

软件质量保证

(英文版)

Testing
CMM
ISO/IEC 15504
Design reviews

Software Quality Assurance

From theory to implementation

CMMI
IEEE/EIA 12207
ASQ's CSQE
ISO 9000-3

DANIEL GALIN



PEARSON

(以) Daniel Galin 著



机械工业出版社
China Machine Press

经典原版书库

软件质量保证

(英文版)

Software Quality Assurance
From Theory to Implementation

江苏工业学院图书馆
藏书章

(以) Daniel Galin 著



机械工业出版社
China Machine Press

Daniel Galin: Software Quality Assurance: From Theory to Implementation (ISBN 0-201-70945-7).

Copyright © 2004 by Pearson Education Limited.

This edition of Software Quality Assurance: From Theory to Implementation is published by arrangement with Pearson Education Limited. Licensed for sale in the mainland territory of the People's Republic of China only, excluding Hong Kong, Macau, and Taiwan.

本书英文影印版由英国Pearson Education (培生教育出版集团) 授权出版。未经出版者书面许可, 不得以任何方式复制或抄袭本书内容。

此影印版只限在中国大陆地区销售 (不包括香港、澳门、台湾地区)。

版权所有, 侵权必究。

本书法律顾问 北京市展达律师事务所

本书版权登记号: 图字: 01-2004-6538

图书在版编目 (CIP) 数据

软件质量保证 (英文版) / (以) 加林 (Galín, D.) 著. - 北京: 机械工业出版社, 2005.7

(经典原版书库)

书名原文: Software Quality Assurance: From Theory to Implementation

ISBN 7-111-16787-2

I. 软… II. 加… III. 软件质量 - 英文 IV. TP311.5

中国版本图书馆CIP数据核字 (2005) 第067783号

机械工业出版社 (北京市西城区百万庄大街22号 邮政编码 100037)

责任编辑: 迟振春

北京牛山世兴印刷厂印刷 · 新华书店北京发行所发行

2005年7月第1版第1次印刷

787mm × 1092mm 1/16 · 38.5印张

印数: 0 001 - 3 000册

定价: 69.00元

凡购本书, 如有倒页、脱页、缺页, 由本社发行部调换
本社购书热线: (010) 68326294

出版者的话

文艺复兴以降，源远流长的科学精神和逐步形成的学术规范，使西方国家在自然科学的各个领域取得了垄断性的优势；也正是这样的传统，使美国在信息技术发展的六十多年间名家辈出、独领风骚。在商业化的进程中，美国的产业界与教育界越来越紧密地结合，计算机学科中的许多泰山北斗同时身处科研和教学的最前线，由此而产生的经典科学著作，不仅肇划了研究的范畴，还揭橥了学术的源变，既遵循学术规范，又自有学者个性，其价值并不会因年月的流逝而减退。

近年，在全球信息化大潮的推动下，我国的计算机产业发展迅猛，对专业人才的需求日益迫切。这对计算机教育界和出版界都既是机遇，也是挑战；而专业教材的建设在教育战略上显得举足轻重。在我国信息技术发展时间较短、从业人员较少的现状下，美国等发达国家在其计算机科学发展的几十年间积淀的经典教材仍有许多值得借鉴之处。因此，引进一批国外优秀计算机教材将对我国计算机教育事业的发展起积极的推动作用，也是与世界接轨、建设真正的世界一流大学的必由之路。

机械工业出版社华章图文信息有限公司较早意识到“出版要为教育服务”。自1998年开始，华章公司就将工作重点放在了遴选、移译国外优秀教材上。经过几年的不懈努力，我们与Prentice Hall, Addison-Wesley, McGraw-Hill, Morgan Kaufmann等世界著名出版公司建立了良好的合作关系，从它们现有的数百种教材中甄选出Tanenbaum, Stroustrup, Kernighan, Jim Gray等大师名家的一批经典作品，以“计算机科学丛书”为总称出版，供读者学习、研究及收藏。大理石纹理的封面，也正体现了这套丛书的品位和格调。

