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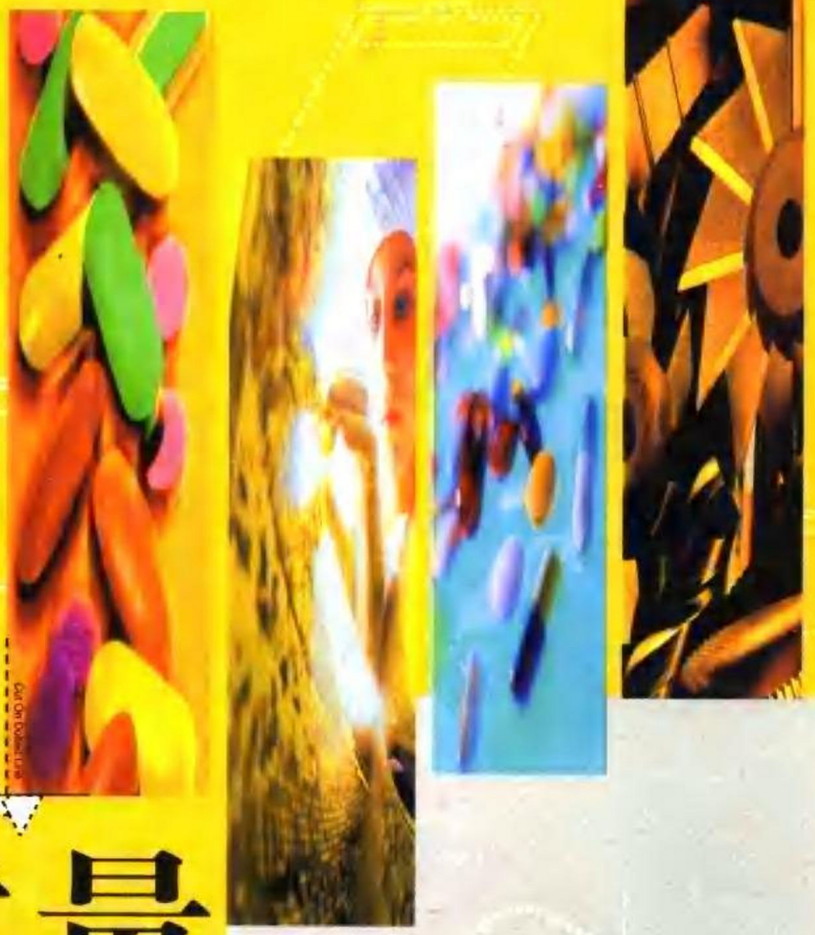

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(英文版 · 第7版)

# Statistical Quality Control

(SEVENTH EDITION)

机械工业出版社 McGraw-Hill

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# 出版者的话

在全球经济一体化的激烈竞争格局中，中国正处于前所未有的经济与产业结构调整与转型的关键时期。飞速发展的社会与错综复杂的变革要求我们的经济与管理水平有一个飞跃。

为了能让读者系统地学习、借鉴国际上先进的管理理论、方法和手段，机械工业出版社从一些世界著名出版公司引进了一批一流品质的经济管理名著，组成了这套《世界经济管理文库》。其中所选图书均为当前国际上最为流行和权威的教材，大部分多次修订重版，有的多达十几版。作者都是哈佛、芝加哥、斯坦福等著名商学院的教授，使您足不出国，便可领略世界知名学府的文化精粹。

为了给中国的MBA教学提供一套完整的MBA系列教材，继与清华大学经管学院、加拿大毅伟管理学院合作共同策划出版的《国际通用MBA教材》与《国际通用MBA教材配套案例》丛书之后，近期，我社又和中国人民大学工商管理学院联手，共同策划本套《MBA专业精品教材》丛书。《国际通用MBA教材》涉及了所有的MBA核心课程，而本套《MBA专业精品教材》包括了MBA各个不同专业方向的全部课程及选修课程，它为各类工商管理学院培养更适

合社会需要的专门管理人才提供了丰富的教材资源库。全套丛书按专业分类，包括经济学、战略管理与组织、管理科学、财务与金融管理、会计、市场营销、商务技能等7大系列、60多个品种。

