

Lecture Notes in Economics and Mathematical Systems

50118
27-

Managing Editors: M. Beckmann and W. Krelle

252

Alessandro Birolini

FB Mathematik TUD



58173533

On the Use of Stochastic Processes in Modeling Reliability Problems



Fachbereich Mathematik
Technische Hochschule Darmstadt
Bibliothek

Inv.-Nr. 3 20505

Springer-Verlag
Berlin Heidelberg New York Tokyo

CONTENTS

1	Introduction and summary	page 1
2	Basic concepts of reliability analysis	4
2.1	Mission profile, reliability block diagram	4
2.2	Failure rate	5
2.3	Reliability function, MTTF, MTBF	10
2.4	More general considerations on the concept of redundancy	12
2.5	Failure mode analysis and other reliability assurance tasks	15
3	Stochastic processes used in modeling reliability problems	17
3.1	Renewal processes	17
3.1.1	Definition and general properties	17
3.1.2	Renewal function and renewal density	18
3.1.3	Forward and backward recurrence-times	21
3.1.4	Asymptotic and stationary behaviour	22
3.1.5	Poisson process	23
3.2	Alternating renewal processes	24
3.3	Markov processes with a finite state space	26
3.3.1	Definition and general properties	26
3.3.2	Transition rates	27
3.3.3	State probabilities	30
3.3.4	Asymptotic and stationary behaviour	33
3.3.5	Summary of important relations for Markov models	34
3.4	Semi-Markov processes with a finite state space	34
3.4.1	Definition and general properties	34
3.4.2	At $t = 0$ the process enters the state Z_i	36
3.4.3	Stationary semi-Markov processes	37
3.5	Regenerative stochastic processes	38
3.6	Non-regenerative stochastic processes	39
4	Applications to one-item repairable structures	41
4.1	Reliability function	42
4.2	Point-availability	42
4.3	Interval-reliability	44
4.4	Mission-oriented availabilities	45
4.4.1	Average-availability	45
4.4.2	Joint-availability	45
4.4.3	Mission-availability	47
4.4.4	Work-mission-availability	47
4.5	Asymptotic behaviour	48
4.6	Stationary state	49
5	Applications to series, parallel, and series/parallel repairable structures	50
5.1	Series structures	50
5.1.1	Constant failure and repair rates	51

5.1.2	Constant failure rates and arbitrary repair rates	53
5.1.3	Arbitrary failure and repair rates	54
5.2	1-out-of-2 redundancies	57
5.2.1	Constant failure and repair rates	57
5.2.2	Constant failure rates and arbitrary repair rate	60
5.2.3	Influence of the repair times density shape	62
5.2.4	Constant failure rate in the reserve state, arbitrary failure rate in the operating state, and arbitrary repair rates	63
5.2.4.1	At $t=0$ the system enters the regeneration state, Z_1	64
5.2.4.2	At $t=0$ the system enters the state Z_0	66
5.2.4.3	Solution for some particular cases	67
5.3	k-out-of-n redundancies	68
5.3.1	Constant failure and repair rates	70
5.3.2	Constant failure rates and arbitrary repair rate	72
5.4	Series/parallel structures	75
5.4.1	Constant failure and repair rates	75
5.4.2	Constant failure rates and arbitrary repair rate	77
6	Applications to repairable systems of complex structure and to special topics	80
6.1	Repairable systems having complex structure	80
6.2	Influence of preventive maintenance	82
6.2.1	One-item repairable structures	82
6.2.2	1-out-of-2 redundancy with hidden failures	84
6.3	Influence of imperfect switching	86
	References	89
	Index	104