AD-A171 447 PROBLEMS IN RELIABILITY STATISTICS AND PROBABILITY(U) 1/1
FLORIDA STATE UNIV TALLAHASSEE J SETHURAMAN 15 JUL 86
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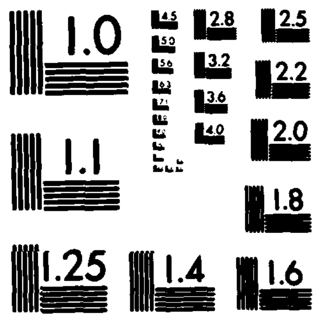

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Reliability, Damage models, Probability inequalities, local limit theorems, large deviations, exchangeability, storage models, inference for stochastic processes, ranking and selection problems.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Research work under the above grant has been summarized.

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ARO 19367.37-MA
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Final Report

on

ARO Proposal Number: 19367-MA 16713-MA 13888-MA

Contract or Grant Number: DAAG-82-K-0168
DAAG29-79-C-0158
DAAG29-76-G-0238

Period covered by Report: August 16, 1982 through May 28, 1986

Title of Proposal: Problems in Reliability, Statistics and Probability

Name of Institution: The Florida State University

Author of Report: Jayaram Sethuraman

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1. ACCOMPLISHMENTS UNDER THE GRANT.

1.1 Introduction.

In this chapter, we briefly describe the accomplishments in research during the grant. We give a list of the technical reports produced, followed by a list of published papers. In this section we give a brief summary of the research findings. Most of this research work was also reported at professional meetings and departmental seminars.

1.2 Publications and technical reports under the grant.

1.2.1 List of technical reports prepared under the grant.

Technical Report No. 52

Ranking and subset selection procedures for exponential populations with type-I and type-II censored data, by Roger L. Berger and Jee Soo Kim, USARO Technical Report No. D-52, May 1982.

Technical Report No. 53

Large deviation local limit theorems for arbitrary sequences of random variables, by Narasingha Rao Chaganty and J. Sethuraman, USARO Technical Report No. D-53, June, 1982.

Technical Report No. 54

Central limit theorems in the area of large deviations for sums of dependent random variables, by N. R. Chaganty and J. Sethuraman, USARO Technical Report No. D-54, July, 1982.

Technical Report No. 55

Testing hypotheses which are unions of linear subspaces, by Roger L. Berger and Dennis F. Sinclair, USARO Technical Report NO. D-55, September, 1982.

Technical Report No. 56

On the stability of Bayes estimators for Gaussian processes, by Ian W. McKeague, USARO Technical Report No. D-56, September, 1982.

Technical Report No. 57

Monotonicity in selection problems: A unified approach, by Roger L. Berger and Frank Proschan, USARO Technical Report No. D-57, September, 1982.

Technical Report No. 58

Applications of a unified theory of monotonicity in selection problems, by Roger L. Berger and Frank Proschan, USARO Technical Report No. D-58, March, 1983.

Technical Report No. 59

Estimation for diffusion processes under misspecified models, by Ian W. McKeague, USARO Technical Report No. D-59, March, 1983.

Technical Report No. 60

A non-clustering property of stationary sequences, by Arif Zaman, USARO Technical Report No. D-60, May, 1983.

Technical Report No. 61

Convex-ordering among functions, by Wai Chan, Frank Proschan and J. Sethuraman, USARO Technical Report No. D-61, July, 1983.

Technical Report No. 62

Urn models for Markov exchangeability, by Arif Zaman, USARO Technical Report No. D-62, July, 1983.

Technical Report No. 63

Testing for the same ordering in several groups of means, by Roger L. Berger, USARO Technical Report No. D-63, August, 1983.

Technical Report No. 64

Some extensions of the Skorohod representation theorem, by J. Sethuraman, USARO Technical Report No. D-64, August, 1983.

Technical Report No. 65

Estimation for infinite dimensional Ornstein-Uhlenbeck process, by Ian W. McKeague, USARO Technical Report No. D-65, October, 1983.

