INTERIM REPORT

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INTERIM REPORT

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ORNL

FOREIGN TRIP REPORT

ORNL/FTR-822

DATE: May 1, 1980

SUBJECT: Report of Foreign Travel of P. M. Haas, Research Staff Member, Engineering Physics Division

TO: Herman Postma

FROM: P. M. Haas

PURPOSE: The purpose of this trip was to present a paper on the NRC-sponsored program, Safety Related Operator Actions, at the Joint Conference: "6th Advances in Reliability Technology Symposium and the 3rd European Reliability Data Bank Seminar" held at the University of Bradford, Bradford, United Kingdom, and also attend and participate in "An International Seminar and Workshop on Data Management Systems for High Technology Industries" which was held in Southport, United Kingdom.

SITES VISITED:	4/9-11/80	Joint Conference	Bradford, UK	A. E. Green
	4/14-16/80	Seminar/Workshop	Southport, UK	A. J. Bourne

ABSTRACT: The traveler attended the Joint Conference: "6th Advances in Reliability Technology Symposium and 3rd European Reliability Data Bank Seminar." He presented a paper there summarizing previous and current work in the NRC-sponsored program "Safety Related Operator Actions" at ORNL. He also co-authored a paper presented by H. E. Knee, Engineering Physics Division, ORNL, which described the development and operation of the Centralized Reliability Data Organization (CREDO), a DOE-sponsored program for which the author has been the principal investigator for several years. Discussions were held with a number of European investigators in the areas of human factors research and reliability/availability data collection and assessment. Following the joint conference at Bradford, the traveler attended the "An International Seminar and Workshop on Data Management Systems for High Technology Industries," during which the development and operation of a number of different major systems for data management relating to nuclear (and to some extent nonnuclear) industries both in Europe and the U.S. were described and demonstrated.

REPORT OF FOREIGN TRAVEL

P. M. Haas

A. Purpose of the Trip. As with any conference attendence, the primary purpose is the exchange of information on current research and ongoing or planned programs which could be of mutual benefit to the participating organizations. The specific objectives for this trip were related to three different activities supported by NRC and DOE, the first two of which are associated with active programs at ORNL:

(1) Quantification of Nuclear Power Plant Operator Reliability Under Accident Conditions. The author is program manager and principal investigator of the "Safety Related Operator Actions" program sponsored by NRC at ORNL. The program involves collection and assessment of quantitative and qualitative data on operator performance under accident conditions by examining records of accident events that have occurred and by performing "experiments" on full-scope nuclear plant simulators. A paper summarizing preliminary results and future plans for this program was presented at the 6th Advances in Reliability Technology Symposium in Bradford, UK. Other specific goals of the trip related to this work were to discuss any relevant research in progress or planned by European investigators present, and to obtain critical comments on the ORNL work. Of special interest was previous work reported to have been carried out by members of the British National Centre for Systems Reliability (NCSR) which included simulator studies with control room operators. The key persons contacted with regard to this goal were Mr. D. M. Hunns of NCSR (at the Bradford meeting), and Mme. A. Carnino of Commissariat a L'Energie Atomique (CEA) (at the Southport meeting) who summarized relevant research efforts in France.

(2) Development and Operation of a Reliability Data Organization for Breeder Reactors. The author has been the principal investigator for the past two years on a DOE-sponsored program at ORNL to design, develop and operate the Centralized Reliability Data Organization (CREDO), a national center for reliability/availability data and related data services for breeder reactors. The initial system development is nearing completion, and the system is moving from the development phase to a routine operation. Mr. H. E. Knee of ORNL, who has more recently taken a major role in this program, presented a paper at the 3rd European Reliability Data Bank Seminar in Bradford which summarized the capabilities and status of CREDO. An important goal for the trip was to discuss the CREDO system with the staff of NCSR. Mr. G. Cannon, Manager of the NCSR

data bank had agreed to provide a critical review of CREDO based on the many years of experience at NCSR, and a copy of the CREDO Input Guide was sent to him prior to the trip. In addition to the discussions with Mr. Cannon and other staff members of NCSR, a very helpful exchange of information and experience in data base development took place with staff members of Joint Research Centre (JRC), Ispra, Italy; Mr. G. Mancini, Mr. S. Capobianchi and Mr. A. G. Colombo, who have recently completed the feasibility study for the Commission of the European Communities (CEC) on development and operation of a centralized European Reliability Data System (ERDS).

