

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

RECEIVED  
JUL 06 1990

Destination(s) and Dates for      7/18-20/88 - Bergen, Norway  
Which Trip Report Being Submitted: 7/22/88 - Augsburg, Germany  
Which Trip Report Being Submitted: 7/25-28/88 - Neuchatel, Switzerland  
Which Trip Report Being Submitted: 8/01-05/88 - London, England

Name of Traveler: Toby J. Mitchell

Joint Trip Report  Yes  
 No

If so, Name of Other Traveler(s): \_\_\_\_\_

MASTER

EB

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

## **DISCLAIMER**

**This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.**

---

## **DISCLAIMER**

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**

**OAK RIDGE NATIONAL LABORATORY**

OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.  
POST OFFICE BOX 2008, OAK RIDGE, TENNESSEE 37831-6285

**ORNL**

**FOREIGN TRIP REPORT**

ORNL/FTR-2998

DATE: August 22, 1988

SUBJECT: Report of Foreign Travel of Toby J. Mitchell, Statistician,  
Engineering Physics and Mathematics Division, ORNL

TO: Alexander Zucker

FROM: Toby J. Mitchell

PURPOSE:

1. To attend and present an invited paper at the First International Conference-Workshop on Design and Analysis of Experiments, held in Neuchatel, Switzerland.
2. To work for one week with Professor Henry Wynn of City University, London, on what we expect will become a joint paper on maximum entropy sampling.
3. To present seminars on DACE at the University of Augsburg, Germany, and at the IBM Scientific Centre in Bergen, Norway.
4. To work for a couple of days with Dr. Leonard Gray, now a visiting researcher at the IBM Scientific Centre in Bergen.

SITES VISITED:	July 18-20, 1988	IBM Bergen Scientific Centre	Bergen, Norway
	July 22, 1988	University of Augsburg	Augsburg, Germany
	July 25-28, 1988	Conference	Neuchatel, Switzerland
	August 1-5, 1988	City University	London, England

ABSTRACT:

The traveler attended the First International Conference-Workshop on Optimal Design and Analysis of Experiments, where he gave an invited paper, "A Bayesian Approach to the Design and Analysis of Computer Experiments (DACE)", jointly with M. D. Morris. Conference topics of particular interest to ORNL's Computational Statistics research were DACE, spatial correlation models, and computer algorithms for construction of experimental designs. The traveler also gave seminars on DACE at IBM's Bergen Scientific Centre and at the University of Augsburg. At Bergen, the traveler met with L. J. Gray and discussed the potential application of DACE methodology to the solution of differential equations. After the Conference, the traveler spent one week in London working with Professor H. P. Wynn of City University on maximum entropy sampling, a principle of experimental design that is of importance to ORNL's research in DACE.

## II. Report

### A. Purposes

1. To attend and present an invited paper at the First International Conference-Workshop on Design and Analysis of Experiments, held in Neuchatel, Switzerland. This meeting provided an opportunity for M. D. Morris and me to present and discuss with European experts the ideas on Design and Analysis of Computer Experiments (DACE) that have been developed during the past three years. DACE has become a major new direction in the Computational Statistics research at ORNL, funded by the Applied Mathematical Sciences program of DOE.
2. To work for one week with Professor Henry Wynn of City University, London, on what we expect will become a joint paper on maximum entropy sampling. The latter is the main principle that determines the design criterion in our work in DACE.
3. To present seminars on DACE at the University of Augsburg, Germany, and at the IBM Scientific Centre in Bergen, Norway. The purpose of the seminars was to expose this work to new audiences and to benefit from their comments.
4. To work for a couple of days with Dr. Leonard Gray, now a visiting researcher at the IBM Scientific Centre in Bergen. The original purpose was to continue joint work on the application of simulated annealing algorithms to the computer construction of optimal experimental designs, but our discussions took a different turn, as noted below.

