Chapter 1

Introduction

This introductory chapter defines the goals of this book with a structured approach to successfully deploy Design for Lean Six Sigma (DFLSS) in any organization. The chapter introduces DFLSS road map that will form a basis for the entire book. The chapter also provides summaries of various chapters in the book and their relation to with each other. It also provides a discussion on the differences between this book and other DFSS books in the market.

1.1 THE GOAL

The goal of this book is to outline a holistic DFLSS approach that businesses can adopt to energize their innovation process, perfect their product introduction process, and improve their new product/service development process. This book will also address the end-to-end DFLSS deployment process with a road map that promises a significantly improved and highly effective methodology compared to other problem solving and design approaches.

Six Sigma has been successfully applied in a variety of industries and functions to solve business problems and improve performance of products, processes, and services. Designing a product, process, or service to provide the intended function at the lowest cost with Six Sigma quality level (3.4 defects per million opportunities) is referred to as Design for Six Sigma (DFSS). This book focuses on the application of the Design for Lean Six Sigma (DFLSS) methodology to achieve desired intent. The approach we provide is a structured, systematic, and disciplined methodology to execute the design process without reducing the importance of designer's intuition and design experience. This, in turn, strikes a balance between rigor and creativity, resulting in optimal design cycle times. The proposed strategy will ensure the following:

- Market driven designs, preventing overdesigns
- Fast, reliable, and more predictable development times
- Focused innovation and inventiveness for growth
- Measurable design activity
- Traceable design logic
- Quick and effective design upgrades
- Robust and reliable designs
- Minimized complexity
- Flexible and modular design
- Designs or redesigns at a six-sigma level

1.2 DESIGN FOR SIX SIGMA – STATE OF THE ART

There are several DFSS books in the market. We have conducted a thorough review of existing books. These books provide a basic overview of DFSS, and some present a collection of tools that will aid DFSS process with very good descriptions and examples. What is missing in these books – and what this book aims to provide – is a structured road map with descriptions

of various concepts, tools, and techniques in both engineering and service context. *Design for Lean Six Sigma* (DFLSS) provides illustrations and case studies with real-life examples so that the reader can easily understand and utilize the concepts. Since we are combining DFSS method with lean principles, our methodology referred to as Design for Lean Six Sigma (DFLSS).

We consider that this book stands on its own on the following points:

- This book integrates various concepts, principles, and tools in a unique way for the successful deployment of DFLSS.
- This book offers DFLSS methodology with examples from both service and manufacturing applications.
- This book helps practitioners understand the DFLSS road map in systematic way with emphasis on practical examples and case studies.

It is to be noted that although techniques like quality function deployment (QFD), failure mode and effect analyses (FMEA) and pugh concept selection are very important in DFLSS process, we are not providing descriptions on these topics since there is extensive literature available on these topics.

1.3 APPROACH

The overall approach to meeting the goal of this book is developed based on the road map to deploy DFLSS in all type of industries across the globe. In our road map, DFLSS processes are synchronized and are aimed at helping the organizations design processes in a systematic and meaningful way. This totally modular DFLSS approach allows a flexible methodology that is adaptable to every existing or new design process, independent of the model chosen or used in the organizations.

