Alessandro Birolini: RELIABILITY ENGINEERING. THEORY AND PRACTICE[*] - A Bible of Reliability
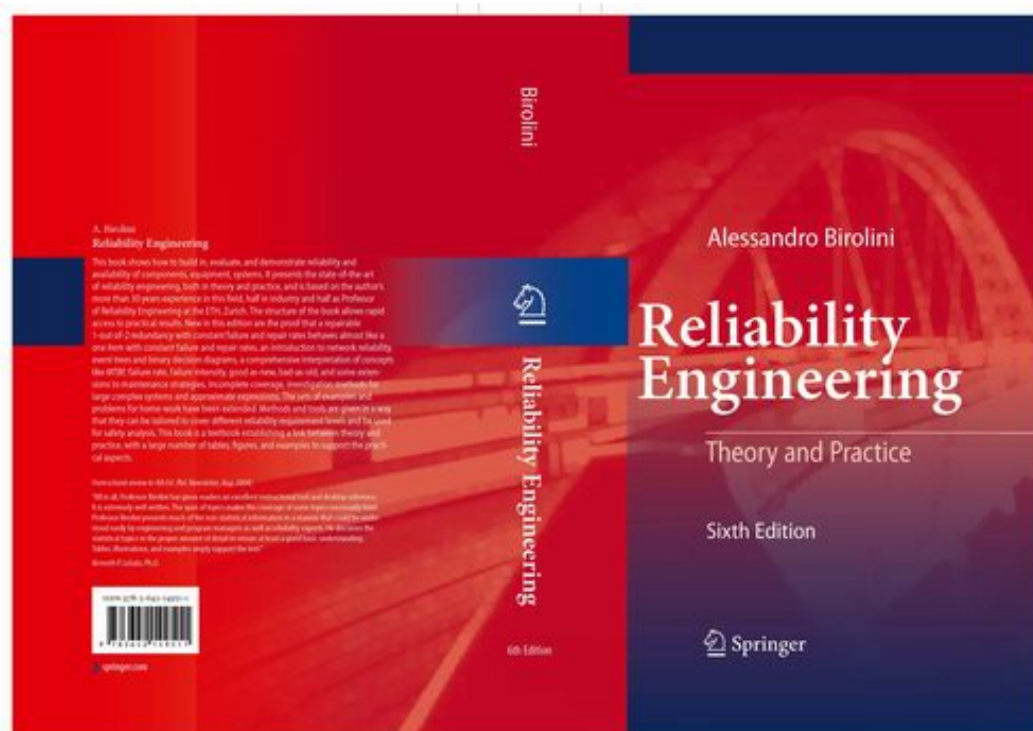
One has to learn to consider causes rather than symptoms of undesirable events and avoid hypocritical attitudes.

Alessandro Birolini

As mentioned Professor **Alessandro Birolini** in the *Preface* of his monumental book **Reliability Engineering: Theory And Practice**, performance, dependability, cost, and time to market are key factors for today's products and services. However, failure of complex systems can have major safety consequences. Reliability engineering can help.

Consequently, in the vision of Prof. **Birolini**, the purpose of this book is to develop *methods and tools to evaluate and demonstrate* reliability, maintainability, availability, and safety of components, equipment & systems, and to support development and production engineers in *building in* these characteristics.

To build in reliability, maintainability, and safety into complex systems, *failure rate* and *failure mode* analyses must be performed early in the development phase and be supported (as far as possible) by *failure mechanism* analysis, *design guidelines*, and *design reviews*. Before production, *qualification tests* are necessary to verify that targets have been achieved. In the production phase, processes have to be qualified and monitored to assure the required quality level.

For many systems, *availability* requirements have to be met and stochastic processes are used to investigate and optimize reliability and availability, including *logistical support* as well.

Software often plays a dominant role, requiring specific *quality assurance* activities. Finally, to be cost and time effective, reliability engineering has to be coordinated with quality management (TQM) efforts, including value engineering and concurrent engineering, as appropriate.

This book presents the state-of-the-art of reliability engineering in theory and practice. It is a *textbook* based on the author's experience of 30 years in this field, half in industry and as founder of the Swiss Test Laboratory for VLSI ICs in Neuchâtel, and half as Professor (full since 1992) of Reliability Engineering at the prestigious Swiss Federal Institute of Technology (ETH), Zurich. It also reflects the experience gained in an effective cooperation between University and industry over 10 years with more than 30 medium and large industries.