“计算机科学丛书”的出版工作得到了国内外学者的鼎力襄助，国内的专家不仅提供了中肯的选题指导，还不辞劳苦地担任了翻译和审校的工作；而原书的作者也相当关注其作品在中国的传播，有的还专程为其书的中译本作序。迄今，“计算机科学丛书”已经出版了近百个品种，这些书籍在读者中树立了良好的口碑，并被许多高校采用为正式教材和参考书籍，为进一步推广与发展打下了坚实的基础。

随着学科建设的初步完善和教材改革的逐渐深化，教育界对国外计算机教材的需求和应用都步入一个新的阶段。为此，华章公司将加大引进教材的力度，在“华章教育”的总规划之下出版三个系列的计算机教材：除“计算机科学丛书”之外，对影印版的教材，则单独开辟出“经典原版书库”；同时，引进全美通行的教学辅导书“Schaum's Outlines”系列组成“全美经典学习指导系列”。为了保证这三套丛书的权威性，同时也为了更好地为学校和老师服务，华章公司聘请了中国科学院、北京大学、清华大学、国防科技大学、复旦大学、上海交通大学、南京大学、浙江大学、中国科技大学、哈尔滨工业大学、西安交通大学、中国人民大学、北京航空航天大学、北京邮电大学、中山大学、解放军理工大学、郑州大学、湖北工学院、中国国

家信息安全测评认证中心等国内重点大学和科研机构在计算机的各个领域的著名学者组成“专家指导委员会”，为我们提供选题意见和出版监督。

这三套丛书是响应教育部提出的使用外版教材的号召，为国内高校的计算机及相关专业的教学度身订造的。其中许多教材均已为M. I. T., Stanford, U.C. Berkeley, C. M. U. 等世界名牌大学所采用。不仅涵盖了程序设计、数据结构、操作系统、计算机体系结构、数据库、编译原理、软件工程、图形学、通信与网络、离散数学等国内大学计算机专业普遍开设的核心课程，而且各具特色——有的出自语言设计者之手、有的历经三十年而不衰、有的已被全世界的几百所高校采用。在这些圆熟通博的名师大作的指引之下，读者必将在计算机科学的宫殿中由登堂而入室。

权威的作者、经典的教材、一流的译者、严格的审校、精细的编辑，这些因素使我们的图书有了质量的保证，但我们的目标是尽善尽美，而反馈的意见正是我们达到这一终极目标的重要帮助。教材的出版只是我们的后续服务的起点。华章公司欢迎老师和读者对我们的工作提出建议或给予指正，我们的联系方式如下：

电子邮件: hzjsj@hzbook.com

联系电话: (010) 68995264

联系地址: 北京市西城区百万庄南街1号

邮政编码: 100037

专家指导委员会

(按姓氏笔画顺序)

尤晋元
石教英
张立昂
邵维忠
周克定
郑国梁
高传善
裘宗燕

王 珊
吕 建
李伟琴
陆丽娜
周傲英
施伯乐
梅 宏
戴 葵

冯博琴
孙玉芳
李师贤
陆鑫达
孟小峰
钟玉琢
程 旭

史忠植
吴世忠
李建中
陈向群
岳丽华
唐世渭
程时端

史美林
吴时霖
杨冬青
周伯生
范 明
袁崇义
谢希仁

*To my parents,
Blima and Elchanan,
who inspired me with their love of learning,
scholarship, and teaching*

Preface

The opening of the new Denver International Airport (DIA) in February 1995 was a day of celebration for Colorado citizens but it was certainly the end of a traumatic period for the information technology industry. DIA was planned to be the largest airport in the United States, to serve 110 000 000 passengers annually by 2020, to handle 1750 flights daily through 200 gates and 12 operating runways. Operations at DIA were delayed by 16 months, mainly due to the failure of the software-based baggage handling system, causing estimated total losses of \$2 billion. Moreover, the baggage handling system finally put into service was substantially downscaled in comparison to the system originally specified. Although several other colossal failures of software systems unfortunately have been recorded since 1995, the failure of IT technology at DIA was especially traumatic to the profession, whether due to the scale of the losses or the public interest and criticism it raised.

