

Preface

This book is primarily for seniors and graduate students in engineering and business and professionals interested in acquiring knowledge of three fundamental processes associated with system development—requirements discovery, trade-off studies, and risk analysis. These three important technical areas are covered in a unified manner in this single, easy-to-read volume. This book is organized into seven parts, with each part comprising multiple independent, self-contained chapters. This structure allows both instructors and students to read the chapters in the order of their need, preference, or interest. It can be used as a textbook for a single course covering the three main topic areas or as a reference text for three separate courses, each covering a topic area. This flexibility should appeal to faculty members, students, professional development instructors, and consultants.

This is a learner-centric book. It allows students to access a relevant body of knowledge from a single source rather than scouring multiple volumes to find the needed information. The examples employed to illustrate the use of different methods also discuss potential pitfalls to avoid when using them. The examples are small enough to be cognitively manageable and rich enough to convey key concepts and highlight key aspects of the methods. A strategy that we employed in scoping the illustrative problems was to ensure that each one spanned the process being discussed, rather than resort to multiple, disconnected examples. The continuity provided by having a few illustrative examples that serve as a common thread across the process being discussed is a distinguishing feature of this book that should make it an easy read.

We cover requirements discovery, trade-off studies, and risk analysis—three core processes in system development, product reengineering, and service design and implementation. We specifically address human cognitive biases and heuristics and their implications while executing these processes. We draw attention to the fact that while on the surface these processes appear to be distinctly different, employ different vocabularies, and require different inputs, they have the same underlying structure and process pattern. We exploited this recognition to identify a

general process and thereby reduced the cognitive load on the readers. In other words, learning how to perform one process facilitates the learning of the others.

Requirements discovery, trade-off studies, and risk analysis are critical and recurrent processes that come into play when developing, redesigning, and deploying systems. These processes require human judgment and frequent assessments. And we know that human judgment can be fallible and humans tend to exhibit significant variability arising from cognitive biases and occasional misapplication of heuristics that can throw off carefully planned trade-off studies and risk analyses. To circumvent these outcomes, we offer recommendations on how to exploit heuristics to cope with problem and system complexity and mitigate the effects of cognitive biases when conducting trade-off studies and performing risk analyses. This is another key discriminator of this book.

The requirements for deriving maximum value from this book are quite modest. You need to be conversant in using calculators and Microsoft Excel® spreadsheets. Knowledge of modeling languages such as UML and SysML is desirable, but not necessary. Knowledge of basic mathematics is also desirable but not necessary to appreciate the full impact of sensitivity analyses and scoring functions—two key functions employed in trade-off studies. Learners unfamiliar with the underlying mathematics can skip the mathematical material without experiencing lack of continuity. This book invites the reader to explore the richness of requirements discovery, trade-off studies, and risk analyses. The illustrative examples provide a continuous thread through each core process. On rare occasions, the illustrative examples can appear to be somewhat long. However, in those instances that length is necessary to illuminate the different aspects of the methods. Such is the case when making multiple iterations through a process in light of new evidence.

This book reflects our real-world experiences in academia and industry. We have had the rare opportunity to be involved in the early and late stages of development of systems ranging from smart portable devices to missiles, satellite networks, spacecraft, commercial aircraft, and electrical power grids, to command and control of complex system-of-systems. The opportunity to participate in the development of systems of such vastly different scales has given us valuable perspectives that we have shared with you in this volume.

We enjoyed writing and assembling the various chapters of this book with you, the intended audience, in mind. We hope you will find the illustrative examples and homework problems to be informative, *fun*, and insightful. We expect to refine and add to the content based on the feedback we receive from you.

You are about to embark on the journey of unraveling the mysteries and understanding the nuances of requirements discovery, trade-off studies, and risk analysis. We hope that you will find the journey rewarding in understanding and applying the methods. And we hope that the methods will prove to be of value when you are engineering new systems or redesigning existing systems and services.

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