigma (DFSS) algorithms with the most commonly applied one being DMADV, an acronym for Define-Measure-Analyze-Design-Verify (Edgeman, 2011a) and while there are many similarities between DMAIC and DMADV, there are also key differences, including in the specific definitions of Define, Measure and Analyze in the two algorithms (Cronemyr, 2007). DFSS applications differ from Six Sigma Innovation ones in that they are mostly commonly used in development of new products, processes or systems or in cases where existing ones are so seriously flawed, or so seriously disadvantaged in comparison to competing ones that "ground up" design provides the preferred path.

Lean Six Sigma methods derive from integration of Six Sigma with lean methods traceable to the Toyota Production System (TPS) that in their modern manifestation are commonly attributed to Taiichi Ohno (1988). Lean methodology fundamentally focuses on waste elimination so that the union of lean with Six Sigma takes simultaneous aim at both cost savings and value creation that contributes to organizational resilience and robustness (Edgeman, in press).

Whether a specific project is a Six Sigma Innovation one, calls for Design for Six Sigma, or requires application of Lean Six Sigma methodology, each project demands clear performance measure definition and expectations with performance measures representing either direct or surrogate CTQ indicators. Additionally, Six Sigma is ordinarily associated with "near perfect performance" that is often cited as "3.4 defects per million opportunities for a defect" (Montgomery & Woodall, 2008). Such performance levels are often aggressively and strategically pursued through use of response surface methodology (RSM), evolutionary operations (EVOP), or other optimization techniques (Myers, Montgomery, & Anderson-Cook, 2009) supported by such frequently used statistical software packages as Minitab or SAS.

Six Sigma Innovation, and Design for Six Sigma are discussed, with lesser attention dedicated to the related, but somewhat divergent topic of Lean

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Enterprise / Lean Six Sigma methods. Related topics addressed include distinctions between the COPIS approach to conception of business processes prior to their SIPOC implementation and execution (Edgeman, 2011b); commonly used supporting tools and techniques such as the Kano Needs Model and Quality Function Deployment or QFD (Tan & Shen, 2010); and product, process and system concept generation and selection.

BACKGROUND

Of many competing Six Sigma definitions, the following, adapted from Klefsjö, Bergquist and Edgeman (2006), is herein employed:

Six Sigma provides highly structured innovation, design, and lean enterprise strategies and methods for acquiring, assessing, and activating customer, competitor, and enterprise intelligence to deliver superior product, process, system, or enterprise performance leading to best and next best practices and sources of sustainable competitive advantage.

The highly structured strategies referenced in this formulation refer to DMAIC, DMADV, and Lean Six Sigma algorithms. General structure is found in each of these approaches, with the specific content of each highly dependent on the application context, interdisciplinary project team assembled, disciplinary traditions, and the collective knowledge array resident in team members. Superior performance may be defined in absolute terms or specific to the enterprise competitive context. Sustainable competitive advantage often relies not on application of Six Sigma or other strategies, but rather on enterprise enculturation and their effective and efficient use of such strategies in areas of strategic importance to the enterprise.

The need to significantly improve product and process performance through innovation provided much of the initial impetus behind Six Sigma, yet it is perhaps its status as a documented driver of superior financial performance that has led to its proliferation, subsequent diversification to design and lean environments, and dissemination across a number of application domains. In addition to traditional manufacturing applications of Six Sigma, significant gains in a number of "soft" or service application areas have been realized and include financial services (De Koning, Does, & Bisgaard, 2008), regional and national security (Edgeman, Bigio, & Ferleman, 2005), healthcare (Kaplan, Bisgaard, Truesdell, & Zetterholm, 2009), and energy production and distribution (Kaushik & Khanduja, 2009). In many of these latter applications, financial performance has been of secondary or tertiary importance and other considerations, such as ecological or societal sustainability has been deemed preeminent.

The key issue of "what is sigma?" remains. Symbolized by σ, the term 'sigma' is a measure of variation or "imperfection" widely recognizable as the standard deviation of process, product, or system output. Contextually, variation does not represent intentional introduced diversity, but is rather any departure from intended performance levels. *Higher* process sigma levels imply *lesser* standard deviation values so that higher sigma levels imply that a higher proportion of output or results lie within acceptable performance limits. Higher sigma levels thus imply reduced 'defect' levels where a defect is anything not matching a required performance profile.

The method used to estimate a sigma level differs depending on whether quantitative or qualitative information is being assessed, but in either case captures the capability of the underlying process to deliver required results (Montgomery, 2008). Relative to prior discussion we find that 'high sigma levels' are associated with more capable processes. Defects per million opportunities for defects (DPMO) in relation to sigma levels and associated cost or loss due to imperfections are reported in Table 1, similar content of which may be found in a large number of sources, including Montgomery and Woodall (2008). DPMO values