(3) General Summary of European Programs in the Area of Operational Data. Shortly before leaving on the trip the author was requested by Mr. J. Helmetes of the recently formed Office for Analysis and Evaluation of Operational Data at NRC to informally survey the active and planned European programs discussed at the two meetings which relate to collection and evaluation of operational data - plant/component performance, reliability data, availability data, abnormal event reporting, etc. - in order to provide some perspective on the European programs and general information of use to that office in coordinating similar U.S. programs. A number of relevant papers were presented applicable to both nuclear and nonnuclear industries and some followup discussions were possible. Key individuals contacted with regard to this goal, in addition to the British NCSR staff and the Italian group noted above were Mssrs. J. Dorey and S. Silberberg of Electricitie de France who discussed data collection and results of some analysis at EdF.

B. Results of Contacts, Discussions With Key Personnel. The following are summaries of information gained from presentations by and discussions with key personnel and any resulting conclusions, agreements or recommendations:

(1) Mr. David Hunns, UKAEA, NCSR. Mr. Hunns pointed out that although there is a great deal of interest in human factors research within NCSR, the level of funding is not large, and the number of people involved are few - primarily himself and, through cooperative arrangements, faculty at Manchester University and Stirling University. He had "inherited" earlier work by Sayers and others at NCSR which involved attempts to obtain quantitative data on operator performance from both simplified experimental arrangement and training simulators. The latter studies were of particular interest, since they involved measurement of operator response times on a full-scope power plant simulator, and are the most directly applicable to the ORNL work that have yet been identified. Two papers (source unreferenced) describing the experiments and results were received. The program of experiments is not currently active.

More recently, Mr. Hunns has been concentrating on deriving quantitative human reliability estimates from psychological interviewing techniques, in particular, the Paired Comparisons approach. He presented a paper at the Joint Conference on the use of the method and a demonstration which involved all of the conference participants. The paired comparisons method was introduced in 1927 and has been used by psychologists for many years, but the practical application of the technique to estimate error rates on tasks applicable to control room operation was interesting and informative. Part of the current ORNL program is to obtain qualitative and quantitative estimates of nuclear power plant operators from operators themselves. Hunns has incorporated the work of other investigators who have developed the necessary relationships between psychological scales and probability scales and has computerized the data analysis. His analysis method and computer programs appear to be of direct benefit to the ORNL work, and followup discussions and exchange of information are planned.

A general impression from the discussions with Mr. Hunns and from his paper is that although he agrees strongly with the need for immediate and extensive work toward quantifying human reliability, he is skeptical and pessimistic about the possibilities of doing so with direct measurement in a work situation and, to some extent, in a simulated experiment of the type previously performed by NCSR and now in progress at ORNL. His apparent reasons are twofold: (a) he does not think measurement systems are possible (at least not available) which have the necessary transparency, sensitivity and comprehensiveness to accumulate the detailed quantitative data without interfering with the performance being monitored, and (b) he does not feel that the current state of knowledge of the fundamental causal factors and basic mechanisms of human error are well enough developed to permit analysts to identify, measure and analyze data on all of the many factors involved with human performance. He would therefore recommend more work to develop the fundamental understanding of human error, primarily by continued analysis of qualitative information from accident reports, and in the meantime, he would (and is) making maximum use of quantitative information that exists in the minds and "experience" of subject experts.

With regard to the ORNL work, the on-line performance monitoring system being used to collect data in the simulator experiments certainly goes a long way toward solving some of the problems of transparency, i.e., recording of much of the data is performed automatically without interference or even visual observation. It certainly does not solve all of the problems of sensitivity or comprehensiveness raised by Mr. Hunns. With regard to his second concern, we would agree with the need for continued work in developing the fundamental understanding of human error through qualitative analysis of events that have occurred and for work in

extraction of quantitative data from expert opinion. Both of these are included as part of the ORNL study. But we would counter, that the simulator experiments, using a state-of-the-art monitoring system in conjunction with observation by a team of psychologists and experienced plant operators can provide extremely useful quantitative data and, in fact, much of the supportive qualitative information desired.