为了保持原作的原汁原味，这套丛书是以英文原版的形式出版的。这样可以避免因翻译而造成的歧义和出版时间的滞后，以便让读者能亲身体味原作者的精彩文风，并在第一时间洞悉经济管理学科各个领域的最新学术动态。

由于作者所处的社会、政治环境的不同，书中所述难免有不妥之处，请读者在阅读时注意比较和鉴别，真正消化吸收其中的精华，这也就达到了出版者出版本套丛书的目的。我们真诚地希望这套《世界经济管理文库》的出版，能为提高中国的MBA教学水平、推动中国的改革开放事业尽点绵薄之力。

机械工业出版社
1998年8月

# 序　言

当前，我国正处于知识经济初露端倪的时代,管理科学已经成为兴国之道，这给我国工商管理教育带来新的机遇与挑战。今年9月，又将有4000余名工商管理硕士生满怀着理想与希望进入各大学学习。一大批机关分流干部与经贸委系统的管理人员也要经过入学考试，在职学习并申请工商管理硕士学位。如何办好工商管理硕士（MBA）项目，为国家和社会培养出一批又一批符合市场需求的高质量的工商管理硕士，是全国可以授予工商管理硕士学位的56所院校所共同考虑与研究的问题。

在这里，MBA课程设计是成功的关键环节之一。记得在1984年的夏天，在加拿大国际开发总署的资助下，加拿大蒙特利尔大学、麦吉尔大学、康克迪亚大学以及魁北克大学蒙特利尔分校的教授们为中国人民大学的年轻教师讲授了管理经济学、会计学、管理学以及管理信息系统等MBA课程。在1985年夏天，加拿大的教授们又讲了另外4门MBA课程。当时，我并没有真正了解这些MBA课程与我过去所学的管理课程在实质上有多大的区别，也没有理解这些课程之间的内在联系，对于MBA核心课与选修课以及专业的主修与副修的区别与联系更是知之甚少，只是感

到加拿大教授的教学在内容和手段上与我们传统方式有较大的区别。1988年初，我到加拿大麦吉尔大学管理学院研修后，才真正对MBA的课程设计有所了解。此后，我先后到美国布法罗纽约州立大学管理学院与澳大利亚悉尼科技大学管理学院任教，又对MBA课程之间的内在联系有了更切身的体会。为了更好地了解美国MBA教育的新潮流，今年6月，我又随中国管理学院院长代表团考察了美国著名管理学院，出席了在芝加哥举办的“全球管理教育论坛会”。

综观北美的工商管理教育，在全球化、信息化与整合化的挑战下，实在是强调其实用性。纵然有的教授学者看重自己的象牙宝塔，勾画着纯理论的模型与理论。但在MBA的教育上，美国现有的750余所管理学院，特别是为美国管理学院联合会（The American Assembly of Collegiate School of Business, AACSB）所承认的300余所管理学院，培养目标明确，课程设计体现出其为社会需求与市场服务的宗旨，没有半点的含糊。美国著名的管理院校明确自己的教育使命，把视野放在全球与创新上，不断地迎接新的挑战，将所授的知识与社会的实际需求密切地结合起来，期望培养出真正的高质量的管理人才。例如，哈佛商学院明确地提出，该院的使命是“影响企业的实践”，培养全面的管理者（general managers），指出“我们要对企业的领导人在如何完成他们的工作上，即在他们如何提出与解决问题、确定战略方向和采取行动上施加重大的影响。同时，我们鼓励从实践中获得反馈，以便了解这些领导人如何在实践中应用我们的思想与知识，从而进一步发展与提炼我们的理论与知识。”麻省理工学院斯隆管理学院的使命“尊重有用的工作”，“为产业提供服务”，提出“作为管理教育与研究的世界领导者，麻省理工学院斯隆管理学院要培养能在快速发展与高度竞争的全球企业环境中获得成功的管理者。当前持续不断的技术创新已成为每个产业各个方面生产力和增长的关键，因此，这正是我们的时机。”伯克利加利福尼亚大学商学院从学院的成立始，就将教育的重点放在国际与企业家的舞台上，研究迅速发展的全球经济，为学生提供创新的学习机会。

根据上述的使命，美国著名的管理学院教育模式基本上有三大流派：一是以哈佛商学院为代表的培养全面管理人员的模式。斯坦福商学院的培养方式也是属于这种模式。他们培养的是全面的MBA，而不是专业化的MBA，通过

