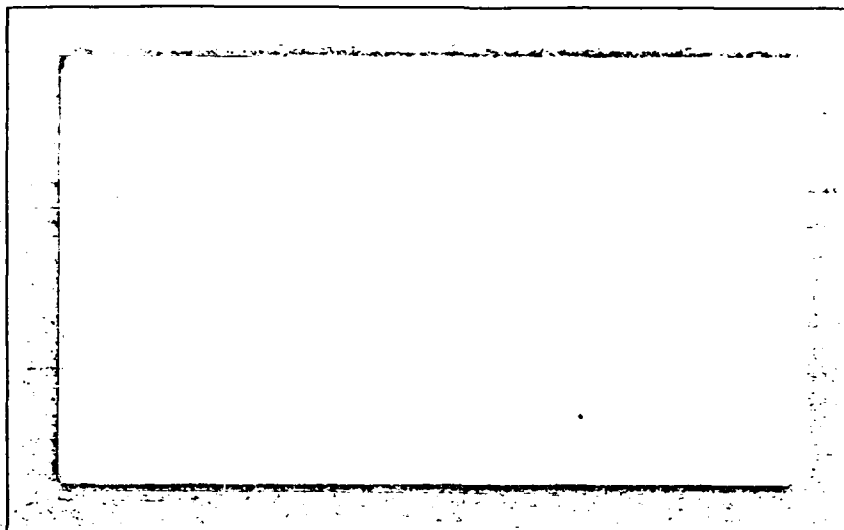


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Applied Research in Statistics - Mathematics - Operations Research

FINAL REPORT
STATISTICAL METHODOLOGY
FOR NAVY PROGRAMS

by
Dennis E. Smith
and
Kevin C. Burns

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Technical Report No. 131-1

April 1990

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I. INTRODUCTION

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The Desmatics, Inc. research effort under Office of Naval Research Contract No. N00014-87-C-0491 was composed of two tasks. The first consisted of research on statistical methodology and the implementation of statistical techniques for various problems, primarily associated with the Navy's Pollution Abatement and Ship Auxiliary Machinery programs. The second task was to investigate development of a statistical decision aid for use by Navy Program Managers in making trade-offs when allocating resources among their various programs. Section II provides a brief summary of the technical effort expended under this contract, while Section III contains a list of the relevant documentation. A major portion of this documentation communicated statistical design plans, data analysis results, and recommendations to cognizant Navy scientists and engineers.

*statistical design, decision
statistical planning, resource allocation,
decision analysis. (KR)*

II. TECHNICAL EFFORT

This section provides a brief discussion of the technical effort accomplished under this contract. All efforts have been fully documented, and the relevant technical notes are listed in Section III.

A. STATISTICAL METHODS FOR APPLICATION TO TECHNICAL PROBLEMS

The U.S. Navy is tasked, through its Pollution Abatement and Ship Auxiliary Machinery Program, with ensuring that possible pollution from Navy ships is kept to an acceptable minimum and that auxiliary machinery is performing optimally within operational constraints. The major goal of this program is to provide improved equipments and procedures for existing and future ships.

Meeting this goal requires extensive development and performance evaluation tasks. In addition, resources must be efficiently allocated to these tasks. The tasks are not necessarily straightforward, since improvement is not defined by a single quantity, but rather by a number of interrelated factors such as efficiency, reliability, maintainability, weight, cost, etc. As a result, the development and evaluation tasks tend to be relatively complex in nature. These tasks generally involve the preparation of test plans tailored to specific experimental requirements and the efficient acquisition, appropriate analysis and proper interpretation of the experimental results.

A major portion of the Desmatics research effort under this contract was concerned with organotin antifouling paint. Exten-

sive research has been conducted at the David Taylor Research Center (DTRC) to develop techniques for measuring the release rates of different paint formulations. Desmatics contributed to the design of release rates experiments, analysis of variability attributable to different sources, modeling the changes in the rates over time, and developing analytical procedures for comparing different paints. In a related effort, Desmatics reviewed the procedures suggested by the EPA for this type of study and suggested ways to improve those procedures based on the results obtained at DTRC.

Another research effort at DTRC with which Desmatics was involved extensively is the evaluation of different materials for mechanical face seals. Desmatics provided recommendations for designing the experiments and a statistical analysis of the data gathered to date. As part of this effort, an extensive simulation study was conducted in order to determine the best analysis procedure for this particular set of experiments.

The main function of the Ship Auxiliary Machinery Program is to develop improved equipments for shipboard use. Desmatics developed test plans for evaluating several new equipments, including a reverse-osmosis desalinators, an oil-water separator, a mercury-removal cartridge, and a shipboard trash compactor. Recommendations were given for evaluating performance, reliability, and maintainability, as well as for determining optimal methods of operation.

B. STATISTICALLY BASED AID FOR RESEARCH ALLOCATION DECISIONS

The second part of the Desmatics effort was focused on the development of a statistically based decision aid for use by Navy Program Managers in making resource allocation trade-offs. To a large extent, these trade-offs involve decisions about whether to commit resources to obtain additional empirical data, often through costly and lengthy experimentation. Thus, the decisions become concerned with the cost-effectiveness of data collection. The entire problem may be conceptually embedded in the framework of statistical decision theory, which is Bayesian-based. In that framework, the expected value of the data to be collected is compared with the cost of resources expended in obtaining the data, and the decision about what data to collect and how much to collect is made on the basis of that comparison.

Desmatics developed the statistical theory necessary to implement the envisioned decision aid and also prepared a prototype computer program. Briefings were given to cognizant Navy personnel to demonstrate the software package and elicit suggestions for improvement. Among the suggestions received were one for more extensive modeling of testing costs and another for including the possibility of sequential reliability tests.

