
Dimensioning and Tolerancing Handbook

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About the Editor

Paul Drake is a Principal Engineer with Honors at the Raytheon Systems Company where he trains and consults in variation management, GD&T and Six Sigma mechanical tolerancing. He began the Mechanical Tolerancing and Performance Sigma Center for Excellence at Raytheon (formerly Texas Instruments, Inc.) in 1995. This center develops and deploys dimensioning and tolerancing best practices within Raytheon. As a member of the Raytheon Learning Institute, Paul has trained more than 3,500 people in GD&T and mechanical tolerancing in the past 12 years. He has also written numerous articles and design guides on optical and mechanical tolerancing.

Paul has ASME certification as a Senior Level GD&T Professional. He is a Subject Matter Expert (SME3) to ASME's Statistical Tolerancing Technical Subcommittee, a member of ASME's Geometric Dimensioning and Tolerancing Committee, a Six Sigma Blackbelt, and a licensed professional engineer in Texas. He holds two patents related to mechanical tolerancing.

Paul resides in Richardson, Texas, with his wife Jane and their three children.

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I wish to dedicate this book to God; my parents, Anne and Paul Drake; and my wife Jane and children Taylor, Ellen, and Madeline.

Between the covers of this remarkable text one can experience, at near warp speed, a journey through the cosmos of subject matter dealing with dimensioning and tolerancing of mechanical products. The editor, as one of the contributing authors, has aptly summarized the content broadly as “about product variation.” The contained chapters proceed then to wend their way through the various subjects to achieve that end. Under the individual pens of the authors, the wisdom, experience, writing style, and extensive research on each of the concerned topics presents the subject details with a unique richness. The authors, being widely renowned and respected in their fields of endeavor, combine to present a priceless body of knowledge available at the fingertips of the reader.

If not a first, this text surely is one of the best ever compiled as a consolidation of the contained related subjects. While possibly appearing a little overwhelming in its volume, the book succeeds in putting the reader at ease through the excellent subject matter arrangement, sequential flowing of chapters, listing of contents, and a complete index. The details of each chapter are self-explanatory and present “their story” in an enlightening, albeit challenging sometimes, individual style. Collectively, the authors and their respective chapters seem to reflect considerations and lessons learned from the past, inspiration and creativity for the state-of-the-art of the present, and insightful visions for the future. This text then equally represents a kind of status report of the various involved technologies, guidance and instruction for absorbing and implementing technical content, and some direction to the future path of progress.

Reflecting upon the significant contribution this text adds to the current state of progress on the contained subjects, a feeling of confidence prevails that there is no fear for the future— to the contrary, only a relish for the enlarging opportunities time will provide. Congratulations to the editor, Paul Drake, for his insight in conceiving this text and to all the authors and contributors. Your product represents a major achievement in its addition to the annals of product engineering literature. It is also a record of our times and a glimpse of the future. It is a distinct pleasure to endorse this text with added thanks for all the dedicated energy expended in behalf of this project and the professions involved. Your work will bring immediate returns and will also instill a pride of accomplishment on behalf of yourselves, our country, and the global community of industrial technology.

Lowell W. Foster
Lowell W. Foster Associates, Inc.
Minneapolis, Minnesota

This book is about transitioning from mechanical product design to manufacturing. The cover graphic illustrates two distinct phases of product development. The gear drawing (computer model) represents a concept that is perfect. The manufactured gear is imperfect. A major barrier in the journey from conceptual ideas to tangible products is *variation*. Variation can occur in the manufacturing of products, as well as in the processes that are used to develop the products.

This book is about mechanical product variation: how we understand it, how we deal with it, and how we control it. As the title suggests, this book focuses on *documenting* mechanical designs (dimensioning) and *understanding* the *variation* (tolerancing) within the product development process. If we accept all product variation into our design, our products may not function as intended. If we throw away parts with too much variation, our product costs will increase.

This book is about how we balance product variation with customer requirements. We generally deal with product variation in three ways.

- We *accept* product variation in our designs;
- We *control* product variation in our processes; or
- We *screen out* manufactured parts that have more variation than the design will allow.

Many experts refer to this balance between design requirements and manufacturing variation as *dimensional management*. I prefer to call it *variation management*. After all, variation is usually the primary contributor to product cost.

In order to manage variation we must understand how variation impacts the mechanical product development process.

This book is process driven. This book is not *just* a collection of related topics. At the heart of this book is the variation management process. Fig. P-1 shows a generic product development process, and captures the key activities we put in place to manage product variation. Your product development process may be similar in some areas and different in others, but I believe Fig. P-1 captures the essence of the design process.

Fig. P-1 does not try to document everything in the variation management process. This information is contained within the chapters. The purpose of Fig. P-1 is twofold; first, it gives a birds-eye view of the process to help the reader understand the “big-picture,” and second, it is a starting point to show the reader where each chapter in the book fits into this process.