为学生提供必要的专业知识，使之毕业以后成为企业或其他组织中高层的有效的全面管理者，而不是职能部门的管理人员。二是以芝加哥大学管理学院为代表的培养专业管理人员的模式，其方向是为企业和组织培养专业的管理人员。斯隆商学院亦属于这种类型。三是介于两者之间的模式。美国多数管理院校采用的是这种培养目标，如伯克利商学院、西北大学的凯洛格商学院、洛杉矶加州大学、康乃尔大学管理学院以及杜克大学管理学院等。因此，各个管理学院在其课程设计上有着不同的战略重点。

哈佛商学院MBA课程设计的思路是“在日益增长的全球商务环境中，提高学生进行战略性与关键性思考的能力。”斯坦福商学院MBA课程设计的思路是“确保学生获得管理运行的知识，了解企业运行的经济、政治和社会环境，以及掌握作为管理者所必须的行为技能。”同时，“MBA项目也要设计成为一种可以终身学习的模式。这样，今天的学生将在今后贯穿其事业的复杂而快速变化的管理世界中有能力自如地作出调整。”斯隆管理学院MBA课程设计的思路是“对日益增长的市场全球化和密集的竞争正在改变工作性质的这一事实作出反映。”哥伦比亚商学院MBA课程设计的思路是“让学生掌握作为管理者能够在全球经济中进行有效竞争所需的基本学科与应用的职能领域。”

总之，这些学院在设计MBA课程时，首先，考虑的是学生要了解全球的竞争环境。其次，考虑学院所在的地域和环境。例如，哥伦比亚商学院极其强调该院处于纽约这个金融中心，其战略重点是国际、金融和纽约，培养出的学生要适合在国际大城市从事金融工作。因此，该学院在课程设计上就对财务与金融等相关课程有所侧重。再次，考虑学院自身资源的特点，如斯隆管理学院在技术管理上设置较多的课程，而哈佛商学院则在全面管理与竞争战略课程上有所突出。最后，要使学生获得相关的专业知识，了解研究与实践的前沿，如企业伦理、领导精神、创新、以及企业与政府关系等。

在课程设计的内容上，美国管理学院根据自己的情况，多按传统划分为核心课程与选修课程。课程内容上并不划一，门数上也多少不等。在学习核心课之前，学生要预先学习计算机应用和技能、商务沟通以及基本数量分析方法等课程。在核心课上，各学院基本上开设了经济学、统计或数据分析、会计、财务、市场营销、运作管理、组织行

为、人力资源管理、战略管理以及公共管理等课程。当然，也有例外。芝加哥大学管理学院就不设置核心课。在选修课程上，除哈佛商学院外，各学院基本上设置了专业，如管理经济学（Managerial Economics）、会计（Accounting）、财务管理（Financial Management）、税收（Taxation）、管理科学（Management Science）、信息系统（Information Systems）、市场营销（Marketing）、组织行为学（Organization Behavior）、人力资源管理（Human Resource Management）、国际商务（International Business）、战略管理(Strategic Management)以及公共管理(Public Management)等。最具特色的是斯隆管理学院的课程设计。该学院除了设计出体现管理基础原理和技能的六门核心课以外，根据学生今后所要从事的工作方向，创造性地设计自我管理模块(Self Managed Track)与管理模块（Management Track）。自我管理模块包括应用宏观与国际经济学、财务管理或财务理论、信息技术、产业关系与人力资源管理、运作管理导论和市场营销导论等六门课。如果学生希望将来从事较为全面的管理工作，则可以选择自我管理模块。而学生希望成为更专业的管理人员，则可以选修管理模块。在这个模块中，有六个分模块，即战略管理与咨询（Strategic Management and Consulting）、新产品与风险开发(Product and Venture Development)、信息技术与企业变革(Information Technology and Business Transformation)、金融工程(Financial Engineering)、财务管理(Financial Management)以及制造与运作(Manufacturing and Operations)。这种设计打破传统职能性课程的框架，切实反映市场的声音，力图符合具体职业领域的要求，使学生能在今后的工作中更快地进入某个具体的管理角色。

