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**COVER SHEET
FOR TRIP REPORTS SUBMITTED TO THE
OFFICE OF ENERGY RESEARCH**

Destination(s) and Dates for
Which Trip Report Being Submitted: Neuchatel, Switzerland, July 23-28, 1988

Name of Traveler: Max D. Morris

Joint Trip Report Yes
 No

If so, Name of Other Traveler(s): _____

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ORNL
FOREIGN TRIP REPORT
ORNL/FTR-2981

DATE: August 9, 1988

SUBJECT: Report of Foreign Travel of Max D. Morris, Statistician,
Engineering Physics and Mathematics Division, ORNL

TO: Alexander Zucker

FROM: Max D. Morris

PURPOSE: To participate in a conference on experimental design at Neuchatel, Switzerland,
July 24-28, 1988.

SITES VISITED: July 23-28, 1988 Conference-Workshop Neuchatel, Switzerland

ABSTRACT: The traveler attended the First International Conference-Workshop on Optimal Design and Analysis of Experiments, and presented an invited paper entitled "A Bayesian Approach to the Design and Analysis of Computational Experiments" (joint with T. J. Mitchell of ORNL). Besides the traditional topics usually covered at design conferences, two general areas of research which were heavily represented are design and analysis techniques related to process quality assurance, and design criteria and procedures for prediction and estimation problems involving "spatially" correlated stochastic processes. The latter topic is particularly relevant to ORNL's effort in experimental design for computer experiments.

II. A. Detailed Statement of Purpose.

The stated purpose of the meeting was to bring together researchers working on problems in the optimal design and analysis of experiments from around the world to discuss the most recent progress in the field and to develop new fields of application. There were approximately 150 participants representing over twenty countries, mostly from Eastern and Western Europe, and North America. Although there have been several workshops on this topic in the U.S. and in Europe in recent years, these have typically been much smaller meetings of regional interest. This marks the first attempt to hold a truly world-wide conference on this set of research topics.

The meeting was composed of two parallel sets of sessions. The "workshop" featured invited papers and discussion sessions grouped by topic. The "conference" included contributed papers on a wide variety of design problems.

DOE has for several years supported basic research in the statistical design of experiments at ORNL through the Applied Mathematical Sciences (AMS) Research Program, Office of Basic Energy Sciences (KC 07 01 02 0). One area in which significant accomplishments have been produced at ORNL is the development of computational algorithms which generate optimal designs. Recently, some researchers in this country have become interested in the application of ideas from statistical experimental design to computational experiments, i.e. numerical experimentation in which a complex computer model takes the place of traditional laboratory apparatus or other physical systems. Work in this area was first supported at ORNL in 1987 by the Exploratory Studies Program, then by the AMS Program. Much of the work presented at this conference is directly or indirectly related to these ongoing research efforts at ORNL.

II. B. Summary of Activities.

The invited papers and discussion sessions were grouped into the following eight topics: nearest neighbor designs, optimization methods for designs, design construction, optimal combinatorial designs, spatial and correlated error models, computational experiments, linear and non-linear models, and quality control.

Several general themes seemed of major concern at this conference. One is the use of experimental design in process quality control or assurance. The role of statistics in industrial quality control has been highly publicized in the U.S. in recent years, with particular interest in techniques which have appeared to be successfully implemented in Japan. At this conference, it was clear that interest in using statistical design techniques to improve industrial process quality is a major world-wide concern, both of industrial and academic researchers. Six of the papers presented explicitly dealt with problems associated with quality assurance; a major emphasis is the firm re-definition, refinement, and improvement of early design ideas introduced by the Japanese engineer Genichi Taguchi.

A second general area of clear interest is the use of stochastic processes, i.e. "spatially" correlated statistical structures, in prediction and estimation problems, and associated questions of experimental design. Applications of these techniques were discussed in the context of the "physically spatial" problem of a meteorological observation network, and the "conceptually spatial" problem of computational experimentation. It is clear that ORNL research motivated by the later problem can be aided by previous and current work in spatial prediction.

