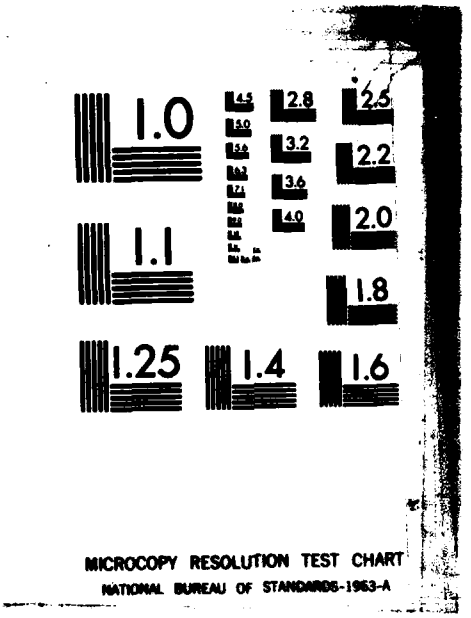
AD-A133 332 EFFICIENT SAMPLING PROCEDURES FOR PROCESS CONTROL IN NON-HOMOGENOUS PRODU..(U) FLORIDA UNIV GAINESVILLE R S LEAVENWORTH ET AL. 20 FEB 83 N00014-75-C-0783 1/1

UNCLASSIFIED F/G 12/1 NL


1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

No DTIC
7/83

(2)

AD-A133 332

FINAL CONTRACT REPORT

Efficient Sampling Procedures for Process Control in Non-Homogenous Product Mix Shops (with Extensions)

ONR Contract No. N 0014-75-C-0783

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

Submitted to:
Statistics and Probability Program
Office of Naval Research
Washington, D.C.

by

Richard S. Leavenworth, Professor
Industrial and Systems Engineering

Richard L. Scheaffer, Professor and Chairman
Department of Statistics

University of [redacted]
Gainesville, Florida 32611

DTIC
ELECTE
S OCT 7 1983
A

February 20, 1983

DTIC FILE COPY

88 10 04 273

FINAL REPORT ON "EFFICIENT SAMPLING PROCEDURES FOR PROCESS CONTROL IN NON-HOMOGENOUS PRODUCT MIX SHOPS"

1.0 Introduction

The following pages constitute the final report on ONR Contract Number N 0014-75-C-0783. Subsequent work on in-process statistical control procedures and acceptance sampling procedures is continuing under ONR Contract Number N 0014-83-K-0093. References in this report to supporting documents pertain to the document listings under Section 2.0, Technical Reports, and Section 3.0, Publications.

Preliminary study was conducted with the cooperation of the Naval Air Rework Facility, Jacksonville, Florida, during 1974-75. The main problem was to develop a practical and theoretically sound sampling system, with its operating procedures, to establish effective control over the output of component rework shops in an aircraft maintenance and rework facility.

The principal issue ~~in this study~~ lay in the difference between process control and product acceptance. Also, because of the wide variation in time and procedures required to refurbish the components flowing through any given shop, a control statistic based on units rejected was virtually useless. Thus, a new control statistic, maintenance errors committed per 100 man-hours worked, was tested amd found to follow relatively well the Poisson distribution within a given shop.

Because of familiarity with the operating procedures of MIL-STD-105D, it was decided that a three-level sampling procedure plus provisions for 100% detailing inspection would be provided. Thus rectifying inspection would be employed with a stipulated AOQL (Average Outgoing Quality Limit) as the principal criterion and a system of plans coded by AQL (Acceptable Quality Level as defined in MIL-STD-105D). (Reference 2.1.)

1.1 Significant Accomplishments

During 1975-76, mathematical models of the system, based on Markov chains, were developed and tested in four NARF-JAX shops. These formed the basis for the "Procedures" manual (Reference 2.2) reviewed by the NARF January through March, 1976. After publication, installation of the system in the remaining shops began in April, 1976. By December, the "Procedure" had been installed in 75 out of a possible 80 shops. The technical backup for the "Procedure" was published in March, 1976 (Reference 2.3), and a condensed version of the "Procedure" manual was published in August, 1977 (Reference 2.4). During this period, the NARF requested that certain non-technical changes be incorporated into the "Procedure" manual and a revised manual was produced in August, 1977 (Reference 2.2).