我国工商管理硕士教育总体来说，还处在试点阶段之中。在课程设计上，全国工商管理硕士教育指导委员会规定了核心课的指导大纲。经过多年的建设，MBA核心课的教材已经初步满足教学的需求。当然，在质量上还有待进一步完善。随着MBA教学的深入发展，一些院校在培养全面管理人员的基础上，进一步根据自己院校的区域环境和办学条件，探索开设专业方向，以便培养出更适合社会需要的专门管理人才。这就对课程设计提出了新的要求，希望有更专门化的课程支持不同的专业方向。这不仅对教师的科研提出了更高的要求，而且对教材的建设也提出新的

需求。教材不足便是当前工商管理教育中最大的困惑之一。

为了满足工商管理专业方向的发展以及相应的课程设计，在中国人民大学工商管理学院的策划下，机械工业出版社推出了英文版的《MBA专业精品教材》，填补教学用书中空白，力图缓解MBA各专业教学上的急需。在这套丛书中，我们精心选择了北美在经济学、战略管理与组织、管理科学、财务与金融管理、会计、市场营销以及商务技能等7个专业的英文版教材，期望对国内各管理学院所开设的管理专业有所帮助。同时，有志于学好MBA某个专业的管理人员、研究生甚至本科生也可以通过系统地学习该专业所列的教材，掌握个中三味。

当然，在学习西方的管理理论与经验时，需要认真对待其内在的文化底蕴。正如同样是绘画，西方的绘画注重光线与颜色，体现出一种形象思维，而中国画则注重线条，体现出内在的逻辑思维，从而表现出中国文化与西方文化的差异。本世纪初以来，我国知识分子一直在研究与吸收西方文化，力图西学中用。正如有人所讲，学习的方法有三种形式，一是鸟瞰的方法，二是仰视的方法，三是平视的方法。鸟瞰者，持才傲物，看不起其他民族的文化，更看不起其他民族的管理理念与方法。仰视者，自卑自弃，看不起自己民族的文化，盲目追求其他民族的管理理念与方法。要真正作到西学中用，而不是仅仅学到一些皮毛的话，则需要运用平视的方法，拉开距离，去观察与学习世界上一切优秀的管理理念与方法。今天，我们利用西方的管理理论与实践，是为了更合理地推动中国的管理教学与科研，促进中国的管理实践，切不可邯郸学步，而是真正做到“以我为主、博采众长、融合提炼、自成一家”。

徐二明 博士

中国人民大学管理学教授
中国人民大学工商管理学院院长
全国MBA教育指导委员会委员
1998年盛夏于北京

# ABOUT THE AUTHORS

**EUGENE L. GRANT** is Professor of Economics of Engineering, Emeritus, at Stanford University. He holds B.S. and C.E. degrees from the University of Wisconsin, an M.A. in Economics from Columbia, and an honorary Doctorate of Engineering from Montana State University. After serving in the U.S. Navy in World War I and with the U.S. Geological Survey thereafter, he joined the faculty of Montana State University in 1920 and left there with the rank of Professor in 1930 to become Associate Professor of Civil Engineering at Stanford. Prior to becoming emeritus in 1962, he served as Executive Head of the Civil Engineering Department (1947–1956) and Chairman of the Industrial Engineering Committee (1946–1952).

From 1941 through 1944, he directed the Engineering, Science, and Management War Training (ESMWT) program at Stanford where, in conjunction with Holbrook Working, he helped develop an intensive short course in Quality Control by Statistical Methods for key personnel of war industries. This became the model for a nationwide program of similar courses sponsored jointly by the War Production Board and the United States Office of Education; alumni of these courses formed the American Society for Quality Control in 1946.

He received the 1952 Shewhart Medal from ASQC and was awarded honorary membership in 1968. In 1966 ASQC established an annual E. L. Grant Award for distinguished contributions to quality control education. He is one of three honorary academicians of the International Academy for Quality. In 1965, the Engineering Economy Division of the American Society for Engineering Education established an annual E. L. Grant Award for the best paper in each volume of *The Engineering Economist.* Professor Grant received the Founders Award from the American Institute of Industrial Engineers in 1965 and the Wellington Award in 1979. He received a Distinguished Service Citation from the University of Wisconsin College of Engineering in 1964. In 1987 he was elected to the National Academy of Engineering.