Technical Report No. 66

Kolmogorov's and Mourier's strong laws for arrays with independent and identically distributed columns, by Arif Zaman and Asad Zaman, USARO Technical Report No. D-66, February, 1984.

Technical Report No. 67

Cumulative damage threshold crossing models, by J. Sethuraman and Thomas R. Young, USARO Technical Report No. D-67, May, 1984.

Technical Report No. 68

TP_2 orderings, by James Lynch, Gillian Mimmack and Frank Proschan, USARO Technical Report No. D-68

Technical Report No. 69

Schur-Ostrowski theorems for functionals on $L_1(0, 1)$, by Wai Chan, Frank Proschan and J. Sethuraman, USARO Technical Report No. D-69, August, 1984.

Technical Report No. 70

Estimation for a semimartingale regression model using the method of sieves, by Ian W. McKeague, USARO Technical Report No. D-70, August, 1984.

Technical Report No. 71

Large deviations for processes with independent increments, by James Lynch and J. Sethuraman, USARO Technical Report No. D-71, September, 1984

Technical Report No. 72

The coding capacity of mismatched Gaussian channels, by Ian W. McKeague and Charles R. Baker, USARO Technical Report No. D-72, September, 1984.

Technical Report No. 73

On a random difference equation for matrices and a characterization of the Gamma distribution, by Eric S. Tollar, USARO Technical Report No. D-73, October, 1984.

Technical Report No. 74

Optimal allocation of components in parallel-series and series-parallel systems, by Emad El-Neweihi, Frank Proschan and J. Sethuraman, USARO Technical Report No. D-74, November, 1984.

Technical Report No. 75

Central limit theorems in the area of large deviations for some dependent random variables, by N. R. Chaganty and J. Sethuraman, USARO Technical Report No. D-75, January, 1985.

Technical Report No. 76

On the limit behavior of a multi-compartment storage model with an underlying Markov chain I: Without normalization, by Eric S. Tollar, USARO Technical Report No. D-76, February, 1985.

Technical Report No. 77

On the limit behavior of a multi-compartment storage model with an underlying Markov chain II: With normalization, by Eric S. Tollar, USARO Technical Report No. D-77, February, 1985.

Technical Report No. 78

Reconciling Bayesian and frequentist evidence in the one-sided testing problem, by Roger L. Berger, USARO Technical Report No. D-78, April, 1985.

Technical Report No. 79

A large deviation principle for the partial sums process and functional Erdos-Renyi laws, by James D. Lynch and J. Sethuraman, USARO Technical Report No. D-79, October, 1985.

Technical Report No. 80

Optimum allocation in multistate systems, with allocations in reliability, by Emad El-Neweihi, Frank Proschan and J. Sethuraman, USARO Technical Report No. D-80, May, 1985.

Technical Report No. 81

A test for program effect in the absence of a proper control group, by Eric S. Tollar, USARO Technical Report No. D-81, September, 1985.

Technical Report No. 82

A characterization of the gamma distribution from a random difference equation, by Eric S. Tollar, USARO Technical Report No. D-82, July, 1985.

Technical Report No. 83

Failure Times in Maintenance Models, by Wai Chan and Jayaram Sethuraman, USARO Technical Report No. D-83, September, 1985.

Technical Report No. 84

The Method of Sieves: A Survey of Recent Applications, by Ian W. McKeague, USARO Technical Report No. D-84, December, 1985.

Technical Report No. 85

A Reversal Argument for Storage Models defined on a Semi-Markov Process, by Eric S. Tollar, USARO Technical Report No. D-85, February 1986.

Technical Report No. 86

Asymptotic Theory for Sieve Estimators in Semimartingale Regression Models, by Ian W. McKeague, USARO Technical Report No. D-86, March, 1086.

