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国外大学优秀教材——工业工程系列（影印版）

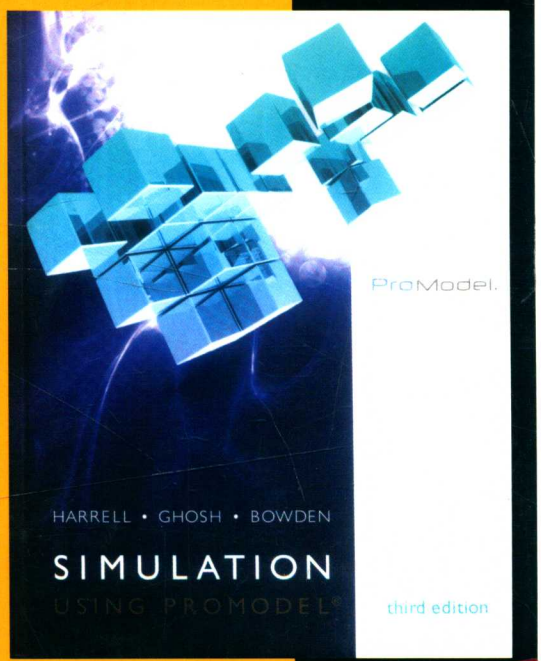
Charles Harrell, Biman K. Ghosh, Royce O. Bowden

系统仿真及ProModel软件应用

（第3版）

Simulation Using ProModel

(Third Edition)



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Forward

This textbook series is published at a very opportunity time when the discipline of industrial engineering is experiencing a phenomenal growth in China academia and with its increased interests in the utilization of the concepts, methods and tools of industrial engineering in the workplace. Effective utilization of these industrial engineering approaches in the workplace should result in increased productivity, quality of work, satisfaction and profitability to the cooperation.

The books in this series should be most suitable to junior and senior undergraduate students and first year graduate students, and to those in industry who need to solve problems on the design, operation and management of industrial systems.

Gavriel Salvendy

Department of Industrial Engineering, Tsinghua University

School of Industrial Engineering, Purdue University

April, 2002

前　言

本教材系列的出版正值中国学术界工业工程学科经历巨大发展、实际工作中对工业工程的概念、方法和工具的使用兴趣日渐浓厚之时。在实际工作中有效地应用工业工程的手段无疑将会提高生产率、工作质量、合作的满意度和效果。

该系列中的书籍对工业工程的本科生、研究生和工业界中需要解决工程系统设计、运作和管理诸方面问题的人士最为适用。

加弗瑞尔·沙尔文迪
清华大学工业工程系
普渡大学工业工程学院（美国）
2002 年 4 月

Dedication

To Paula, Raja, and Pritha
B.K.G.

To Yvonne, Emily, Elizabeth, Richard, Ryan, and Polly
C.H.

To CeCelia, Taylor, and Robert
R.O.B.

Charles Harrell

Charles Harrell is an associate professor of engineering and technology at Brigham Young University and founder of PROMODEL Corporation. He received his B.S. from Brigham Young University, M.S. in industrial engineering from the University of Utah, and Ph.D. in manufacturing engineering from the Technical University of Denmark. His area of interest and expertise is in manufacturing system design and simulation. He has worked in manufacturing and systems engineering positions for Ford Motor Company and the Eaton Corporation. At BYU he teaches courses in manufacturing systems, manufacturing simulation, and manufacturing information systems. He is the author or coauthor of several simulation books and has given numerous presentations on manufacturing system design and simulation. He serves on the board of directors of PROMODEL Corporation. He is a senior member of IIE and SME. He enjoys sports and playing with his grandchildren.

Biman K. Ghosh

Biman K. Ghosh is a professor of industrial and manufacturing engineering at the California State Polytechnic University, Pomona. He has been teaching and consulting all over the United States for the past 25 years. Prior to that Dr. Ghosh worked for such multinational companies as Tata, Mercedes Benz, Sandvik, and Siemens. Dr. Ghosh has been a consultant to Northrop Grumman, McDonnell Douglas, Boeing, Rockwell, Loral, Visteon, UPS, Sikorsky, Baxter, Paccar, Johnson Controls, Powersim, and Galorath. Dr. Ghosh has published extensively. His teaching and consulting interests are in the areas of simulation, supply chain management, lean manufacturing, flexible manufacturing, cellular manufacturing, computer-aided manufacturing, design for manufacturing, design of experiments, total quality management, and work measurement. His passion is still and video photography.

Royce O. Bowden

Royce Bowden is professor and head of Industrial and Systems Engineering at Mississippi State University. Prior to joining Mississippi State, Dr. Bowden worked in manufacturing engineering positions with Texas Instruments and Martin Marietta Aerospace. His research program centers on the use, development, and integration of simulation, artificial intelligence, and statistical techniques to solve systems engineering problems and has been funded by organizations such as the National Science Foundation, United States Department of Transportation, and the National Space and Aeronautics Administration. Dr. Bowden's research provided the foundation for the first widely used commercial simulation optimization software. He is the author (or coauthor) of numerous research papers and two simulation books. Dr. Bowden serves on the executive board of the Boy Scouts of America Pushmataha Area Council and enjoys organizing and participating in high adventure outdoor programs for the youth.