In addition to "Statistical Quality Control," his books are "Principles of Engineering Economy," now in its eighth edition (1990), published by John Wiley & Sons and now coauthored with W. G. Ireson and R. S. Leavenworth; "Depreciation," published by The Ronald Press Company (1949), coauthored with P. T. Norton, Jr.; and "Basic Accounting and Cost Accounting," published by McGraw-Hill

Book Company (1956 and 1964), the second edition coauthored with L. F. Bell. He was coeditor with W. G. Ireson of "Handbook of Industrial Engineering and Management," published by Prentice-Hall (1955 and 1971).

**RICHARD S. LEAVENWORTH** received his Ph.D. degree in Industrial Engineering from Stanford University in 1964. After two years at Virginia Polytechnic Institute and State University, he joined the faculty of the University of Florida, where he is now Professor Emeritus of Industrial and Systems Engineering. Over the years, he has won teaching awards and has served the University as Acting Chairman of the Department, and as Assistant Dean for Planning and Analysis.

Dr. Leavenworth's research, sponsored in part by the Office of Naval Research, has resulted in numerous technical reports and publications in the *Journal of Quality Technology, Naval Research Logistics Quarterly,* and *Transactions of the Institute of Industrial Engineers.* He has developed a number of courses for in-plant training and presented seminars and short courses nationally and internationally. His consulting and training activities have included such organizations as the U.S. Department of Commerce, General Electric Company, Manhattan Industries, Florida Department of Transportation, U.S.D.A. Food Safety Inspection Service, Harris Corporation, the Tennessee Valley Authority, the Naval Aviation Depot, Jacksonville, Florida, Blue Cross/Blue Shield of Florida, George Washington University, and Technology Training, Inc.

He is coauthor with E. L. Grant and W. G. Ireson of "Principles of Engineering Economy" (8th ed., 1990) published by John Wiley & Sons, New York, and with E. L. Grant of "Statistical Quality Control" published by McGraw-Hill, New York, since its fourth edition (1972). Both texts have been translated into Spanish and are widely distributed through International Students Editions.

He has served the Institute of Industrial Engineers (IIE) nationally as Region Vice President and Vice President for International Operations, has held numerous offices in local chapters, and has served as editor, *The Engineering Economist.* In 1984 he was presented the IIE Quality Control and Reliability Engineering Division Award of Excellence. He is a Fellow of IIE and a Senior Member of the American Society for Quality Control and a member of the American Society for Engineering Education and the American Statistical Association and is a Registered Professional Engineer in California and Florida. In 1991, he served on the Board of Examiners for the Malcolm Baldrige National Quality Award and, in 1993, on the Board of Examiners for the Florida Governor's Sterling Award for quality.

TO THE MEMORY OF
John Charles Lounsbury Fish

# PREFACE

This book is a practical working manual. It deals primarily with various types of control charts and acceptance sampling systems and procedures. These are simple but powerful techniques that have been widely used in many industries and in many countries throughout the world to improve product and service quality and to reduce costs. The most effective use of these techniques depends upon their being understood by production and inspection operators and their supervisors, by engineers, and by middle and upper level management.

The objective has been to write a book that might be immediately useful to all of these groups. No attempt has been made to write for the professional statistician or the mathematician. The aim has been to give just enough theory to supply practical working rules that will enable one to recognize the limitations of the methods as well as their many uses.

A special feature of this book is the liberal use of descriptions of actual cases from a number of economic sectors. Each example has been selected to bring out one or more important points. These examples reflect the general viewpoint of the book that the statistical techniques described should be studied primarily as a means to various ends desired by a cost-conscious management. A number of examples deal not only with the behavior of random variables but also with the behavior of people in various industrial and business situations.

The book retains its intuitive approach to probability and statistics. The authors believe that this approach is very important to engineering and business students who may have very little industrial experience but may have some responsibility for teaching SQC courses in-house to operators and inspectors. Just as in previous editions, the changes from the preceding edition have been made in part to improve the presentation of fundamental principles and in part to try to keep the treatment of various topics up-to-date. Some of the changes are as follows:

1. The book is now divided into four parts. Part One is a short introduction to the topics covered in the other three parts. Part Two treats topics concerning statistical process control (SPC), Part Three discusses scientific sampling, and Part Four deals with the economics of quality as well as some management and teaching aspects of quality control.