Technical Report No. 87

A Two-Compartment Storage Model with an Underlying Semi-Markov Process, by Eric S. Tollar, USARO Technical Report No. D-87, April, 1986.

1.2.2 List of publications under the grant.

1. Bahadur efficiency of the F-test, by L. Barker and J. Sethuraman (1982), Journal of Statistical Planning and Inference 6, 301-304.

2. A minimax and admissible subset selection rule for the least probable multinomial cell, by Roger L. Berger (1982), Statistical Decision Theory and Related Topics - III, Vol. 1. (Eds. Gupta, S. S. and Berger, J. O.), Academic Press, New York, 143-156.

3. Multiparameter hypothesis testing and acceptance sampling, by Roger L. Berger (1982), Technometrics 24, 295-300.

4. Convergence of Dirichlet measures and the interpretation of their parameter, by J. Sethuraman and Ram C. Tiwari (1982), Statistical Decision Theory and Related Topics - III, Vol. 2. (Eds. Gupta, S. S. and Berger, J. O.) Academic Press, New York, 305-315.

5. A multivariate new better than used class derived from a shock model, by Emad El-Neweihi, Frank Proschan and J. Sethuraman (1983), Operations Research, Vol. 31, 177-183.

6. Testing hypotheses concerning unions of linear subspaces, by Roger L. Berger and Dennis Sinclair (1984), Jour. Amer. Statist. Assoc. 79, 158-163.

7. *Monotonicity in selection problems*, by Roger L. Berger and Frank Proschan (1984), Annals of Statistics 12, 387-391.

8. A non-clustering property of stationary sequences, by Arif Zaman (1984), Annals of Probability 12, 193-203.

9. Urn models for Markov exchangeability, by Arif Zaman (1984), Annals of Probability 12, 223-229.

10. Estimation for diffusion processes under misspecified models, by Ian W. McKeague (1984), J. Appl. Prob. 21, 511-520.

11. On the stability of Bayes estimators for Gaussian processes, by Ian W. McKeague (1984), Annals of Statistics 12, 1310-1323.

12. Testing whether one regression function is larger than another, by Roger L. Berger (1984), Communications in Statistics: Theory and Methods 13, 1793-1810.

13. Testing for the same ordering in several groups of means, by Roger L. Berger (1984), Design of Experiments: Ranking and Selection (ed. by T. J. Santner and A. C. Tamhane), Marcel Dekker, Inc., New York, 241-249

14. Applications of a unified theory of monotonicity in selection problems, by Roger L. Berger and Frank Proschan (1984), Inequalities in Statistics and Probability (ed. by Y. L. Tong), IMS Lecture Notes - Monograph Series Volume 5, 199-205.

15. Linear least squares estimates and non-linear means, by Roger L. Berger and Naftali A. Langberg (1984), Jour. Statistical Planning and Inference 10, 277-288.

16. Asymptotic normality and efficiencies of tests based on modified spacings, by Jammalamadaka S. Rao and J. Sethuraman (1984), Tamkang Jour. Math. 15, 55-76.

17. Large deviation local limit theorems for arbitrary sequences of random variables, by Narasingha R. Chaganty and J. Sethuraman (1985), Ann. Prob. 13, 97-114.

18. On the limit behavior of certain quantities in a subcritical storage model, by Prem S. Puri and Eric S. Tollar (1985), Adv. Appl. Prob. 17, 443-459.

19. Ranking and subset selection procedures for exponential populations with Type-I and Type-II censored data, by Roger L. Berger and Jee Soo Kim (1985) The Frontiers of Modern Statistical Inference Procedures (Ed. E.J. Dudewicz) American Science Press, OH. pp. 425-455.

20. Cumulative Damage Threshold Crossing Models by J. Sethuraman and Thomas R. Young (1986) Reliability and Quality Control. Ed. A. P. Basu. Elsevier Science Publishers B.V. (North Holland) 309-319.

21. The coding capacity of mismatched Gaussian channels, by I.W. McKeague and C.R. Baker (1986) IEEE Trans. Information Theory. IT-32, 431-436.