Many SQA professionals, including the author, believe that had appropriate software quality assurance systems been applied to the project at its start, a failure of this scale would not have occurred or, at least, its losses would have been dramatically reduced. The methods and tools discussed in this book, especially the risk management procedures, could have identified the severity of the situation at very early stages and enabled timely employment of the appropriate corrective measures throughout the project. Other SQA tools could probably have assured completion of the system on schedule and in full compliance with its specifications.

According to the author's conception of software quality assurance, an acceptable level of software quality can be achieved by:

- Combined application of a great variety of SQA components.
- Special emphasis on quality in the early phases of software development, including the pre-project phase.
- Performance of comprehensive SQA activities to control the quality of the work carried out by external participants (subcontractors, suppliers of reused software modules and COTS software products, and the customers themselves in cases where they carry out parts of the project).
- Extension of SQA activities to project schedules and budget control, based on the expectation that functional requirements, schedule and budget plans behave according to the *principle of communicating vessels*, that is, a failure (or reduced level of achievement) in one of these three fluid components induces immediate failure in the others.

This conception of software quality assurance guides us throughout the book.

Unique features of this text

The following features of this book are of special importance:

- A broad view of SQA
- Comprehensive discussion of SQA implementation issues
- Comprehensive coverage of SQA topics
- State-of-the-art topics.

A detailed discussion of these features follows.

A broad view of SQA

The book extends discussion of SQA issues much beyond the classic boundaries of custom-made software development by large established software houses. It dedicates significant attention to the other software development and maintenance environments that reflect the current state of the industry:

- **In-house software development by information systems departments.** The book discusses SQA of in-house projects, situations where traditional customer-supplier relations are missing or vague, and outlines recommended solutions to the attendant risks (see Sections 5.6 and 6.4.2).
- **COTS software packages.** COTS software packages represent a growing proportion of software packages used throughout the industry. Assurance of the quality of these packages, which are integrated directly into the customer's software systems, has become an important issue (see Chapter 12).
- **Small projects and small organizations.** Issues related to software development by small organizations and the execution of small software projects are likewise dealt with in the book (see Section 6.4.1).

Comprehensive discussion of SQA implementation issues

Stress is placed throughout the book on organization, control and other aspects arising in the implementation of SQA components:

- **Specialized chapter sections** and subsections dealing with implementation processes.
- **Examples** that refer to real-life situations, especially those involving implementation issues, are integrated into the text.
- **Implementation tips** related to special implementation problems are integrated into most of the chapters.
- **Topics for discussion**, found at the conclusion of each chapter, encourage the reader to suggest innovative solutions to implementation issues.

Comprehensive coverage of SQA topics

The book is very comprehensive in the range of SQA subjects covered. It includes topics rarely if ever covered in other SQA texts. These topics include:

- **Procedures and work instructions**, their preparation, implementation and updating (Chapter 14).
- **Supporting quality devices**, that is, templates and checklists, their preparation, implementation and updating (Chapter 15).
- **Costs of software quality**, estimated according to the classic quality costs model in addition to a new extended model that better represents the special nature of software quality costs (Chapter 22).
- **The SQA unit and other actors in the SQA framework**, specifically the activities and responsibilities of active and occasional bodies that promote SQA issues within the organization: the SQA unit, SQA trustees, SQA committees and SQA forums (Chapter 26).

