Service Design for Six Sigma: A Roadmap for Excellence
Basem El-Haik and David M. Roy. Hoboken, NJ: John Wiley & Sons, 2005. 417 + vii pages. US$84.95.

Axiomatic Quality: Integrating Axiomatic Design with Six-Sigma, Reliability, and Quality Engineering
Basem Said El-Haik. Hoboken, NJ: John Wiley & Sons, 2005. 280 + viii pages. US$89.95.

Design for Six Sigma as Strategic Experimentation
H. E. Cook. Milwaukee: American Society for Quality (ASQ), 2005. 348 + iii pages. US$85.00.

Design for Six Sigma (DFSS), is a technical methodology for *developing* complex systems, products, or services so that they meet customer requirements at launch. DFSS has a linage in engineering and statistics, but it has assimilated methodologies such as Voice of the Customer (VOC) and TRIZ (Russian acronym for the theory of inventive problem solving) that are familiar to the broader new product development community. The goal of DFSS is to design so as to avoid manufacturing process problems. DFSS follows a methodology known as DMADV: define, measure, analyze, design, and verify. DFSS had it origins in Six Sigma.

Six Sigma applies a process of DMAIC (define, measure, analyze, improve, and control). The purpose of Six Sigma is to solve *existing* manufacturing or service problems. The Six Sigma term has its origin in statistics and implies very low variation (in the parts-per-million range) and high performance levels. Typically, Motorola and General Electric are cited as supporters Six Sigma systems (DMAIC Six Sigma) for measuring defects and improving quality.

These DFSS books will appeal to new product developers who have an engineering or statistics background. They share an academic textbook style and contain mathematical proofs. The books will help readers transition from a technical feasibility viewpoint to a commercial feasibility viewpoint. Each of the books highlights a different aspect of DFSS. There is little overlap between the books because DFSS has a diverse and rich toolset.

The preface of *Service Design for Six Sigma* states "This book is the first to address service design for Six Sigma and to present an approach to applications via a supply chain design case study" (p. xx). To deliver a high-performance service, Basem El-Haik and David Roy state, "We need a system of methods and activities that can provide the overarching structure to successfully plan and develop the service. Such a system is called the quality operating system" (p. 4). Their 10-stage service life cycle includes (1) idea creation; (2) voice of the customer and business; (3) concept development; (4) preliminary design; (5) design optimization; (6) verification; (7) launch readiness; (8) mass production; (9) service consumption; (10) disposal/phase out. The "Service DFSS project road map" segments the service life cycle into "Identify, Conceptualize, Optimize, and Validate" phases and adds "DFSS Tollgate Requirements" and "DFSS Tools" (p. 78).

In chapter 7, El-Haik and Roy present all four phases of the quality function deployment (QFD) house of quality as a planning tool to address their stage 2 of the service life cycle – to translate customer needs and wants into focused design actions. In stage 3, the book develops concepts to fulfill the functional requirements obtained in Stage 2. In this stage, the design team is able to specify, "*what* needs to be accomplished to satisfy the customer wants" and not "*how* to accomplish these wants" (p. 5). Chapter 9 provides readers with the basics of TRIZ and states "TRIZ is a tool that can be used heavily in the DFSS road map conceptualize phase" (p. 189).

Chapter 12 covers topics such as design of experiments (DOE) – "a structured method for determining the transfer function relationship between factors affecting a process and the output of that process" (p. 310) -- and Analysis of Variance (ANOVA). Chapter 14, "Discrete Event Simulation" provides an introduction to modeling in the context of Six Sigma. El-Haik and Roy state, "The Six Sigma black belt will decide on the modeling approach by choosing a certain type of model to represent the actual

system." (pp. 335-6). In a service-based industry, such models could be used to characterize non-value-added time.

Chapter 15 begins with "The final aspect of DFSS methodology that differentiates it from the prevalent 'launch and learn' method is design validation… Design validation helps identify unintended consequences and effects of design, aids in development plans, and helps reduce risk for full-scale commercialization" (p. 365). El-Haik and Roy introduce a design validation flowchart (p. 366) and conclude, "Any go/no-go decision should be based on statistically significant criteria and all lessons learned should be incorporated into the final design if appropriate" (p. 377).