Finally, there exists a broad continuing interest in the development of computer algorithms for generating optimal experimental designs. Three invited talks featured new algorithms.

II. C. Traveler's Role.

Along with Toby Mitchell of ORNL, the traveler presented an invited paper entitled "A Bayesian Approach to the Design and Analysis of Computational Experiments" at the workshop.

The traveler had significant conversations with individuals as follows:

1. Hirsto Yonchev, Higher Institute of Chemical Technology, Bulgaria. This individual presented a paper on his research in the area of algorithms for generating exact D-optimal designs for linear factorial models. This work is essentially unknown in the west due to communications problems with eastern block countries. The traveler's discussions with this individual were centered on details of his presented algorithm, and his extension of it to continuous problems. Discussions also included work by this individual in design for model

discrimination, which is related in some ways to earlier DOE-supported work of the traveler (e.g. Morris, M. D. and T. J. Mitchell, 1983, "Two-Level Multifactor Designs for Detecting the Presence of Interactions," *Technometrics*, V. 25, 345-355).

2. Robert Nagtegaal, Volvo Car B. V., The Netherlands. The individual is a mechanical engineer whose work involves computer simulation of mechanical systems at the product design stage; an example discussed was the design of bells or chimes so as to achieve certain desirable sound wave characteristics. Due to his organization's heavy reliance upon computer models in place of physical prototypes, the traveler's work in experimental design for computer experiments was of interest, and the discussion covered potential uses of our methodology to his applications.
3. David Steinberg, Tel-Aviv University, Israel. Discussion with this individual centered on the topic of his presentation, optimal configuration of sensors in a seismographic network. His work in this area is related to Israel's interest in building nuclear reactors for electric power generation, and where they might be sited. Related topics which were discussed are concepts such as "acceptable risk" used in planning and design, and the use of historical data of questionable reliability in estimating event rates.
4. Lisa Moore, Los Alamos National Laboratory, USA. This individual is involved in research in design construction based upon criteria related to inter-observation distances. While the original motivation for these criteria is not statistically based, they lead to designs which are easily interpreted by practitioners, and are typically "good" if not optimal from several standpoints. Discussions centered on current work of Don Ylvisaker of UCLA who is formulating statistically-based criteria for these designs, and on other distance-related design criteria.
5. Werner Mueller, Vienna University, Austria. Over the last few years, this individual has collaborated with the Soviet statistician V. V. Fedorov--one of the universally recognized leading names in the statistical design community--on the theory underlying an application of optimal design of a meteorological observation network. This work has been carried out at the International Institute for Applied Systems Analysis in Vienna, where Fedorov has been visiting for the last 5 years. Discussion was centered on similarities and differences between their approach and the traveler's approach to the similar problem of computer experiments.

In addition to the above individuals, who might be classified as "new contacts" for the traveler, continuing discussions were held with Jerome Sacks (Univ. of Illinois), William Welch (Univ. of Waterloo, Canada), and Donald Ylvisaker (Univ. of California at Los Angeles) on our joint and individual research efforts in the design of computational experiments and related topics.

II. D. Recommendations on Future Participation.

Many of the presented papers and discussions at this workshop-conference were directly related to ongoing DOE-funded design research at ORNL. In particular, ORNL's work in computer-aided experimental design and the design and analysis of computational experiments (AMS/BES KC 07 01 02 0) is similar in some ways to work of other researchers in algorithm development and design for the use of stochastic processes as predictors, and this conference provided a means of information exchange which will be mutually beneficial. Additionally, the meeting was a valuable experience for the traveler, in that it provided a clear overview of how the world's leading researchers are approaching difficult experimental design issues today. Because of the current international interest and level of activity in experimental design related to ORNL's ongoing research activities, participation of ORNL's research staff in future meetings of this type would be highly desirable.

II. E. Developments in Other Countries.

Since the application of design techniques to specific energy problems was not a central theme of this conference, little was learned about specific energy-related programs and progress in other countries.