State-of-the-art topics

The text emphasizes up-to-date SQA topics:

- **Automated testing**, including a discussion of the various types of automated tests and their implementation, concluding with a review of the advantages and disadvantages of automated testing (Section 10.3).
- **Computerized SQA tools**, discussed in conjunction with almost all SQA components mentioned in the book. A special chapter (Chapter 13), entirely dedicated to computerized tools, reviews CASE tool issues. Special emphasis is placed on techniques that dramatically improve the performance of SQA tools, such as automated testing, software configuration management and documentation control.
- **International SQA standards**. Two chapters (Chapters 23 and 24) are dedicated to a survey of recent developments in software quality management standards and project process standards.

A downloadable *Instructor's Guide*, *PowerPoint Slides* and additional testing material are also available free of charge to lecturers and tutors adopting the main book. They can be accessed at www.booksites.net/galin.

The book's audience

The book is intended to meet the needs of a wide audience of readers interested in software quality assurance. We can identify four main groups of such readers, as follows:

- Managers of software development departments, project managers and others
- Those attending or presenting vocational training courses
- University and college students
- Practitioners involved in quality issues of software development and maintenance.

In addition, there are special groups of readers who are addressed on page xiii.

Acknowledgements

This book has benefited from comments by software consumers as well as questions from students in the many courses I have taught at the Technion, Israel Institute of Technology, the Ruppin Academic Center and elsewhere. They helped me improve my explanations and inspired many of my examples. Others helped by directly answering questions or supplying valuable articles, books and other material. Their numbers prevent my mentioning all their names. I am grateful to each.

Special thanks to Andrea Shustaritch, representative of Pearson Education in Israel, who encouraged me to write this book and followed its progress. My editor, Keith Mansfield, a senior acquisition editor at Pearson Education in the UK, also deserves special recognition for his cooperation, continuous guidance and valuable advice throughout the long months of writing. I would especially like to express my appreciation to Nicola Chilvers, responsible for production of this book at Pearson Education, whose efficiency and amiable manner made working together such pleasure. In addition, I wish to express my appreciation to Nina Reshef, who edited my drafts with devotion and contributed substantially to the book's readability and accuracy.

Finally, I wish to say how grateful I am to my family, my wife Amira Galin, my daughter Michal Nisanson and my son Yoav Galin for their continuous support and encouragement as well as for their important comments on the book's drafts.

Publisher's acknowledgements

We are grateful to the following for permission to reproduce copyright material:

Figure 7.1 adapted from Royce, W.W. (1970) Managing the Development of large Software Systems: Concepts and Techniques, *Proceedings of the IEEE WESCON*, August 1970 and *Software Engineering Economics* by Boehm, B.W. © 1981. Reprinted by permission of Pearson Education, Inc., Upper Saddle River, NJ. Figure 7.3 adapted from Boehm, B.W. (1988) A Spiral Model of Software Development and Enhancement, *Computer*, Vol. 21, No. 5, pp. 61–72; Figure 7.4 adapted from Boehm, B.W. (1998) Using the Win-Win Spiral Model: A case study, *Computer*, Vol. 31, No. 7, pp. 33–44; Table 8.3 and Table 21.11 from *Japan's Software Factories: A Challenge to U.S. Management* by Michael A. Cusumano, copyright 1991 by Oxford University Press, Inc. Used by permission of Oxford University Press, Inc.; Table 10.6 adapted from Dustin/Rashka/Paul, *Automated Software Testing: Introduction, Management and Performance*, Table 2.4 (p. 53), © Pearson Education, Inc. Reprinted by permission of Pearson Education, Inc.; Table 23.1 and Table 23.2 reproduced with the permission of BSI under licence no. 2003SK/0025. British Standards can be obtained from BSI Customer Services, 389 Chiswick High Road, London W4 4AL (Tel. +44 (0) 208 996 9001). Figure 23.2 Capacity Maturity Model by Paulk et al. © Reprinted by permission of Pearson Education, Inc., Upper Saddle River, NJ. Table 23.5 and 23.6 adapted from Jung, H.-W., Hunter, R., Goldenson, D.R. and El-Eman, K. (2001) Finding the Phase 2 of the SPICE Trials, *Software Process Improvement and Practice*, 7(6) pp. 205–42. © John Wiley & Sons Limited. Reproduced with permission. Figure 24.1 reprinted with permission from IEE Std 1045-19992 by IEEE. The IEEE disclaims any responsibility or liability resulting from the placement and use in the described manner.