In the foreword of *Axiomatic Quality*, Professor Nam P. Suh states "To be successful, a company must have products that are multisuperior – that is, superior in design, technology, quality, reliability, and cost" (p. xiii). The precursor to understanding axiomatic quality is to understand axiomatic design. Axiomatic design is a theory and methodology developed by Professor Suh at the Massachusetts Institute of Technology. The two fundamental axioms are the independence axiom and the information axiom. El-Haik elaborates (p. 4) on these axioms, respectively:

- "Maintain the independence of the functional requirements." This axiom is used "to address the conceptual vulnerabilities" that are established due to the violation of design principles.
- "Minimize the information content in a design." This axiom addresses the operational design vulnerabilities that are created as a result of factors beyond the designer's control – noise factors. This can be stated as maximize the probability of success.

Axiomatic Quality can be diagramed as the intersection of Axiomatic Design and other components such as DFSS and Robust Design, which is also known as Taguchi methods or quality engineering.

El-Haik states that the design process involves three mappings among four domains customer attributes (CAs), functional requirements (FRs), design parameters (DPs), and process variables (PVs) (p. 5). In addition, axiomatic design requires a zigzagging, or iterative, method of mapping from FRs to DPs to FRs for a solution-neutral environment.

"The axiomatic quality process identifies premier design vulnerabilities in the concept stage and includes strategies to minimize them at the lowest possible cost" (pp. 15-6). The axiomatic quality process map (pp. 112-113) illustrates that these activities impact` Stages 2-5 of the service life cycle. During Stage 3, El-Haik states "Black belts as project leaders will implement the DFSS or axiomatic quality process and tools on project aligned with the business objectives. They lead projects, institutionalize a timely project plan, determine appropriate tool use, perform analyses, and act as the central point of contact for their projects" (p. 142).

Case studies include a global commercial process (pp. 161-70), a Transmission Vane Oil Pump (pp. 181-9), and a Passive Filter Design (pp. 260-5). El-Haik does not elaborate on synergy with marketing specialists. *Axiomatic Quality* advocates an engineering-centric approach to new product development. "Starting with the voice of the customer, axiomatic quality focuses on establishing a comprehensive design process that utilizes ingredients from comparative tools: quality engineering, axiomatic design, theory of inventive problem solving, deterministic optimization, and in the absence of quantitative data, fuzzy set theory" (p. xvi).

In *Design for Six Sigma as Strategic Experimentation*, *DFSS/SE*, H. E. Cook's intended audience is engineers, statisticians, and scientists involved in the product realization process. "Forecasts of cash flow, market share, and price are used to select the final design from among the alternatives considered." (p. xxv) A CD-ROM is included with this book to partially automate the computations. It contains Strategic Design Workbook files for many commonly used experimental designs and 12 tutorial files.

Cook states, "In a highly competitive marketplace, the following will always be true: (1) value -- the value of the product is too low; (2) cost -- its cost is too high; (3) innovation -- the pace of innovation is too slow. Success in a competitive marketplace is thus derived from timely and continuous improvement of the product's three fundamental metrics. If they are improved at a rate higher that that of major competitors, the desired bottom-line metrics will follow and the company will remain in business" (p. 4).

Cook enumerates four key tasks (p. 8) that form the basis of strategic experimentation within the overall DFSS/SE structure:

SE1: Setting financial targets - system level design
SE2: Multi-attribute value and cost analysis –

coupling of system level design attributes to value and cost

SE3: Statistical analysis of designed experiments – Influence of factors on the means and variance of attributes

SE4: Strategic analysis of designed experiments – Influence of factors on value, market share, price, and cash flow

These four tasks provide the outline for the book.

Chapter 3 defines entrepreneurial engineering as a skill set of engineers participating in the highly competitive, global market in regard to commercial superiority as well as technical feasibility. This chapter includes a discussion of the theoretical set of prices where the price war stops - the Cournot/Bertrand (CB) price model. A discussion of the system viewpoint presents an insight of adding a product feature even if its associated cost is greater than its added value when considered alone. Chapter 6 illustrates how Monte Carlo simulation can be used to develop confidence levels for financial metrics.

A key insight of Chapter 10 is that "Strategic significance is influenced by the range of uncertainty in both the mean and variance for the CTV (critical to value) attribute of interest" (p. 165). This is explored using a problem of computer monitor illumination intensity. Chapter 11 acknowledges that "Things can go wrong in planned experiments" (p. 175) and then illustrates several means for recovery. The remaining chapter titles are "Applications of Lognormal, Binomial, and Poisson Distributions," (12) "LIB and the Weibull Distribution," (13) "Signal-Response (Dynamic and Multiple Target) Problems," (14) and "Strategic Response Surface Maps" (15).

Many of the techniques and strategies assimilated into DFSS are identical to those advocated by PDMA for new product development. These three books confirm that DFSS is an umbrella term that has its origins in engineering but that the goal of "developing the product correctly" is shared by developers in both communities.

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