2. The treatment of simple $\overline{X}$ and $R$ charts (Chap. 2) begins Part Two. This change is intended to emphasize the idea that control needs to be achieved before histograms and estimates of process centering and dispersion (introduced in Chaps. 3 and 4) can be relied on to predict future results.
3. The material on rational subgrouping (Chap. 8) has been separated from that on process capability (Chap. 9) to emphasize the importance of establishing purpose when setting up sampling procedures and methods of recording data. The addition of error of measurement material and gage repeatability and reproducibility (R&R) studies at this point emphasizes the importance of purpose in determining rational subgrouping.
4. Process capability analysis and aspects of design and inspection specifications and design tolerances have been combined into Chap. 9 to emphasize their importance in process improvement.
5. Chapter 10 on special process control procedures now contains comments on the so-called precontrol technique (10.2.8), the use of box plots (10.3.4), exponentially weighted moving average (EWMA) charts (10.6.3), and the special problems introduced by extremely small production runs (10.9) and extremely high-quality production (10.10). The chapter concludes with CuSum charts for averages.
6. The scope of Part Three has been somewhat reduced without deleting material important to U.S. students. All standard measures of effectiveness of sampling procedures are now covered in Chap. 11. The emphasis has shifted to that of analyzing any sampling process, rather than simply sampling for product acceptance purposes, because nearly all quality inspection involves sampling, either from an unknown and possibly shifting universe, or from a lot. Standard plans therefore are used more as a vehicle for understanding the implications of various kinds of sampling.
7. Chapter 17 on economic aspects of quality control has been expanded to include the ASQC categories of quality costs (17.3.1) and Taguchi's loss function and its related index, $C_{pm}$ (17.4).
8. A new chapter (Chap. 18) describes some of the history and evolution of statistical quality control and the dramatic impact that Walter Shewhart, Harold Dodge, and W. Edwards Deming have had on quality control in the twentieth century.
9. Another new chapter (Chap. 19) introduces and compares the two most influential quality management models that are evolving in this last quarter of the twentieth century: *(a)* the total quality model best exemplified by the criteria and guidelines for the U.S. Malcolm Baldrige National Quality Award and *(b)*, the registration requirements of the ISO 9000 set of quality standards. The difficulty of integrating and implementing these management models in an operational setting, such as a factory floor or a service facility, is presented through the use of problem solving models, the "seven basic tools," and storyboard models.
10. A computer disk accompanies the book. It contains simple SPC software, some easily identifiable data tables for examples and problems in the book,

and some probability calculation programs written in BASIC. TXT files on that disk contain instructions for running the programs. Instructions are also included in the Instructor's Solutions Manual that accompanies this book and is available to instructors from the publisher.

This edition follows the general pattern of the six earlier editions, which were greatly influenced by the viewpoint and philosophy of Dr. W. Edwards Deming. The authors also wish to acknowledge their debt to Harold F. Dodge, whose extensive comments had a great influence on the writing of the second and third editions. Particular mention should be made of Ms. Bonnie Small for her review and suggestions for the fourth edition and of the staff of the University of Tennessee Center for Productivity through Quality for their review of the fifth edition. Our thanks are also extended to a number of users of the sixth edition for their suggestions for changes and improvements.

Reviewers of the manuscript of this edition provided much valuable input in its modification. These reviewers included Suraj Alexander, Roger Berger, Richard Buhman, Kenneth Case, who also is a Consulting Editor in the field for McGraw-Hill, Owen Miller, Joel Nachlas, Ahmad Seifoddini, Jill Swift, and Gary Wasserman. Their approaches to the subject, which ranged from strong management to strong statistics orientations, contributed many insights. Needless to say, not all of their suggestions could be incorporated while still maintaining the essential character of the book as previously described. Further acknowledgment should be made of the reviews by Professors Swift and Wasserman of the accompanying software developed by Mr. Mark Shewhart.

In addition, our thanks are offered to Mr. Seymour Selig for his assistance with material on military standards and to Dr. John F. Mahoney for his comments and help in the development of new tables of factors for control charts. Nevertheless, as in all technical books, the final responsibility for the selection and treatment of material must fall on the shoulders of the authors, and they should receive the blame for any deficiencies.

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