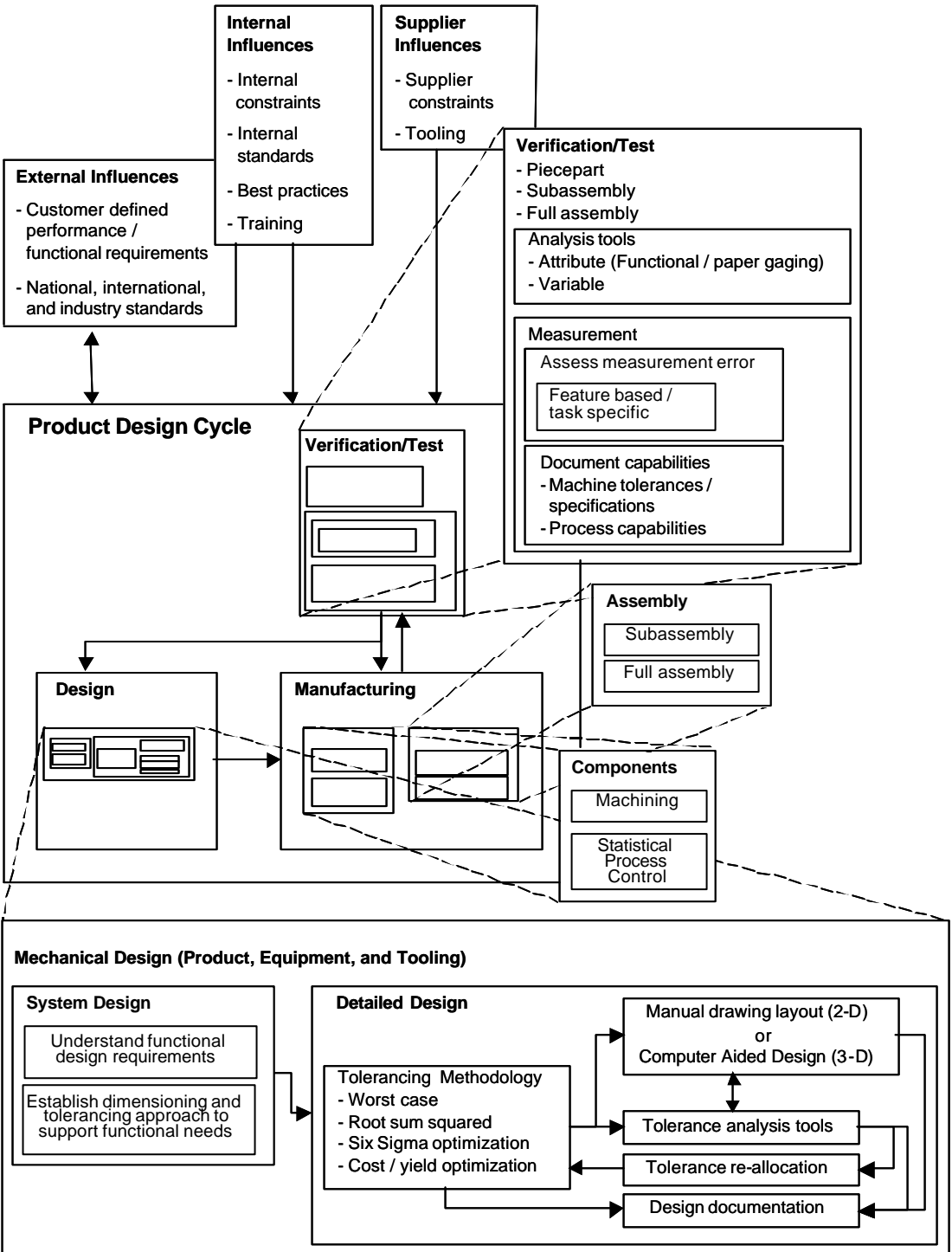


Figure P-1 Product development process

Each chapter of this book is linked to the product development process. The book is divided into seven parts that map to the process. Each chapter details the activities associated with the variation management process. By no means does this book capture everything. Although there is a wealth of information here, there is an endless amount of information that we could add. Likewise, new techniques, processes, and technologies will continue to evolve.

Although each chapter is a piece of the variation management puzzle, each chapter can stand alone. In practice, however, it is important to understand how each piece of the puzzle relates to others.

This book is about assessing design risk. If we understand the sources of product variation, and we understand the process(es) to manage them, we are well on our way to designing competitive products that meet customer requirements. If we capture the sources of variation and input these into the design process, we can assess the risk of meeting the manufacturing requirements as well as the performance of our designs.

Several experts contributed to this book. Each chapter reflects a wealth of experience from its author(s), many of whom are nationally and internationally recognized experts in their fields. This book could not contain the depth of information that it contains, without so many qualified contributors.

The audience for this book is very broad. Because it looks at the entire process of managing product variation, the audience for this book is large and very diverse. As a minimum, however, I suggest that everyone read the first chapter and the last chapter. Chapter 1 is a high-level historical perspective of where product quality has focused in the past. Chapter 26 is a compilation of where we think we will be in the future. Chapters 2 through 25 tell us how we are getting there today.

I appreciate any comments you have. Please send them to me at pdrake@mechsigma.com.

Paul Drake