1.2.3 List of papers accepted for publication.

1. Large deviations for processes with independent increments, by James D. Lynch and Jayaram Sethuraman, Annals of Probability, subject to revision.

2. Central limit theorems in the area of large deviations for some dependent random variables, by N. R. Chaganty and J. Sethuraman, Annals of Probability, subject to revision.

3. Optimal allocation of components in parallel-series and series-parallel systems, by Emad El-Neweihi, Frank Proschan and J. Sethuraman, Journal of Applied Probability.

4. Multidimensional large deviation local limit theorems, by N. R. Chaganty and J. Sethuraman, Journal of Multivariate Analysis, subject to revision.

5. Convex-ordering among functions, with applications to reliability and mathematical statistics, by Wai Chan, Frank Proschan and J. Sethuraman, Proceedings of the Conference on Theoretical Probability and its Applications.

6. Optimum allocation in multi-state systems, with applications to reliability, by Emad El-Neweihi, Frank Proschan, and J. Sethuraman, to appear in volume 7, Handbook of Statistics, (ed. P. R. Krishnaiah).

   The coding capacity of mismatched Gaussian channels, by I. W. McKeague and C. R. Baker, to appear in IEEE Trans. Information Theory.

7. Estimation for a semimartingale regression model using the method of sieves, by I. W. McKeague, to appear in Annals of Statistics, March, 1986.

8. On a random difference equation for matrices and a characterization of the gamma distribution, by Eric S. Tollar, Journal of Applied Probability.

1.3 Nontechnical summary of research carried out under the grant.

1.3.1 Reliability theory.

New results in the area of optimal allocation of components were obtained in Technical Reports Numbers 74 and 80. The powerful method of Schur functions was used to arrive at the optimal allocations. Parallel-Series sytems and Series-Parallel systems consisting of binary or multi-state components were studied.

The Cumulative damage threshold model for survival functions were developed in Technical Report No. 67 and found to give a superior fit to many data.

Probability inequalities, comparison of distributions, etc., give useful bounds in Reliability. We introduced the notion of convex ordering among distributions in Technical Report No. 61 which allowed us to obtain useful inequalities. Technical Report No. 68 studied the preservation of uniform stochastic ordering under convolution, mixing and formation of coherent systems. The Schur-Ostrowski theorem was generalized to apply to Schur functions on $L_1(0, 1)$ in Technical Report No. 69.

1.3.2 Large deviations, local limit theorems, with applications in statistical mechanics.

Local limit theorems are theorems that establish the convergence of densities as opposed to central limit theorems that establish the convergence of distributions. In Technical Report No. 53 we establish

local limit theorems in the region of large deviations for an arbitrary sequence of random variables, under conditions solely based on their moment generating functions. This result was also generalized to the case of arbitrary random vectors. These results were used to study the distributions of normalized sums of dependent variables which are generalizations of magnetic spins that arise in Statistical Mechanics. The limiting distribution was shown to be Guassian at high temperatures and non-Gaussian at low temperatures, thus establishing a phase transition. This work may be found in Technical Reports Numbers 54 and 75.

Large deviation results for processes with independent increments not having a Gaussian component obtained in Technical Report No. 71. Previous results in this area had used a growth condition on the large deviation rate for the increments, which has now been removed. Large deviation rates for the Gamma and Dirichlet processes have therefore become available.

1.3.3 Probability theory.

The famous Skorohod representation theorem states that a sequence of random variables that converges in distribution can be replaced by those that converge with probability one. In Technical Report No. 64, necessary and sufficient conditions are obtained to replace the random variables so that they differ from the limiting random variables with a probability that converges to zero or so that they are identical with the limiting random variable after a certain stage.

Technical Report No. 66 gives a generalization of the strong law of

large numbers for random variables which are themselves infinite sequences. A neat generalization of Kolmogorov's and Mourier's strong laws is obained, with applications to kernel density estimation.