(2) Mme. A. Carnino, CEA. Mme. Carnino is well known for her work in the human factors area in the French CEA program and on the Organization for Economic Cooperation and Development, Nuclear Energy Agency, Committee on the Safety of Nuclear Installations, in particular on the CSNI Task Force on Problems of Rare Events in the Reliability Analysis of Nuclear Power Plants. During discussions at the Southport meeting she reviewed and commented on the ORNL NRC program. Her general comments were somewhat similar to those of Mr. Hunns, i.e., she strongly feels the need for more fundamental, more qualitative analysis of human error to identify basic causal factors and the impact of the many performance shaping factors involved with operator reliability. The French and OECD programs she described were directed along these lines rather than quantitative measurement.

The CEA has a joint program with EdF (Mr. Dorey of EdF participated in the discussions with Mme. Carnino) which involves development of methods to determine and categorize causes for human error from analysis of nuclear plant operating experience. Their early investigations found that the existing accident event reporting system (equivalent to USNRC Licensee Event Reports) did not provide sufficient information on human error, and part of their work has been to develop improved means for data collection. Initial results of their analysis of events has led to classifying human error causes into eight categories: education and training of personnel, installation design, work organization (primarily procedures), time and work duration, physical environment, social environment, plant history, and operator performance (psychological physiological capabilities, etc.). Of these, she noted that the most important factor in the events examined has been the work organization, i.e., procedures. A special group has been formed to specifically incorporate human factors considerations into the writing and implementation of procedures.

With regard to the use of simulators in training and in particular the use of performance monitoring systems, Mme. Carnino expressed some skepticism about the General Physics system (which is being used by ORNL) for training,because it is very much procedure oriented, and therefore is less flexible and comprehensive in monitoring performance not directly related to a specific procedure. She agreed, however, that the General Physics PMS is ideally suited for the specific purposes of the ORNL experiments, i.e., to measure operator error and response times in carrying out specific,

procedure-required tasks. She indicated that Westinghouse, Framatome, CEA and EdF were cooperating in a joint effort in the use of simulators, which includes development of a performance monitoring system that is not rigidly linked to specific procedures. That work includes an effort to obtain qualitative input from very experienced operators and training staff (senior instructors) on problems with procedures and specific means for improving procedures.

A third effort noted by Mme. Carnino was one under the Task Force on Rare Events of the OECD-CSNE, which involves task analyses for various routine maintenance and monitoring tasks. The effort is attempting to identify the many performance requirements for routine maintenance tasks, to reduce unnecessary tasks or demands on operators and to clarify and simplify procedures. She cited an example of one case in which maintenance of a single pressure monitoring channel had associated with it 186 tasks, while their study suggested that only eight of these were "meaningful" and only two were considered "critical."

Mme. Carnino strongly urged that NRC continue to participate in the OECD-CSNI Task Force efforts in the human factors area and in the other problems of rare events, in particular she urged that an NRC staff representative attend the annual meeting summarizing progress. Mr. Dorey of EdF extended an invitation and encouraged a visit to Bugey Nuclear Power Plant and Simulator to observe and discuss EdF power plant (especially control room) design and operation, operator training programs and the use of simulators.

In response to questions about French efforts in the area of reliability data collection for breeder reactors, Mme. Carnino and Mr. Dorey indicated that there was only a small effort in operation at Phenix directed only at key safety systems - primarily the shutdown system - but that plans were to extend and expand this effort to include SuperPhenix. Persons in the French breeder program more familiar with those efforts were suggested for future contacts.

Mme. Carnino agreed to send printed reports available on the different research projects she described as well as some related documents on work at RISO, and the author agreed to send her copies of published reports on the ORNL work.

(3) Mr. A. G. Cannon, UKAEA, NCSR. Mr. Cannon is the Manager of the NCSR reliability data bank of the NCSR Systems Reliability Services (SRS). ORNL, represented by CREDO staff, is an Associate Member of SRS, and CREDO has maintained an on-going interface with SRS staff since ORNL began CREDO development. Mr. Cannon summarized his staff's written critical review of the CREDO system.