### B. Activities

The conference at Neuchatel was a major international gathering of researchers in optimal design of experiments (perhaps the largest ever convened). The attendance (135) was much larger than expected, reflecting the recent resurgence of interest in the subject. Two of the principal "themes" that emerged from the conference were the design and analysis of computer experiments (which was the subject of the keynote address given by Professor Jerome Sacks of the University of Illinois) and the related area of spatial designs, e.g., the optimal location of meteorological stations. Both of these are of direct interest to ORNL's DACE research. In the first area, the most significant technical development that was reported at the conference was Professor Donald Ylvisaker's (UCLA) paper that characterized the geometrical properties of designs that are optimal under certain commonly used criteria. There was not much contribution to this topic from the Europeans, although Valeri Fedorov of the Soviet Union presented methods for siting meteorological stations that were similar in many ways to the methods we use for choosing the input configurations for computer experiments. The Bulgarians (A. Donev and H. Yonchev) have made some advances in the area of computer algorithms for designing experiments, which has been one of our main research themes for a long time. A topic that should be of interest to DOE production programs is experimental design for quality control. The methods that are currently attracting a lot of attention in American industry are those that were pioneered by the Japanese engineer Taguchi. Largely through the efforts of Professor Henry Wynn of City University, London, these methods have been recently introduced to European statisticians and their industrial clients. Six or seven papers in this area were given at the Conference, and I got the impression that the Europeans will give it increasing attention in the future.

There seemed to be a strong feeling among the participants at the Neuchatel conference that similar conferences should be held every year. In the past, there has not been a great deal of communication between experimental design researchers in the U.S. with those in Europe (outside of Britain), and the feeling among the participants was that a series of conferences

would be very useful. However, there was also a strong feeling, particularly among the American and British participants, that these conferences should be independent of the principal organizer of this one, Professor Yadolah Dodge of the University of Neuchatel. Among the complaints: the program was completely reordered at the last minute, the main hotel was distant from the conference site, and promises of financial support for some speakers were not kept. I make these remarks here only to recommend that ORNL and DOE look carefully at arrangements (particularly financial ones) made at future conferences organized by Professor Dodge.

Some of my time at the Conference was spent with collaborators on various research projects having to do with DACE. These discussions included J. Sacks (Illinois), D. Ylvisaker (UCLA), W. Welch (Waterloo), F. Wynn (City, London), and M. Morris (ORNL). Apart from that, I did not participate in any particularly notable conversations, with the exception of one with Sacks, Wynn, and Fedorov on the "world dialogue" Soviet-American agreement, which apparently makes it easier for software exchanges between the two countries to take place. Fedorov, who had most of the information, seems to be quite interested in this, and mentioned a Mr. Joseph Ritchie at CRT in Chicago as being the person to contact.

The seminars at Bergen and at Augsburg served as trial runs for my talk at the Conference, and gave me a chance to get some reaction to it. In both cases, my audiences were small but friendly, and I benefited from the discussion that followed. An additional purpose of the visit to Bergen was to continue collaborative research with Dr. Leonard Gray on the use of simulated annealing algorithms in the computer construction of optimal experimental designs. However, our attention soon turned to what seems to us to be a much more exciting topic: the use of DACE methodology to solve differential equations. Dr. Gray is one of the few people familiar with our DACE work who are also knowledgeable about the kinds of differential equations that are important. My conversations with him were extremely valuable in determining the direction of our future research in this area.

Probably the most lasting benefit of my visit to Augsburg was that a good personal relationship was established with my host, Professor Friedrich Pukelsheim, and with his Ph.D. student Susanna Gutmaier. Professor Pukelsheim is one of the most respected European scholars in experimental design. Ms. Gutmaier intends to do her advanced study in Bayesian design of experiments, a general area that is highly relevant to our DACE work. I hope that we will continue to communicate with one another.

After the Neuchatel Conference, I spent a week in London with Professor Henry Wynn of City University, doing joint research on the principle of maximum entropy sampling. This is a principle of experimental design for prediction of a function based on exact or approximate evaluations of that function. My interest in it stems from the fact that it is a cornerstone of our DACE research. During the week, we considered its more general ramifications, including its sequential implementation and its application to the detection of a sudden change in the function.