Markov exchangeability, a generalization of exchangeability that was proposed by de Finetti, requires that a probability on a string of letters be constant on all strings which have the same initial letter and the same transition counts. The set of Markov exchangeable measures forms a convex set. A graph theoretic and an urn interpretation of the extreme points of this convex set is given in *Technical Report No. 62.*

Technical Report No. 60 deals with the behavior of the expectations of $(X_k + \ldots + X_{k+m-1})/(X_1 + \ldots + X_n)$, where X_1, X_2, ... are indicator random variables. This can be viewed as a measure of clustering among events. When the X's are i.i.d. or even exchangeable, it is well known that the above expectation can be no more than m/n. If instead of exchangeability, only stationarity is assumed, the upper bound on the expectation is larger and depends on k as well. For small values of m/n the bound is roughly 2m/n when k is near n/2 and like $m/n \cdot \log n$ when k is near 1 or n.

1.3.5 *Stochastic models.*

In Technical Reports Numbers 73 and 82, we examine the behavior of a random difference equation, typically used to model material flow in a multiple compartment storage system in which interchanges and outputs are proportional to the amount of material presently in storage. Some simple criteria are given which can be used to determine the asymptotic

behavior of the system. For a special case, it is established that asymptotic independence of the limiting material in various compartments is a characterization of the Gamma distribution.

In Technical Reports Numbers 76 and 77, a different multiple compartment storage model is considered. In this model, the allocation is quantitative instead of proportional. The asymptotic behavior in this case is substantially more complicated, and it is shown that first moment conditions on the input/output mechanism are sufficient to determine asymptotic convergence or divergence. It is further shown that the limit distribution of the convergent compartments is asymptotically independent of the limit distribution of the divergent compartments, when these divergent compartments are appropriately normalized.

In Technical Report No. 81, we examine a problem arising in the design of experiments: how to deal with data where we have no proper control group? For a specific model, a testing procedure is proposed, and it is shown that the proposed test statistic has an asymptotic t distribution as the sample sizes approach infinity.

1.3.6 Inference for stochastic processes.

Our work in the area of inference for stochastic processes appeared in USARO Technical Reports 56, 59, 65 and 70. It began with a study of the robustness of Bayes estimators for Gaussian processes. This appeared in Technical Report No. 56. In this paper we used quasi-noise laws to perturb the laws of Gaussian processes and study the effects of this kind of contamination on the performance of the Bayes estimators. Quasi-noise laws had previously only been used in signal detection and

information theory. Upper bounds on the increase in mean square error under contamination in the prior and noise distributions were obtained. Results describing the effect of perturbation of Gaussian distributions in a Kalman filter were also given.

We next considered the robustness properties of estimators for parametric models of diffusion processes. In Technical Report No. 59 we determined the asymptotic behavior of the maximum likelihood estimator of a parameter in the drift term of a stationary ergodic diffusion process when the model is misspecified. Here misspecification was in the sense that the true drift function and true noise function of the diffusion do not coincide with those given by the parametric model.

In Technical Report No. 65 we turned our attention to the problem of estimation for infinite dimensional Ornstein-Uhlenbeck processes. Assuming that the generating operator could be represented as a finite linear combination of known commuting dissipative operators we showed that the coefficients in the linear combination could be consistently estimated. The estimator was also shown to have a asymptotic normal distribution.

In Technical Report No. 70 we introduced a regression model for semimartingales and used Grenander's method of sieves to obtain estimators of time varying coefficients in the model. The important classes of nonstationary diffusion processes and point processes were contained in the semimartingale regression model. In the point process case we noted that the model provides an alternative to Cox's model for the analysis of censored survival data. We showed that the sieve esti-

mators are consistent in L^2-norm under various conditions on the covariate processes and the rate of growth of sieve size.