Progress in developing familiarity with the flexibility of the system continued into 1980. During this period, methods were developed for quality management to assess the performance of individual artisans and in April, 1980, the monthly Product Quality Report was modified to conform with shop data and shop control charting procedures.

During the development period, certain statistical results led to the publication of a paper on count data (Reference 3.1), a paper on the development of the sampling system model (Reference 3.2), a paper on estimating average quality (Reference 3.3), and a paper on applications of the Poisson (Reference 3.4).

During 1978, a companion procedure for treating the case of homogenous product flow was developed (Reference 2.5) and delivered to the NARF. A tutorial based on this binomial modeled system employing only two stages, sampling and detailing, was prepared in 1979 (Reference 2.6).

During 1979, attention was focused on the development of Acceptance Control Charts (ACC) for cases other than that developed by Richard Freund for subgroup averages, $\bar{X}$. In 1980, a report was prepared employing the Poisson in ACC's (Reference 2.7) which was subsequently published (Reference 3.5). An adaptation of ACC's to the binomial case was completed in 1982 and is included as part of this report (Reference 2.8). Results of this investigation will be submitted to the Journal of Quality Technology for possible publication in 1983.

During 1981-82 a computerized system for finding double sampling plans to minimize average sample size was developed. The basic algorithm was adapted by previous work by Guenther (1971). Publication as a Technical Report (Reference 2.9) is expected soon.

In 1979, Dr. Leavenworth began work on an advanced-level text, Statistical Models in Quality Control intended for use at the graduate level by students planning to do research in the field. Progress has been slow to date and is expected to continue for the next two years before completion of the manuscript. The prospective publisher is McGraw-Hill Book Company.

2.0 Technical Reports

2.1 "ANNUAL PROGRESS REPORT - Efficient Sampling Procedures for Process Control in Non-Homogenous Product Mix Shops," R. S. Leavenworth, R. L. Scheaffer, D. Hill, and C. Lyon, 1 August, 1975.

2.2 R. Leavenworth, R. Scheaffer, and C. Lyon, "Procedure for Maintenance and Rework Process Quality Control Based on Random Sampling," prepared for Naval Air Rework Facility, Jacksonville, Florida, January, 1976. Published as Industrial and Systems Engineering Technical Report 76-4 in February, 1976. Revised August, 1977.

2.3 R. Leavenworth, R. Scheaffer, and C. Lyon, "Technical Report Accompanying Procedure for...," Industrial and Systems Engineering Technical Report 76-5, March, 1976.

2.4 R. Leavenworth, Z. Lekic, and H. Lorberbaum, "Condensed Operating Manual for NARF Sampling Systems," Industrial and Systems Engineering Technical Report 77-8, August, 1977.

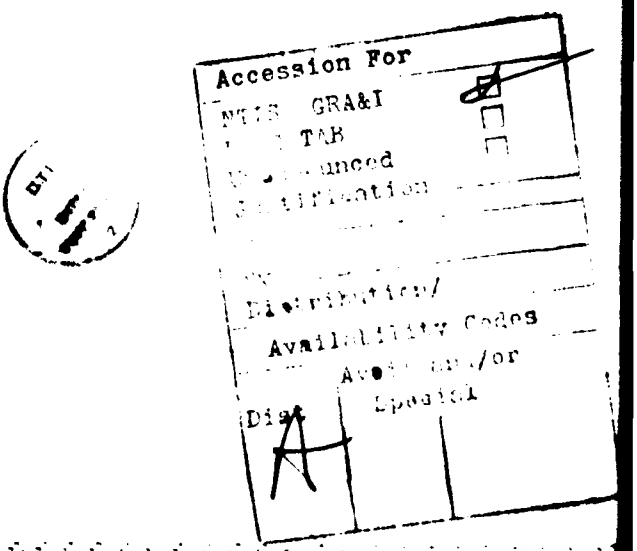
2.5 R. Leavenworth, Z. Lekic, and H. Lorberbaum, "An AQL-AOQL Process Control System for Fraction Defective," Industrial and Systems Engineering Technical Report 78-8, June, 1978.