BSI for the eight principles of ISO 9000.3 and the structure of the ISO/IEC TR 15504 Standard (under licence number 2003DH0143), and IEEE for IEEE Std. 10278 (reviews) © 1994 IEEE and list of IEEE Software Engineering Standards.

In some instances we have been unable to trace the owners of copyright material, and we would appreciate any information that would enable us to do so.

About the author

Dr Daniel Galin received his B.Sc. in Industrial and Management Engineering, and his M.Sc. and D.Sc. in Operations Research from the Faculty of Industrial and Management Engineering, the Technion, Israel Institute of Technology, Haifa, Israel. He serves on the faculty of the Ruppin Academic Center, where he is the current Head of Information Systems Studies.

Dr Galin acquired his expertise in SQA through teaching, writing and consulting in the field. He teaches courses in software quality assurance and information systems at the Ruppin Academic Center, Information Systems Studies, at the Faculty of Computer Sciences, the Technion, Haifa and at the College of Administration, Tel-Aviv.

Dr Galin co-authored (with Dr Z. Bluvband) the book *Software Quality Assurance*. His many papers have been published in professional journals, the majority in English-language journals. All his former books on analysis and design of information systems and software quality assurance were written in Hebrew and published by Israel's leading publishers.

Dr Galin's professional experience of over 20 years includes consulting on numerous projects in software quality assurance as well as analysis and design of information systems.

Guides for special groups of readers

Among the readers interested in software quality assurance, one can distinguish two special groups:

- Readers interested in ISO 9000-3 requirements
- Readers interested in the American Society for Quality's (ASQ) CSQE (Certified Software Quality Engineer) body of knowledge.

The following tables direct the reader to the chapters and sections relevant to their interests.

Guide to readers interested in ISO 9000-3 requirements

The reader interested in ISO 9000-3 requirements will find a comprehensive discussion of standard ISO issues in Chapter 23. In addition, related material is spread throughout the book, as detailed in the following table. The ISO 9000-3 requirements numbers quoted are taken from the outline of ISO/IEC 9000-3:2001 (final draft).

ISO 9000-3 requirements: chapter	ISO 9000-3 requirements: subject	Book references (chapter/section)
4. Quality management system	4.1 General requirements	Ch. 4
	4.2 Documentation requirements	Ch. 19
5. Management responsibilities	5.1 Management commitments	Sec. 25.1
	5.2 Customer focus	Sec. 25.1.1
	5.3 Quality policy	Sec. 25.1.1
	5.4 Planning	Ch. 25
	5.5 Responsibility authority and communication	Ch. 25
	5.6 Management review	Sec. 25.1.3
6. Resource management	6.1 Provision of resources	Sec. 25.1.1
	6.2 Human resources	Ch. 16
	6.3 Infrastructure	Secs 10.3, 11.4, Chs 13, 14, 15, Secs 18.7, 19.5, 20.4
	6.4 Work environment	Sec. 1.2

ISO 9000-3 requirements: chapter	ISO 9000-3 requirements: subject	Book references (chapter/section)
7. Product realization	7.1 Planning of product realization	Chs 6, 23, 24
	7.2 Customer-related processes	Chs 3, 5, 6, 12, 20
	7.3 Design and development	Chs 7, 8, 9, 10, Sec. 18.3
	7.4 Purchasing	Ch. 12
	7.5 Production and service provision	Chs 11, 12, Secs 18.4–18.6, Ch. 20
	7.6 Control of monitoring and measuring devices	Sec. 18.1
8. Measurement, analysis and improvement	8.1 General	Secs 21.1, 21.2, 22.1–22.3
	8.2 Monitoring and measurement	Secs 21.3, 21.4, 22.4, 22.5
	8.3 Control of non-conforming product	Secs 21.5, 22.4, 22.5, 26.1
	8.4 Analysis of data	Sec. 17.6
	8.5 Improvement	Ch. 17