In brief, the review was extremely favorable. There were no serious problems. In Mr. Cannon's words, they were "jealous" of the system capabilities. He strongly supported the overall approach, i.e., of a comprehensive collection of engineering or "pedigree" data followed by routine reporting of operational and event data, as an ideal procedure for collecting reliability data, as well as the specifics of the CREDO input data to be collected. The very strong support of the general CREDO approach is somewhat surprising, since the SRS data bank generally does not operate in this fashion, rather they almost always collect historic data only, and then tend to concentrate primarily on analysis of events that have occurred. Previous comments both private and public as well as the public presentation at the Bradford and Southport meetings strongly touted this approach, in particular the importance of experienced analysis reviewing event reports. Even their recently developed computerized system (LEXIBOSS, which was one of the primary topics at the Southport meeting) emphasizes collection, storage and detailed search of textual information more useful for reviewing written reports of events than for automatic compilation of reliability data and calculation of reliability parameters. The reasons for this difference between what Mr. Cannon indicated is the ideal (CREDO approach) and what they are doing appear to be (a) lack of sufficient manpower and funds to carry out a "CREDO-style" system for the broad scope of NCSR activities (it should be remembered that the scope of NCSR reliability data collection includes all "high-technology" industry, nuclear as well as nonnuclear), and (b) the lack of direct control over reporting organizations (participation in SRS, especially the nonnuclear industries, is totally voluntary), many of whom are completely commercial and thus have little interest in contributing the necessary time and effort without direct and near-term financial benefit to their particular organization. By contrast, CREDO's scope is much narrower and reporting organizations are supported by one organization - DOE - and have a direct interest in a cooperative effort that benefits the LMFBR program as a whole.

In addition to the review of the CREDO system, the discussions with Mr. Cannon included:

(i) An update on the sodium component data collected by SRS since the visit in 1978 by Dr. Bott of the CREDO staff during which CREDO data and SRS data were exchanged. Mr. Cannon agreed to compile the updated data from the SRS data bank and transmit it to CREDO.

(ii) Specific details of SRS input data for comparison to CREDO. Mr. Cannon provided copies of two informal reports which described the detailed input and coding system used at SRS and included sample copies of input forms.

(iii) The possibility for cooperative data collection/exchange efforts on the British Prototype Fast Reactor (PFR). The author inquired about the possibility of establishing the complete CREDO system of data collection on a selected set of equipment at PFR, with data collection under the supervision of NCSR. In return, data collected on EBR-II and possibly FFTF would be made available to NCSR and PFR. Obviously, approval of such a cooperative effort would have to be obtained from appropriate authorities at UKAEA and USDOE. Mr. Cannon was personally very strongly in favor of the proposed effort and optimistic that an agreement could be reached. He suggested a specific proposal be initiated by appropriate authorities at DOE, and the author is preparing this recommendation to DOE.

Further details of these discussions with Mr. Cannon are provided in ORNL/FTR-821, a trip report by Mr. H. E. Knee, who is currently more directly involved with CREDO operation.

(4) G. Mancini, et al., Staff, Joint Research Center, Ispra. JRC-Ispra has recently completed a several-year feasibility study (supported by the Commission of the European Communities) for a centralized reliability data system for LWRs. The summary of the feasibility study and a description of the proposed system, European Reliability Data System (ERDS), were the subject of one complete session at the Data Bank Seminar part of the Bradford meeting, with five papers being presented by JRC staff members. In addition to the papers, Mr. Mancini gave us a copy of the complete report on the feasibility study including executive summary, main report and various appendices (several inches of paper in total) which describe the proposed reference classification for LWR components, set of components to be included, input/output formats, and computer programs for statistical analysis (including some FORTRAN listings) as well as results of some preliminary studies of reliability data performed as part of the feasibility study.