FOREWORD

Simulation is a modeling and analysis technique used to evaluate and improve dynamic systems of all types. It has grown from a relatively obscure technology used by only a few specialists to a widely accepted tool used by decision makers at all levels in an organization. Imagine being in a highly competitive industry and managing a manufacturing or service facility that is burdened by outdated technologies and inefficient management practices. In order to stay competitive, you know that changes must be made, but you are not exactly sure what changes would work best, or if certain changes will work at all. You would like to be able to try out a few different ideas, but you recognize that this would be very time-consuming, expensive, and disruptive to the current operation. Now, suppose that there was some magical way you could make a duplicate of your system and have unlimited freedom to rearrange activities, reallocate resources, or change any operating procedures. What if you could even try out completely new technologies and radical new innovations all within just a matter of minutes or hours? Suppose, further, that all of this experimentation could be done in compressed time with automatic tracking and reporting of key performance measures. Not only would you discover ways to improve your operation, but it could all be achieved risk free—without committing any capital, wasting any time, or disrupting the current system. This is precisely the kind of capability that simulation provides. Simulation lets you experiment with a computer model of your system in compressed time, giving you decision-making capability that is unattainable in any other way.

This text is geared toward simulation courses taught at either a graduate or an undergraduate level. It contains an ideal blend of theory and practice and covers the use of simulation in both manufacturing and service systems. This makes it well suited for use in courses in either an engineering or a business curriculum. It is also suitable for simulation courses taught in statistics and computer science programs. The strong focus on the practical aspects of simulation also makes it a book that any practitioner of simulation would want to have on hand.

This text is designed to be used in conjunction with ProModel simulation software, which accompanies the book. ProModel is one of the most powerful and popular simulation packages used today for its ease of use and flexibility. ProModel was the first fully commercial, Windows-based simulation package and the first to introduce simulation optimization. ProModel is already being used in thousands of organizations and taught in hundreds of universities and colleges throughout the world. While many teaching aids have been developed to train individuals in the use of ProModel, this is the first full-fledged textbook written for teaching simulation using ProModel.

Simulation is definitely a learn-by-doing activity. The goal of this text is not simply to introduce students to the topic of simulation, but to actually develop competence in the use of simulation. To this end, the book contains plenty of real-life examples, case studies, and lab exercises to give students actual experience in the use of simulation. Simulation texts often place too much emphasis on the theory behind simulation and not enough emphasis on how it is used in actual

problem-solving situations. In simulation courses we have taught over the years, the strongest feedback we have received from students is that they wish they had more hands-on time with simulation beginning from the very first week of the semester.

This text is divided into two parts: a section on the general science and practice of simulation, and a lab section to train students in the use of ProModel. While the book is intended for use with ProModel, the division of the book into two parts permits a modular use of the book, allowing either part to be used independently of any other part.

Part I consists of study chapters covering the science and technology of simulation. The first four chapters introduce the topic of simulation, its application to system design and improvement, and how simulation works. Chapters 5 through 10 present both the practical and theoretical aspects of conducting a simulation project and applying simulation optimization. Chapters 11 through 13 cover specific applications of simulation to manufacturing, material handling, and service systems.

Part II is the lab portion of the book containing exercises for developing simulation skills using ProModel. The labs are correlated with the reading chapters in Part I so that Lab 1 should be completed along with Chapter 1 and so on. There are 13 chapters and 13 labs. The labs are designed to be self-teaching. Students are walked through the steps of modeling a particular situation and then are given exercises to complete on their own.

This text focuses on the use of simulation to solve problems in the two most common types of systems today: manufacturing and service systems. Nearly 15 percent of the U.S. workforce is employed in manufacturing. In 1955, about one-half of the U.S. workforce worked in the service sector. Today nearly 80 percent of the American workforce can be found in service-related occupations. Manufacturing and service systems share much in common. They both consist of activities, resources, and controls for processing incoming entities. The performance objectives in both instances relate to quality, efficiency, cost reduction, process time reduction, and customer satisfaction. In addition to having common elements and objectives, they are also often interrelated. Manufacturing systems are supported by service activities such as product design, order management, or maintenance. Service systems receive support from production activities such as food production, check processing, or printing. Regardless of the industry in which one ends up, an understanding of the modeling issues underlying both systems will be helpful.

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Online Supplements

In addition to the printed text, numerous supplemental materials are available on the McGraw-Hill Web site at www.mhhe.com/harrell3e. These include case studies, PowerPoint slides and ProModel software downloads. The case studies are taken mostly from actual scenarios that can be assigned as simulation projects. They are intended as capstone experiences to give students an opportunity to bring together what they have learned in the course to solve a real-life problem.

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No work of this magnitude is performed in a vacuum, independently of the help and assistance of others. We are indebted to many colleagues, associates, and other individuals who had a hand in this project. John Mauer (Geer Mountain Software) provided valuable information on input modeling and the use of Stat::Fit. Dr. John D. Hall (APT Research, Inc.) and Dr. Allen G. Greenwood (Mississippi State University) helped to develop and refine the ANOVA material in Chapter 9. Kerim Tumay provided valuable input on the issues associated with service system simulation.

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Thanks to all of the students who provided valuable feedback on the first and second editions of the text. It is for the primary purpose of making simulation interesting and worthwhile for students that we have written this book.

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BRIEF CONTENTS

CONTENTS

PART I

STUDY CHAPTERS

注:阴影部分内容本影印版已删除。