We carried out some work in Information Theory dealing with the coding capacity of mismatched Gaussian channels. This appeared in Technical Report No. 72. Mismatched channels arise in jamming situations, in problems where there is insufficient knowledge of the environment, and where the power constraint is not expressed in terms of the noise covariance. They represent an important class of channels for secure communications. Several different models of mismatched channels were treated in the paper. When the channel noise is assumed to be Gaussian and have a Cramér-Hida representation of finite multiplicity, an exact expression for the channel capacity was obtained, even in the feedback case.

1.3.7 Ranking and selection problems.

Ranking and selection procedures for exponential populations with various types of censoring are studied in Technical Report 52. The likelihood ratio test (LRT) for hypotheses which are unions of linear subspaces are derived for the normal linear theory in Technical Report No. 55, and then applied to special problems. The LRT for testing whether two or more groups of normal means are in a specified order, is derived in Technical Report No. 63 and shown to depend on the minimum of several t-statistics.

Monotonicity properties of selection rules are discussed in Technical Reports Numbers 57 and 58 and general monotonicity results concerning selection problems are derived. These properties are shown to be

found among many selection procedures currently available.

1.4 Professional activities during the period covered by the grant.

1.4.1 J. Sethuraman.

Gave a lecture at Bell Laboratories, Murray Hill, NJ in July, 1982.

Attended and presented a paper at the 1982 Joint Annual Meetings of the Institute of Mathematical Statistics and the American Statistical Association at Cincinatti, Ohio in August, 1982.

Attended the 1982 Annual meeting of the American Mathematical Society at Toronto, Canada in August, 1982.

Attended and presented an invited paper at the Symposium on Inequalities in Statistics and Probability in Lincoln, Nebraska in October, 1982.

Gave a lecture at the Department of Statistics, University of California, Davis, CA in January, 1983.

Attended and presented an invited paper at the First Saudi Symposium on Statistics and its Applications at King Saudi University in Riyadh, Saudi Arabia in May, 1983.

Presented a lecture at the Indian Statistical Institute, Bangalore, India in August, 1983.

Presented two papers at the IMS meetings at Orlando, FL in March, 1984.

Attended the Conference on Frontiers in Industrial Experimentation held at Mohonk Mountain Hotel, New Paltz, NY, arranged by AT&T Bell Laboratories in May, 1984.

Presented a paper at the Conference on Reliability and Statistical Quality Control held at the University of Missouri, Columbia, MO in June, 1984.

Participated in the Conference on Phase Transitions held at Boudin College, Brunswick, ME, arranged by the American Mathematical Society in June, 1984.

Presented a series of lectures on Dirichlet Processes at the Department of Statistics, Pennsylvania State University, State College, PA in July, 1984.

Presented a talk at the Thirteenth Conference on the Design of Experiments in Army Research, Development and Testing, Physical Science Laboratory, New Mexico State University, Las Cruces, NM in October, 1984.

Gave a seminar at the Department of Mathematics, University of South Florida, Tampa, FL in February, 1985.

Presented a paper The Workshop on System Reliability at George Washington University, Washington, DC in March, 1985.

Visited the Department of Applied Mathematics, Brown University, Providence, RI, for consultation with Profesor U. Grenander and gave a seminar in March, 1985.

Visited the Statistics Center, M.I.T., Cambridge, MA and gave 3 seminars in May, 1985.

Visited AMMRC, Watertown, MA, and had discussions with Donald Neal in May, 1985.

Principal speaker of the NSF-CBMS conference "Non-parametric Bayesian Analysis: The construction and salient properties of Dirichlet Processes" at the Pennsylvania State University, State College, PA, June 3-7, 1985.

1.4.2 R. L. Berger.

Attended and presented an invited paper at the 26th Annual Fall Technical Conference of the Chemical Division of the ASQC and the Section on Physical and Engineering Sciences of the ASA in Atlantic City, NJ, October 21-22, 1982.

Attended and presented a paper at the Central Regional meetings of the Institute of Mathematical Statistics at Nashville, TN in March, 1983.