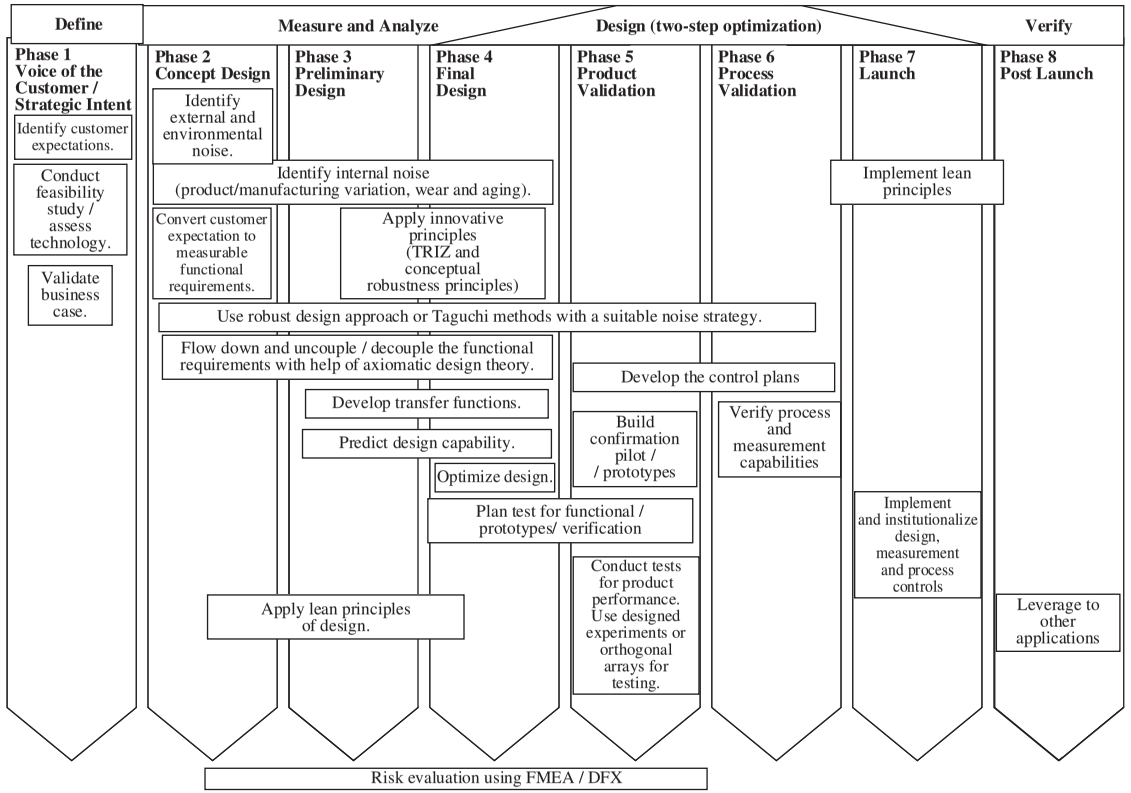

Figure 1.1 DFLSS Roadmap using DMADV (Define, Measure, Analyze, Design, and Verify) Approach.

Figure 1.1 gives various phases of the DFLSS methodology. Various engineering, managerial and statistical concepts, tools, and philosophies are integrated and used in a systematic fashion to achieve Six Sigma quality levels. This DFLSS road map is built in accordance with DMADV (define, measure, analyze, design, and verify) methodology. It is an eight-phase approach that covers all the requirements of DMADV and is aligned to the following main steps:

1. **Define** – Identify customer needs and strategic intent.
2. **Measure and analyze** – Deliver the detailed design by evaluating various design alternatives.
3. **Design** – Design from a productivity (business requirements) and quality point of view (customer requirements), and realize it.
4. **Verify** – Pilot the design, update as needed and prepare to launch the new design.

Phase 1: Customer expectations – In this phase, the customer expectating are identified. After this step, a feasibility study needs to be conducted, and the business case is validated. This corresponds to the *define* step in the DMADV approach.

Phase 2: Concept design – Customer expectations are converted to actionable and measurable functional requirements. Functional requirements are also referred to as critical quality characteristic (CTQs). In this phase, the expectations are flowed to lower levels to understand the design requirements better and come up with good concepts. Application of robust design approach through identification internal (inner) and external (outer) noise will also takes place in this step.

Phase 3: Preliminary design – A detailed design is identified by evaluating various design alternatives. In this phase also, flow down approach and robust design strategies will be used. Pugh concept selection process may be used to select the best alternative against required criteria such as cost or cycle time.

Phases 2 and 3 correspond to the *measure* and *analyze* steps of the DMADV approach.

Phase 4: Final design – The design from a productivity (business requirements) and quality point of view (customer requirements) is developed. Development of transfer function, Taguchi methods of robust design, and two-step optimization are very important in this phase for the purpose of optimization. Readers can refer to Chapter 10 for Taguchi methods and two-step optimization. The capability of the design is also predicted in this phase.