All of this material is of direct interest to the CREDO effort and also should be examined by NRC staff and others in the U.S. involved in reliability and operational data collection for nuclear power plants. This system, and in fact all of the European LWR data collection efforts rely heavily on U.S. programs, both data collection programs and actual power plant experience. The

generally open U.S. policy toward free release of data, especially following the Freedom of Information Act, has provided the European nuclear community with an invaluable source of information for their LWR programs, which (at least in terms of number of units) lag 5-7 years behind the U.S. As the European programs grow and their experience base expands, it seems much could be gained by U.S. participation in joint data collection and analysis efforts. For example, it may be possible for NRC or, more likely, an independent representative such as Southwest Research Institute or ORNL, to become a member of EuReDatA, the European Reliability Data Bank Association. Although its membership consists primarily of European organizations, the literature provided indicates exceptions can be made.

With regard to the proposed ERDS presented by Ispra staff, that system includes four data stores that are more or less independent:

(i) Abnormal Occurrence Reporting System (AORS) - a systematic collection ordering and classification of information contained in national abnormal occurrences reports. The U.S. LERs are included and in fact are the major source of information. The proposed organization will not itself institute data collection programs; rather its main goal is to provide a uniform system for consolidating reports from the various reporting systems in operation.

(ii) Component Event Data Bank (CEDB) - the goal of this store is to merge component failure reports from existing systems in the various European countries, and the U.S. (NPRDS), in a unified system with common terminology in order to pool data. Here again the U.S. is likely to be a major supplier of data without, to this author's knowledge, receiving any direct benefit.

(iii) Generic Reliability Parameter Data System (GRPDS) - this part of the data bank will collect and organize reliability data (reduced data-reliability parameters, etc.) from published reports and specific data collection efforts by members.

(iv) Operating Unit Status Report (OUSR) - collects, organizes and disseminates productivity and outage data similar to the Edison Electric Institute Reports on Equipment Availability and NRC Operating Unit Status Reports (Grey Book). Although the feasibility study report indicates the reactors included are the approximately 50 operating European units, the existing U.S. systems heavily influenced the development of the proposed ERDS and will no doubt be incorporated into the data store.

As noted above, these four elements operate independently, though it is the stated intent to be able to combine information from the different stores to arrive at the desired reliability-availability information of concern to a particular user. As part of the feasibility study, some limited attempts have been made to demonstrate the proposed future capabilities to link some of the different stores, extract desired information, perform statistical analysis, and produce desired reliability parameter estimates. No generalized software structure yet exists to do so. Such a generalized software structure has been an integral part of CREDO's development from its inception, and in this sense, CREDO is considerably advanced. The different data stores in the proposed ERDS operate under the control of the ADABAS data management system, which includes flexible routines for searching keyworded and textual information within a given data store, but will require specific software development to perform the merger of specific information and calculation of statistical parameters. The primary emphasis by JRC in the area of statistical analysis has been in the area of Bayesian techniques, because of the presumed scarcity of data. The computer programs developed by JRC for statistical analysis may be of direct benefit to the CREDO program.

(5) J. Dorey, EdF. Mr. Dorey discussed the French system SRDF (Systéme de Recueil de Données de Fiabilité) designed to collect and assess reliability data on French PWRs. A paper describing the collection systems was presented at the Bradford meeting by his associate Mr. S. Silberberg, and Mr. Dorey presented a paper on results of initial analysis of pump failures in the six operating French PWR units. These two papers provide an excellent description of the system and the analysis being performed by the EdF research staff and thus details are not discussed here. Copies will be forwarded to the NRC Office for Analysis and Evaluation of Operational Data, and other interested parties who need information prior to publication of the meeting proceedings can contact P. M. Haas at ORNL. Generally, the development of the system relied heavily on the experience of systems in operation in the U.S. and most of the data currently stored is from U.S. reactors. Data collection on the six French units was initiated in April, 1978, and the pump failure study reported by Mr. Dorey included data through April 1979. Incidentally, the estimated failure rate for mechanical pumps appears to be somewhat higher (e.g., on the order of 10^{-4}/hr vs. 10^{-5} or 10^{-6} per hr) than for typical estimates we have seen previously, but the total number of failures (43) is not great, and the pumps have not been operating long, so that there may be some effects of wear-in. The system does not collect data in as detailed and comprehensive a manner as CREDO (and probably not as NPRDS), and it certainly does not have the computerized data management capabilities or statistical analysis capabilities of CREDO. Data collection is

limited to a relatively small set of key components (presently about 800 components per twin unit). But, in this author's judgement, the system is capable of accumulating and processing information of considerable value to the French program. As that program expands, the information could add significantly to the experience base in the U.S., and efforts should be made by NRC or its representatives to obtain cooperative exchange of data.

