

Preface to the 7th Edition

The large interest granted to the 6th edition (over 2000 on-line requests per year) incited me for a 7th and last edition of this book (11 editions with the 4 German editions 1985 - 97).

The book shows how to build in, evaluate, and demonstrate reliability, maintainability, and availability of components, equipment, and systems. It presents the state-of-the-art of reliability engineering, both in theory and practice, and is based on the author's more than 30 years experience in this field, half in industry (part of which in setting up the Swiss Test. Lab. for VLSI, 1979 - 83 in Neuchâtel) and half as Professor of Reliability Engineering at the Swiss Federal Institute of Technology (ETH), Zurich. Considering that performance, dependability, cost, and time to market are key factors for today's products and services, but also that failure of complex systems can have major safety consequences, reliability engineering becomes a necessary support in developing and producing complex equipment and systems.

The structure of the book has been conserved through all editions, with main Chapters 1 to 8 and Appendices A1 to A11 (A10 & A11 since the 5th Edition 2007). Chapters 2, 4, and 6 deal carefully with analytical investigations, Chapter 5 with design guidelines, Chapters 3 and 7 with tests, and Chapter 8 with activities during production. Appendix A1 defines and comment on the terms commonly used in reliability engineering. Appendices A2-A5 have been added to support managers in answering the question of *how to specify and achieve high reliability (RAMS) targets for complex equipment and systems*. Appendices A6- A8 are a compendium of probability theory, stochastic processes, and mathematical statistics, as necessary for Chapters 2, 4, 6, and 7, consistent from a mathematical point of view but still with reliability engineering applications in mind (demonstration of established theorems is referred, and for all other propositions or equations, sufficient details for complete demonstration are given). Appendix A9 includes statistical tables, Laplace transforms, and probability charts. Appendix A10 resumes basic technological component's properties, and Appendix A11 gives a set of 70 problems for homework.

This structure makes the book *self contained* as a text book for postgraduate students or courses in industry (Fig. 1.9 on p. 24), allows a rapid access to practical results (as a desktop reference), and offers to theoretically oriented readers all mathematical tools to continue research in this field.

The book covers many aspects of reliability engineering using a common language, and has been improved step by step. Methods & tools are given in a way that they can be tailored to cover different reliability requirement levels, and be used for safety analysis too. A large number of tables (60), figures (190), and examples (210 of which 70 as problems for homework), as well as comprehensive reference list and index, amply support the text. This last edition reviews, refines, and extends all previous editions. New in particular includes:

- A strategy to mitigate *incomplete coverage* (p.255), yielding new models (Table 6.12c & d, p. 256).
- A comprehensive introduction to *human reliability* with a set of design guidelines to avoid human errors (pp. 158-159) and new models combining human errors probability and time to accomplish a task, based on semi-Markov processes (pp. 294-298).
- An improvement of the design guidelines for maintainability (pp. 154-158).
- An improvement of *reliability allocation* using Lagrange multiplier to consider cost aspects (p. 67).
- A comparison of four *repair strategies* (Table 4.4, p. 141).
- A comparison of basic models for *imperfect switching* (Table 6.11, p. 248).
- A refinement of *approximate expressions*, of concepts related to *regenerative processes*, and of the *use and limitations* of stochastic processes in modeling reliability problems (e.g. Table 6.1, p.171).
- New is also that relevant statements and rules have been written cursive and centered on the text.

Furthermore,

- Particular importance has been given to the selection of *design guidelines and rules*, the development of *approximate expressions* for large series-parallel systems, the *careful simplification of exact results* to allow in-depth trade off studies, and the *investigation of systems with complex structure* (preventive maintenance, imperfect switching, incomplete coverage, elements with more than one failure mode, fault tolerant reconfigurable systems, common cause failures).

- The central role of *software quality assurance* for complex equipment and systems is highlighted.
- The use of *interarrival times* starting by $x=0$ at each occurrence of the event considered, instead of the variable t , giving a sense to *MTBF* and allowing the introduction of a failure rate $\lambda(x)$ and a mean time to failure *MTTF* also for *repairable systems*, is carefully discussed (pp. 5-6, 41, 175, 316, 341, 378, 380) and consequently applied. Similar is for the *basic difference* between failure rate, (probability) density, and renewal density or intensity of a point process (pp. 7, 378, 426, 466, 524). In this context, the assumption *as-good-as-new* after repair is critically discussed wherever necessary, and the historical distinction between nonrepairable and repairable items is scaled down (removed for reliability function, failure rate, *MTTF*, and *MTBF*); national and international standards should better consider this fact and avoid definitions intrinsically valid only for constant (time independent) failure rates.
- Also valid is the introduction since the 1st edition of indices S_i for *reliability figures at system level* (e. g. $MTTF_{S_i}$), where S stands for system and i is the state entered at $t=0$ (system referring to the highest integration level of the item considered, and $t=0$ being the beginning of observations, $x=0$ for interarrival times). This is mandatory for judicious investigations at the system level.
- In agreement with the practical applications, *MTBF* is reserved for $MTBF = 1 / \lambda$.
- Important *prerequisites for accelerated tests* are carefully discussed (pp. 329-334), in particular to transfer an acceleration factor A from the *MTTF* ($MTTF_1 = A \cdot MTTF_2$) to the (random) failure-free time τ ($\tau_1 = A \cdot \tau_2$).
- *Asymptotic & steady-state* is used for *stationary*, by assuming *irreducible embedded chains*; *repair for restoration*, by neglecting administrative, logistical, technical delays; *mean for expected value*. For reliability applications, pairwise independence assures, in general, totally (mutually, statistically, stochastically) independence, *independent* is thus used for *totally independent*.

The book has growth from about 400 to 600 pages, with main improvements in the 4th to 7th Editions.

- 4th Edition: Complete review and general refinements.
- 5th Edition: Introduction to phased-mission systems, common cause failures, Petri nets, dynamic FTA, nonhomogeneous Poisson processes, and trend tests; problems for homework.
- 6th Edition: Proof of Eqs. (6.88) & (6.94), introduction to network reliability, event trees & binary decision diagrams, extensions of maintenance strategies and incomplete coverage, refinements for large complex systems and approximate expressions.

The launching of the 6th Edition of this book coincided with my 70th anniversary, this was celebrated with a special Session at the 12th Int. Conf. on Quality and Dependability CCF2010 held in Sinaia (RO), 22-24 September 2010. My response to the last question at the interview [1.0] given to Prof. Dr. Ioan C. Bacivarov, Chairman of the International Scientific Committee of CCF2010, can help to explain the acceptance of this book:

"Besides more than 15 years experience in the industry, and a predisposition to be a self-taught man, my attitude to life was surely an important key for the success of my book. This is best expressed in the three sentences given on the first page of this book. These sentences, insisting on generosity, modesty and responsibility apply quite general to a wide class of situations and people, from engineers to politicians, and it is to hope that the third sentence, in particular, will be considered by a growing number of humans, now, in front of the ecological problems we are faced and in front of the necessity to create a federal world wide confederation of democratic states in which freedom is primarily respect for the other."

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