Phase 5: Product validation – Final design is tested against predicted performance and capability. A pilot design is created and confirmation run is conducted to validate the performance of the design. Once this is done, a control plan will be put in place to sustain the gains.

Phase 6: Process validation – The process that was used to build the product is measured and verified, and an appropriate control plan is selected for process variables.

Phase 7: Product launch – The final design is brought to actual practice and results of earlier phases are implemented. The design, measurement controls, and process controls are institutionalized.

Phases 5 to 7 correspond to the *design* step of the DMADV approach.

Phase 8: Postlaunch – The results of this product design are verified and if possible leveraged with other applications. This step corresponds to the *verify* step of the DMADV approach.

1.4 GUIDE TO THIS BOOK

The following brief descriptions of the various chapters will help readers quickly browse through the contents of this book.

Chapter 1 is an introductory chapter that provides goal of this book, an approach for DFLSS deployment with the help of a road map and other distinctive features of this book.

Chapter 2 highlights the role of innovation for growth and survival in the market place. The focus of creating the future is to drive growth and achieve long-term objectives. It also describes the role of management of such organization for successfully integrating and separating cultures, processes, systems, and structures that operate at opposing levels.

Chapter 3 provides a process for systematic innovation by focusing on the evolution aspect of identifying and creating newer and better promises to the customers through innovations resulting in new and better-performing products.

Chapter 4 gives a brief introduction to Lean Six Sigma methodology, including *Define, Measure, Analyze, Improve, and Control* (DMAIC) phases, the concept of variation, and the concept of lean designs. The chapter also briefly highlights the importance of various tools, techniques, philosophies, and concepts of Six Sigma and principles of elimination of waste.

Chapter 5 explores how we might create a system across the organization to deploy the principles of Design for Lean Six Sigma (DFLSS). It also talks about creating an infrastructure and establish a governance structure that promotes the deployment objective if the principles of DFLSS were to become pervasive and the processes of DFLSS were to be followed rigorously.

Chapter 6 describes how we capture *voice of the customer* (VOC) by understanding customer needs and mapping them

into functional domain, and then create products or service in such way that these needs are met flawlessly, thus providing value for the customers. This chapter is very important to DFLSS methodology.

Chapter 7 is dedicated for *axiomatic design*. This theory helps us map VOC into the functional domain; map functional domain to physical domain; and map physical domain to process domain to enable us to follow a process to flawlessly design a product or service to satisfy customer needs. The chapter describes two axioms related to this subject: independence axiom and information axiom with examples.

Chapter 8 is dedicated to implementing lean design strategies and related approaches that are required for DFLSS. These strategies aim to maximize value and minimize waste. The chapter also gives brief introduction to 3P process, as popularized by Toyota.

Chapter 9 provides a discussion on the theory of inventive problem solving (TRIZ) methodology, with a systematic road map and examples. A distinctive feature of this chapter is that we have included an add-on section to TRIZ in the form of *robustness through inventions*. This section gives about nineteen principles that would be helpful to create robust concepts. These principles are classified by using the elements of parameter diagram, or p-diagram.

Chapter 10 gives an overview for design for robustness-based Taguchi approach for robust engineering. Robustness concepts are very important for DFLSS, and strategies for countering noise effects can help increase market share of a company in this competitive world. This chapter describes different aspects of quality, strategies for reducing effects of noise factors, role of signal-to-noise ratios, and importance of simulations in the design for robustness. Real-world

case studies are used as examples to illustrate concept of robustness.

Chapter 11 provides a new method for testing a system (product or service) by using designed experiments or orthogonal arrays. It helps in testing the product under various customer usage conditions and studying two-factor combination effects, in addition to main factor effects. The methodology is explained with the help of case studies and is useful in later stages of DFLSS methodology.

Chapter 12 discusses the development of multivariate measurement system using the *Mahalanobis–Taguchi Strategy* (MTS). MTS applies in situations where we have to make decisions based on more than one variable or characteristic of the system. These systems are known as *multidimensional systems*. This method will be helpful in creating a measurement system in multidimensional cases and thus is in line with Six Sigma–based thinking, where we always talk about metrics and challenges associated with measuring success of the system with a higher degree of confidence.