### C. Summary of Technical Value

The Neuchatel conference was valuable in several ways. It provided an opportunity for us to meet, for the first time, several of the European experts in experimental design. It served as an international forum for our DACE work, and allowed us a good view of what is going on around the world in areas that are related to it. It also brought together many of the people that have been collaborating rather actively on DACE-related work, so we were able to make some progress at the paper-writing level. Partly because of this, and partly because of the heavy scheduling of talks, many of my conversations with other participants were rather superficial.

The week with Henry Wynn in London was very valuable technically. We were able to make significant progress in our study of maximum entropy sampling as a principle of experimental design. I was able to focus for one week on a topic of great interest in our approach to DACE, in the company of perhaps the world's leading expert on that topic, without distraction by other work-related problems. It is unlikely that this would have been possible in any other setting.

The seminars at Bergen and Augsburg were somewhat less valuable to me technically, although they did serve as an opportunity for me to spread the gospel of DACE to audiences that might not otherwise be exposed to it: numerical analysts at Bergen and "mainstream" optimal design researchers at Augsburg. I did benefit to some extent from the comments that arose from their viewpoints. I also think that the friendly personal relationships that I established with Friedrich Pukelsheim and Susanna Gutmaier may lead to technical collaboration in the future.

My work with Len Gray at Bergen, while not extensive in terms of time, turned out to be very valuable, since it strongly influenced the direction of the research that Max Morris and I will take in the application of DACE methods to the solution of differential equations.

With respect to future DOE support for such trips, I wholeheartedly recommend encouragement of foreign travel, beginning with a significant reduction in the paperwork required both before and after. Although officials are naturally sensitive to the potential for misuse of foreign travel, the potential benefits in terms of increased communication with other researchers around the world are far more important. This was the second official foreign trip for me. The first, in 1973, had a very positive impact on my research, and I have no doubt that this one will also.

## APPENDIX

### A. Itinerary

- 7/16-17/88 Travel from Oak Ridge, Tennessee to Bergen, Norway.
- 7/18-20/88 Visit and seminar at IBM Scientific Centre, Bergen.
- 7/20-22/88 Travel from Bergen, Norway to Augsburg, Germany.
- 7/22-23/88 Visit and seminar at University of Augsburg.
- 7/24/88 Travel from Augsburg, Germany to Neuchatel, Switzerland.
- 7/25-28/88 Conference participation (invited speaker) at First International Conference-Workshop on Optimal Design and Analysis of Experiments, Neuchatel.
- 7/28-29/88 Travel from Neuchatel, Switzerland to London, England.
- 8/01-05/88 Visit, research collaboration with Professor H. P. Wynn, City University, London.

### B. Persons Contacted to a Significant Extent.

#### 1. Technical conversation, seminar discussion:

- Dr. Patrick Gaffney, Director, IBM Bergen Scientific Centre.
- Professor Friedrich Pukelsheim, Professor of Probability and Statistics, University of Augsburg.
- Professor Norbert Gaffke, Professor of Probability and Statistics, University of Augsburg.
- Ms. Susanna Gutmaier, Graduate Student, Instructor in Probability and Statistics, University of Augsburg.
- Mr. A. Donev, Department of Mathematics, Imperial College, London.
- Professor Valeri Fedorov, Visiting Scientist, International Institute for Applied Systems Analysis, Laxenburg, Austria.
- Professor H. Yonchev, Professor, Higher Institute of Chemical Technology, Sophia, Bulgaria.

## 2. Research Collaboration:

Dr. Leonard Gray, Visiting Mathematician, IBM Bergen Scientific Research Centre.  
Professor Jerome Sacks, Chairman, Department of Statistics, University of Illinois.  
Professor William Welch, Professor, Department of Statistics, University of Waterloo, Ontario.  
Professor Henry Wynn, Professor, Department of Mathematics, City University, London.  
Professor Donald Ylvisaker, Department of Mathematics, University of California, Los Angeles.

## C. Literature Acquired

None.

## 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. T. J. Mitchell
- 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