(6) Mr. B. K. Daniels, UKAEA, NCSR. Mr. Daniels is the NCSR staff person responsible for much of the development of the newly instituted LEXIBOSS data management system which will be used by NCSR to store, search and process data files. A description and on-line demonstration of that system was a major part of the Southport meeting. This author did not have discussions at length with Mr. Daniels, but H. E. Knee of ORNL did discuss some of the details of current vs. planned capabilities with Mr. Daniels, and his trip report (ORNL/FTR-821) should be of interest to NRC staff. We did receive a sizeable stack of written information about the system, much of which will not appear in the seminar proceedings. This will be transmitted to the Office for Analysis and Evaluation of Operational Data.

The major point to note about the system is that it is primarily a manager of textual information. It uses computer software developed by Turnkey Limited of the UK which appear to have state-of-the-art features for storing, searching, compiling and extracting textual data comparable to (but certainly not more advanced than) existing U.S. systems. Information in virtually any textual form can be input, stored and searched. Both "key-worded" (rigid format) and "tagworded" (essentially free-formatted using previously identified words) searches can be made. In addition to information stored directly in the computer, the system can operate in a "hybrid" mode as a document reference and retrieval system for microfiche. The system as it currently exists does not have any automated capabilities such as CREDO has for selecting and combining information from different stored files and performing computations, say statistical analysis for reliability parameters. Future plans are to incorporate that capability as well as add features such as "standing searches" and "detached searches" which are helpful to the user at a remote terminal. All user operation presently is through use of terminals in an interactive mode. This system will supersede the current NCSR storage and retrieval methods which have very limited computer capability and require comparatively rigidly coded data.

(7) Dr. I. Watson, UKAEA, NCSR. Dr. Watson is a well-known expert in the area of common-cause analysis methods, data collection and data analysis. Only a brief conversation on some of the key problems he is now dealing with was possible. In response to queries about how CREDO might improve its input and output to

aid common-cause analysis, Dr. Watson responded that he finds the major source of common-cause failure is the design process and these errors are probably the most difficult to identify and control, and to record in a reliability data system such as CREDO. He did agree to review the CREDO Input Guide in detail, specifically from the point of view of an analyst concerned with common-cause failures. He will respond within the next few weeks.

C. General Comments on the Conferences, General Impressions of Research in Progress. The meetings at Bradford and Southport were well worth the effort and expense of attending for both technical and technical management personnel in the areas of reliability technology, especially in the areas of data collection and analysis. Greater U.S. participation is recommended. From the point of view of general information on human factors research, it was not as useful, though the presentations, demonstrations and background discussion with Mr. Hunns and the lengthy discussion with Mme. Carnino were extremely valuable and have provided information directly beneficial to the ORNL program. The general impression formed is that the human factors research in Europe, unlike the "post-TMI" era in the U.S., are remaining at a relatively low level and will concentrate on obtaining and analyzing more qualitative data to develop a more fundamental understanding of human behavior, or human error. On the other hand, the few comments received on the ORNL research were quite favorable. Even though this may have been largely a result of a wish to be kind to a foreign visitor, it seemed that given equivalent support and equipment capabilities, they would be inclined to perform more quantitative studies such as this one.

The information accumulated on the European reliability data systems at both conferences and the feedback of comments on CREDO was extremely valuable and could not have been obtained without attending meetings such as these, held in Europe. In this area, the CREDO system is clearly superior in many facets to any system described at the conference. Certainly in the breeder reactor field no one has even come close to initiating a comparable system. In the LWR area, it is obvious that very much of the European work has followed and benefited tremendously from U.S. experience. As the European community pools its efforts through organizations such as EuReDatA and the centralized ERDS, the combined body of operating experience will approach that of the U.S. It seems cooperative data exchange would be of great benefit to U.S. programs and should be pursued by appropriate NRC officials.

Proceedings will be published for both meetings. Many papers of direct interest to the two ORNL programs and to the Office for Analysis and Evaluation of Operational Data were presented. Some of the most significant are listed in Appendix C of this report.