Following Chapter 1, the book is structured in three parts:

1. Chapters 2 - 8 deal with reliability, maintainability, and availability *analysis and test*, with emphasis on *practical aspects* in Chapters 3, 5, and 8. This part answers the question of *how to build in, evaluate, and demonstrate reliability, maintainability, and availability.*

2. Appendices A1 - A5 deal with definitions, standards, and program plans for quality and reliability assurance / management of complex systems. This *minor part* of the book has been added to comment on definitions and standards, and to support managers in answering the question of *how to specify and achieve high reliability targets for complex systems, when tailoring is not mandatory.*

3. Appendices A6 - A11 give a comprehensive introduction to probability theory, stochastic processes, and statistics, as needed in Chapters 2, 6, and 7, respectively. Markov, semi-Markov, and semi-regenerative processes are introduced with a view developed by the author. *This part is addressed to system oriented engineers.*

Methods and tools are presented in a way that they can be tailored to cover different levels of reliability requirements (the reader has to select this level). Investigation of *repairable systems* is performed systematically for many of the structures occurring in practical applications, starting with constant failure and repair rates and generalizing step by step up to the case in which the process involved is regenerative with a minimum number of regeneration states.

For large series - parallel systems, *approximate expressions* for reliability and availability are developed in depth, in particular using *macro structures* as introduced by the author in 1991. Procedures to investigate *repairable systems with complex structure* (for which a reliability block diagram often does not exist) are given as further application of the tools introduced in Appendix A7, in particular for imperfect switching, incomplete fault coverage, elements with more than two states, phased-mission systems, and fault tolerant reconfigurable systems with reward & frequency / duration aspects. New design rules have been added for imperfect switching and incomplete coverage. A Monte Carlo approach useful for *rare events* is given. *Spare parts provisioning* is discussed for decentralized and centralized logistical support. Estimation and demonstration of a *constant failure rate* λ and statistical evaluation of *general reliability data* are considered in depth. *Qualification tests* and *screening* for components and assemblies are discussed in detail. Methods for *causes-to-effects analysis*, *design guidelines* for reliability, maintainability & software quality, and *checklists for design reviews* are considered carefully. Cost optimization is investigated for some practical applications. *Standards* and trends in *quality management* are discussed. A large number of tables, figures, and examples support practical aspects.

It is emphasized that care is necessary in *statistical analysis of reliability data* (in particular for accelerated tests and reliability growth), *causes-to-effects analysis* should be performed systematically at least where *redundancy* appears (also to support *remote maintenance*), and further efforts should be done for developing *approximate expressions* for

complex repairable systems as well as models for fault tolerant systems with *hardware and software*.

Most of the methods & tools given in this book can be used to investigate / improve *safety* as well, which no longer has to be considered separately from reliability (although modeling human aspects can lead to some difficulties). The same is for *processes* and *services reliability*.

The book has been used for many years (beginning with the 1st German edition - 1985, Springer) as a textbook for three semesters beginning graduate students at the ETH Zurich and for courses aimed at engineers in industry. The basic course (Chapters 1, 2, 5 & 7, with introduction to Chapters 3, 4, 6 & 8) should belong to the curriculum of most engineering degrees, considers the author.

The large interest granted to this book by the community of reliability students and engineers (which consider this book as veritable "**Bible of Reliability**") made necessary six successive editions in English, all published by the well-known publishing house Springer. The basic structure of the book has been conserved through all editions, with main Chapters 1 to 8 and Appendices A1 to A9 (A10 & A11 since the 5th edition), allowing a rapid access to the practical results. But, it is important to mention that content of this book has been extended, reviewed and improved by the author for each new edition. New models & considerations have been added for each successive new edition.

All in all, the book of Professor **Birolini** is an excellent one, which can be highly recommended for both academia and industry as a veritable guide to the interdisciplinary field which is reliability.

New for the 6th edition in English of this book are the proof that a repairable 1-out-of-2 redundancy with constant failure and repair rates behaves almost like a one item with constant failure and repair rates, an introduction to network reliability, event trees and binary decision diagrams, a comprehensive interpretation of concepts like *MTBF*, failure rate, failure intensity, good as-new & bad-as-old, and some extensions to maintenance strategies, incomplete coverage, investigation methods for large complex systems & approximate expressions. The sets of examples and problems for home-work have been extended. Methods & tools are given in a way that they can be tailored to cover different reliability requirement levels and be used for safety analysis.

The 6th edition in English of the book **Reliability Engineering: Theory And Practice** - published by Springer in September 2010 - will be launched during the 12th International Conference on Quality and Dependability CCF2010, organized in Sinaia, Romania. The event will be organized on 23 September 2010, during the special session "*Homage to Professor Emeritus Alessandro Birolini at his 70th anniversary*".

It is important to mention that summed over the German and English editions (1st edition - 1985 and 1994, respectively), this is the 10th edition of this monumental book, distributed over 25 years all around the world. This last edition reviews, refines, and extends all previous editions of this book.

*With the ability, patience and talent of a Swiss jeweler, Professor **Birolini** has polished this book to perfection for over 25 years and in 10 successive editions, of which six in English.*

*And the result - the sixth edition of the book Reliability **Engineering: Theory And Practice**, published in 2010, is a real jewel, with an infinite value for both theory and practice in the field of Reliability; a true Bible for this domain.*

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