2.6 C. Nguyen, R. Leavenworth, and R. Scheaffer, "A Two-Stage System for Process Control of Fraction Rejected," Industrial and Systems Engineering Technical Report 79-6, December, 1979.

2.7 S. Mhatre, R. Leavenworth, and R. Scheaffer, "Acceptance Control Charts Based on Normal Approximations to the Poisson Distribution," Industrial and Systems Engineering Technical Report 80-9, July, 1980.

2.8 C. Amado, R. Leavenworth, and R. Scheaffer, "Acceptance Control Charts Based on Exact and Normal Approximations to the Binomial Distribution," Industrial and Systems Engineering Technical Report 82-6, December, 1982.

2.9 R. Rangarajan and R. Leavenworth, "Developing Double Sampling Plans for Atrributes to Meet Sample Size Criteria," Industrial and Systems Engineering Technical Report 83-6 (expected) March, 1983.



3.0 Publications

3.1 R. L. Scheaffer and R. S. Leavenworth, "The Negative Binomial Model for Counts in Units of Varying Sizes," Journal of Quality Technology, Vol. 8, No. 3, July, 1976.

3.2 R. S. Leavenworth and R. L. Scheaffer, "Design of a Process Control Scheme for Defects per 100 Units Based on AOQL," Naval Research Logistics Quarterly, Vol. 26, No. 3, September, 1979.

3.3 M. Doviak and R. L. Scheaffer, "A Sequential Scheme for Estimating Average Quality in a Mixed Product Production Process," Technometrics, Vol. 21, No. 4, November, 1979.

3.4 R. L. Scheaffer, "Multiple Comparisons for Poisson Rates," Journal of Quality Technology, Vol. 12, No. 2, April, 1980.

3.5 S. Mhatre, R. Scheaffer, and R. Leavenworth, "Acceptance Control Charts Based on Normal Approximations to the Poisson Distribution," Journal of Quality Technology, Vol. 13, No. 4, October, 1981.

4.0 Graduate Students Supported - Industrial and Systems Engineering Department

Charles J. Lyon, ME	March, 1976
Jose Ortiz, ME	December, 1976
Zoran Lekic, ME	December, 1977
Henri Lorberbaum, ME	December, 1977
Suresh Mhatre, ME	August, 1978
Cong Nguyen, ME	March, 1979
Carlos Amado, ME	August, 1982
Rageswaren Rangarajan, MS	December, 1983

ME - Master of Engineering degree

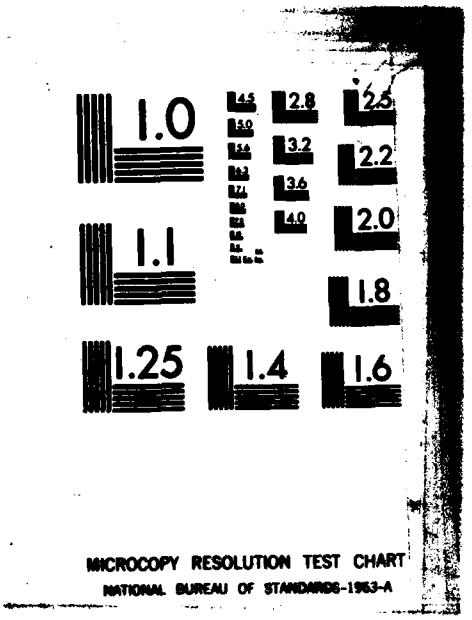
MS - Master of Science degree

END

FILMED

10-83

DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A