Gave a lecture at the Department of Statistics, Purdue University, W. Lfayette, IN in June, 1983.

Presented a paper at the annual joint statistical meetings in Toronto, Canada in August, 1983.

Presented a paper at the North Carolina Chapter of the American Statistical Association September meeting in September, 1983.

Gave a talk at the Statistics Departmental Colloquium, Ohio State University in October, 1983.

Gave a talk at the Mathematics Department Colloquium, East Carolina University in November, 1983.

Presented a paper at the Computer Science and Statistics 16th Symposium Interface, held at Atlanta, GA in March, 1984.

Attended and presented a paper at the joint annual meetings of the ASA and IMS at Reno, Las Vegas, UT in August, 1985.

1.4.3 I. W. McKeague.

Attended the NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and their Applications by K. Ito at Louisiana State University at Baton Rouge, LA as an invited participant in June, 1983.

Spent about 10 days in the Department of Electrical Engineering, University of Texas at Austin, TX working on some research problems with Charles R. Baker in June, 1983.

Presented a paper at the annual joint statistical meetings of the ASA and IMS at Toronto, Canada in August, 1983.

Presented a paper at the IMS meeting in Orlando, FL in March, 1984.

Invited participant and contributed talk speaker at the Lecture Series on Inference for Stochastic Processes of Semimartingale Type, Johns Hopkins University in July, 1984.

Visited the University of Padua, Italy and gave a series of seminars at the Instituto per Ricerche di Dinamica dei Sistemi e di Biongegneria, May 17-June 15, 1985.

Gave a talk at the joint Statistics/Biostatistics Colloquium, University of North Carolina, Chapel Hill in August, 1985.

1.4.4 Eric S. Tollar.

Presented a talk at the departmental colloquium, Department of Statistics, Florida State University, Tallahassee, FL in April, 1984.

Presented a talk at the departmental colloquium, Department of Statistics, Florida State University, Tallahassee, FL in November, 1984.

1.4.5 A. Zaman.

Presented a talk at the IMS meeting in Orlando, FL in March, 1984.

1.5 Awards received and Ph.D. degress awarded.

1.5.1 Awards received.

Roger L. Berger was awarded the 1982 Frank Wilcoxon Prize by the American Society for Quality Control for the best practical applications paper in Technometrics. The paper was "Multiparameter Hypothesis Testing and Acceptance Sampling," USARO Technical Report No. D-48.

1.5.2 Ph.D. degress awarded.

Jee Soo Kim. Dissertation Title: Ranking and Selection Procedures for Exponential Populations with Censored Observations. Major Professor: R. L. Berger. December, 1982.

Wai T. Chan. Dissertation Title: Partial Orderings, with Applications to Reliability. Major Professors: F. Proschan and J. Sethuraman. April, 1985.

1.6 List of participating personnel.

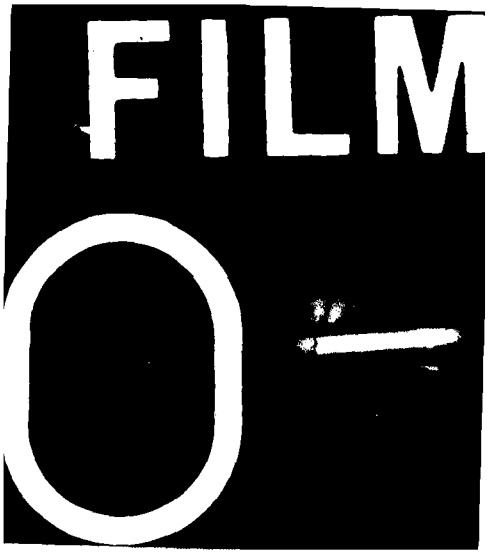
Jayaram Sethuraman, Florida State University

Roger L. Berger, North Carolina State University

Ian W. McKeague, Florida State University

Eric S. Tollar, Florida State University

Arif Zaman, Florida State University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