III. DOCUMENTATION

The results of the Desmatics technical effort were well-documented, primarily in a number of technical notes. The following is a list of the project documentation:

Technical Paper (Draft) 9-15-87

The Role of Risk and Information in Navy R&D Program Management

Technical Note No. 131-1 9-22-87

Recommendations for the Evaluation of the Reverse Osmosis Desalination Unit

Technical Note No. 131-2 9-24-87

Recommendations for Evaluating PV Limits of Mechanical Face Seal Materials

Technical Note No. 131-3 10-15-87

Considerations in Evaluating a New Technique for Measuring Organotin Concentrations

Technical Note No. 131-4 11-04-87

Comments on EPA Review of TBT Release Rate Studies

Technical Note No. 131-5 11-30-87

Recommendations for Laboratory Evaluation of In-Tank Oil/Water Separator Performance

Technical Note No. 131-6 11-30-87

Comments on the Standard Test Procedure for Measuring TBT Release Rates of Antifouling Paints

Technical Note No. 131-7 12-10-87

Statistical Analysis of a Set of Organotin Release-Rate Experiments

Technical Note No. 131-8 12-14-87

Further Comments on the Standard Test Procedure for Measuring TBT Release of Antifouling Paints

Technical Note No. 131-9 12-16-87

Estimating Steady-State Release Rates for Organotin Antifouling Paints

Technical Note No. 131-10 12-28-87

Establishing Target Release Rates to Ensure Satisfying the EPA Criterion

Technical Note No. 131-11 1-11-88

Preliminary Analysis of PV Limit Data for Mechanical Face Seal Materials

Technical Note No. 131-12 2-12-88

A Simulation Study of Two Statistical Techniques for Comparing PV Limits of Mechanical Face Seal Materials

Technical Note No. 131-13 2-22-88

Further Analysis of a Set of Organotin Release-Rate Experiments

Technical Note No. 131-14 3-08-88

Statistical Analysis of Organotin Release From Panel Specimens
After Removal From USS Kittyhawk

Technical Paper (Draft) 9-15-88

Decision Analysis Paper

Technical Note No. 131-15 3-22-88

Performance Bounds for Small-Scale Mercury Removal Cartridges
Updated: 5-12-88 (131-15A)

Technical Note No. 131-16 4-29-88

Recommendations for TECHEVAL of the Shipboard Vertical Trash
Compactor

Briefing Handout For NAVSEA 5-31-88

Reliability Test Decision Aid

Technical Note No. 131-17 6-16-88

Statistical Analysis of Corrosion Rates for Metallic Coupons
Exposed to Chlorinated Seawater

Technical Note No. 131-18 7-28-88

The Shipboard Vertical Trash Compactor: Statistical Consider-
ations and Recommendations for the TECHEVAL

Technical Note No. 131-19 8-30-88

Statistical Analysis of PV Limit Data for Mechanical Face Seal
Materials

Technical Note No. 131-20 10-27-88

Statistical Analysis of Data From Round-Robin Crevice Corrosion Testing

Technical Note No. 131-21 11-07-88

A Sequential Bayes Reliability Test Procedure

Technical Note No. 131-22 3-22-89

Preliminary Comments on TECHEVAL for Invert Emulsion Fluid

Technical Note No. 131-23 4-04-89

Preliminary Discussion of Statistical Aspects of Qualification Testing for Mechanically Attached Fittings

Technical Note No. 131-24 4-10-89

Statistical Considerations in the Design of an Experiment for Evaluating Crevice Corrosion Countermeasures

Technical Note No. 131-25 5-31-89

Preliminary Evaluation of In-Tank Oil/Water Separator Performance

Technical Note No. 131-26 6-27-89

Preliminary Analysis of Copper Release Rates

Technical Note No. 131-27 8-02-89

Updated Analysis of PV Limit Data for Mechanical Face Seal Materials

Technical Note No. 131-28 8-07-89

Statistical Analysis of Organotin Release Rates

Technical Note No. 131-29 12-08-89

A Statistical Analysis of Comparison Readings between Calibrated and Isolator Gauges

Technical Note No. 131-30 1-04-90

Revised Performance Bounds for Small-Scale Mercury Removal Cartridges

Technical Note No. 131-31 1-16-90

Statistical Analysis of Reliability Data for Vacuum-Flush Fixtures

Technical Note No. 131-32 1-22-90

A Statistical Review of an Approach to Monitoring Submarine Machinery Vibration

Technical Note No. 131-33 1-24-90

Statistical Considerations in Sampling for Airborne PCBs on Navy Ships

Technical Note No. 131-34 1-30-90

Further Statistical Analysis of Comparison Readings between Calibrated and Isolator Gauges Based on Additional Data

Technical Note No. 131-35 2-08-90

Statistical Recommendations for the Invert Emulsion Fluid
TECHEVAL

Technical Note No. 131-36 2-15-90

Confidence Intervals for the Probability of Detecting Imminent Bearing Failures

Technical Note No. 131-37 3-06-90

Statistical Recommendations for Surface PCB Sampling

Technical Note No. 131-38 3-06-90

A Statistical Analysis of Comparison Readings Between Calibrated and Isolator Gauges for January 1990 Data Set

Technical Note No. 131-39 3-19-90

Analysis of the Relationship Between Bearing Condition Assessments and Vibration Monitoring Program Flags

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Desmatics, Inc. research effort under Office of Naval Research Contract No. N00014-87-C-0491 was composed of two tasks. The first consisted of research on statistical methodology and the implementation of statistical techniques for various Navy problems. The second task was to investigate development of a statistical decision aid for use by Navy Program Managers in making trade-offs when allocating resources among their various programs.		