Guide to readers interested in ASQ's CSQE body of knowledge

Almost all the elements of the CSQE (Certified Software Quality Engineer) body of knowledge, as outlined in ASQ (American Society for Quality) Item B0110, are included in the book. The following table directs the reader to the relevant chapters and sections.

CSQE body of knowledge: chapter	CSQE body of knowledge: subject	Book references (chapter/section)
I. General knowledge, conduct, and ethics	A. Standards	Sec. 2.1, Ch. 23
	B. Quality philosophy and principles	Secs 2.4, 2.5
	C. Organizational and interpersonal techniques	Ch. 25
	D. Problem-solving tools and processes	Secs 6.2, 6.3, App. 6A
	E. Professional conduct and ethics	–
II. Software quality management	A. Planning	Ch. 6, Secs 7.4, 17.2, 17.3
	B. Tracking	Ch. 6, Secs 17.4–17.8, Ch. 18
	C. Organizational and professional software quality training	Sec. 11.4, Ch. 16
III. Software processes	A. Development and maintenance methods	Sec. 7.1, Chs 8, 11, 13, 19
	B. Process and technology change management	Secs 18.3–18.7, Ch. 25

CSQE body of knowledge: chapter	CSQE body of knowledge: subject	Book references (chapter/section)
IV. Software project management	A. Planning	Chs 3, 5, 6, Secs 7.2, 12.2, App. 21A
	B. Tracking	Chs 20, 22, 25
	C. Implementation	Secs 7.4, 12.3, 12.4, Ch. 20, Sec. 22.4
V. Software metrics, measurement and analytical methods	A. Measurement methods	Secs 21.1, 21.2
	B. Analytical methods	Sec. 21.5
	C. Software measurement	Ch. 21
VI. Software inspection, testing, verification and validation	A. Inspection	Ch. 8, Sec. 25.1.3
	B. Testing	Chs 9+10
	C. Verification and validation	Sec. 7.3, Chs 8, 10, Sec. 18.3, Ch. 24
VII. Software audits	A. Audit types	Secs 23.3, 26.1.4
	B. Audit methodology	Ch. 17, Secs 23.3, 26.1.4
	C. Audit planning	Secs 23.3, 26.1.4
VIII. Software configuration management	A. Planning and configuration identification	Secs 18.1, 18.2, 18.4
	B. Configuration control, status accounting and reporting	Secs 18.3, 18.5

Contents

<i>Preface</i>	vii
<i>Unique features of this text</i>	viii
<i>The book's audience</i>	ix
<i>Acknowledgements</i>	x
<i>Publisher's acknowledgements</i>	xi
<i>About the author</i>	xii
<i>Guides for special groups of readers</i>	xiii
<i>Guide to readers interested in ISO 9000-3 requirements</i>	xiii
<i>Guide to readers interested in ASQ'S CSQE body of knowledge</i>	xiv
Part I Introduction	1
Chapter 1 The software quality challenge	3
1.1 The uniqueness of software quality assurance	4
1.2 The environments for which SQA methods are developed	7
Summary	11
Review questions	12
Topics for discussion	12
Chapter 2 What is software quality?	14
2.1 What is software?	15
2.2 Software errors, faults and failures	16
2.3 Classification of the causes of software errors	19
2.4 Software quality – definition	24
2.5 Software quality assurance – definition and objectives	25
2.6 Software quality assurance and software engineering	30
Summary	30
Selected bibliography	32
Review questions	32
Topics for discussion	33