At a more basic level, the traveler is left with two impressions concerning how the state of research in experimental design looks at an international level. First, as mentioned above, industrial design for the purpose of quality control seems to be of universal interest in virtually all industrialized countries represented, both to industrial and academic researchers. Second, the lack of access to modern computing facilities in eastern block countries (specifically Bulgaria) leads to a different approach to research involving computation. Priority is placed upon computing a solution to a design problem once, and tabulating the results in catalogues. This contrasts to the western emphasis on development of efficient and portable algorithms (as opposed to solutions) which can be used when needed in different contexts.

II. F. Summary Evaluation.

It is fair to say that the general goal of the conference given above was more than fulfilled. Due to the nature of the meeting, no official "conclusions" or "decisions" were made. If quantity of presented papers and discussion can be used as a guide to what are judged to be the important issues facing researchers in this area, three such issues are surely (1) design for stochastic process-based prediction and estimation procedures, (2) design for process quality control, and (3) development of algorithms for the construction of optimal experimental designs.

An additional comment seems in order concerning the reaction of conference attendees to the contributions and remarks of Toby J. Mitchell, ORNL's other participant at this conference. The members of the Mathematical Sciences Section of ORNL (and the U.S. statistical community, generally) have for some years recognized Dr. Mitchell as one of the real leaders in the development of ideas related to optimal experimental design. This traveler was left with the clear impression that this high regard for Toby Mitchell's work is truly international, and that he is clearly regarded as one of the leading authorities, world-wide, in algorithm development for experimental design.

APPENDIX

A. Itinerary

7/22 - 23/88	Travel from Oak Ridge to Neuchatel, Switzerland, via Frankfurt, West Germany, and Zurich, Switzerland.
7/23-28/88	Neuchatel, Switzerland. To attend and present an invited paper at the First International Conference-Workshop on Optimal Design and Analysis of Experiments, University of Neuchatel.
7/28-29/88	Travel from Neuchatel, Switzerland, to Oak Ridge, via Zurich, Switzerland, and Frankfurt, Germany.

B. Persons Contacted

Hirsto Yonchev, Professor of Statistics, Higher Institute of Chemical Technology, Sofia, Bulgaria.

Robert Nagtegaal, Mechanical Engineer, Volvo Car B.V., Helmond, The Netherlands.

David Steinberg, Professor of Statistics, Tel-Aviv University, Ramat-Aviv, Israel.

Werner Mueller, Professor of Economics, Vienna University, Vienna, Austria.

William Welch, Professor of Statistics, University of Waterloo, Waterloo, Canada.

Lisa Moore, Research Statistician, Los Alamos National Laboratory, Los Alamos, New Mexico, USA.

Jerome Sacks, Professor and Head of Statistics, University of Illinois, Urbana, Illinois, USA.

Donald Ylvisaker, Professor of Mathematics, University of California at Los Angeles, Los Angeles, California, USA.

C. Listing of Literature Acquired:

Collected abstracts of talks given at the workshop-conference.

Fedorov, V. and Mueller, W. (1988). "Two Approaches in Optimization of Observing Networks." A corrected version of the manuscript which appears in the conference proceedings.

D. Distribution

- 1-2. Assistant Secretary for International Affairs, DOE, Washington, D.C. 20545
3. Dr. James F. Decker, Acting Director, Office of Energy Research, Washington, D.C. 20545
4. Dr. Donald K. Stevens, Associate Director for Basic Energy Sciences, Washington, D.C. 20545
5. J. A. Lenhard, Assistant Manager, Energy Research and Development, DOE/ORO
6. D. J. Cook, Director, Safeguards and Security Division, DOE/ORO
- 7-8. Office of Scientific and Technical Information, P. O. Box 62, Oak Ridge, TN 37831
9. B. R. Appleton
12. D. J. Downing
14. J. K. Ingersoll
15. F. C. Maienschein
16. M. D. Morris
19. R. C. Ward
20. A. Zucker
- 21-22. Laboratory Records Department
23. Laboratory Records Department - RC
24. Laboratory Protection Division
25. ORNL Patent Section
26. ORNL Public Relations Office