APPENDIX A

Itinerary

April 7-8, 1980	Travel, ORNL to Bradford, United Kingdom
April 9-11, 1980	Attend "6th Advances in Reliability Technology Symposium and 3rd European Reliability Data Bank Seminar," University of Bradford, Bradford, United Kingdom
April 11, 1980	Travel, Bradford to Southport, United Kingdom
April 14-16, 1980	Attend "International Seminar and Workshop on Data Management Systems for High Technology Industries"
April 17, 1980	Travel, Southport to ORNL

APPENDIX B

Key Persons Contacted

1. Human Factors Research

Person	Organization
M. D. M. Hunns	UKAEA, NCSR
Dr. A. E. Green	UKAEA, NCSR
Dr. A. J. Bourne	UKAEA, NCSR
Mr. B. Sayers	UKAEA, NCSR
Mme. A. Carnino	CEA
Mr. J. Dorey	EdF

2. Reliability Data Collection and Analysis, Data Bank Systems, Cooperative Data Exchange, etc.

Mr. A. G. Cannon	UKAEA, NCSR
Dr. I. Watson	UKAEA, NCSR
Mr. G. Mancini	JRC, Ispra
Mr. S. Capobianchi	JRC, Ispra
Mr. A. G. Colombo	JRC, Ispra
Mr. J. Dorey	EdF
Mr. S. Silberberg	EdF

APPENDIX C

Bibliography of Key Papers, Documents Received

A. Bradford Meetings

1. D. M. Hunns, "The Method of Paired Comparisons."
2. A. A. M. van de Wijderen, "Availability Evaluation of a Liquid Metal Fast Breeder Reactor."
3. G. Mancini, "Feasibility Study for the European Reliability Data System (ERDS)."
4. J. R. W. Andrews, et al., "An Information Structure for the Component Event Data Bank of the ERDS..."
5. A. Al, et al., "A Proposal for a Reference Family Code for LWR Components and Their Failure Classification."
6. M. Goretti, et al., "A Proposal for a Reference Classification of LWR Systems to be Used in the ERDS."
7. A. G. Colombo, R. J. Jaarsma, "Statistical Methods for Data Analysis in ERDS."
8. G. C. Bello, "The ENI Reliability Data Bank Project."
9. S. Silberberg, "Nuclear Power Plant Operational Data Compilation System."
10. J. Dorey, "Consideration on the Reliability of Pumps, Derived from the First Year of Experience of the SRDF..."
11. G. C. Bello, "The Human Factors in Risk Analyses of Process Plants, THE CONTROL ROOM OPERATOR MODEL 'TESEO'."
12. T. Monkamo, "Dependent Failure Modelling."
13. O. Platz, "Fault-Tree Reliability Calculations when Some Components are Statistically Interdependent."
14. R. N. Allen, "Effect of Common Mode Failures on Availability."

B. Southport Meetings

1. K. R. Montgomery, "The PFR Fuels Data Bank and IDMS Irradiation Data Base."
2. J. B. Garrick, "A National Centre for the USA Power Industry."
3. B. K. Daniels, "The Lexiboss System."
4. D. T. Taylor, "A Reliability/Availability Reporting Scheme for Power Station Plant."*
5. J. Appleyard, "The Data Processing Viewpoint."

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*NOTE: Fellow ORNL traveler H. E. Knee had some follow-up discussions with Mr. Taylor, from CEGB, and a summary of the CEGB system is contained in his trip report (ORNL/FTR-821).

C. Other Material

1. G. Mancini, "Report on the Feasibility Study for the European Reliability Data System (ERDS)," Executive Summary, Main Report, and Appendices. Tech. Note Nr 1.06.01.79.103, November, 1979.
2. B. Sayers, "Human Factors," Systems Reliability Service, UKAEA.
3. B. Sayers, "An Introduction to Reliability Assessment Theory and Practice at University of Liverpool," Systems Reliability Service, UKAEA.
4. A. G. Cannon and G. Jones, "The Collection and Assembly of Reliability Data for Components in Chemical Plants."
5. A. G. Cannon, "The SRS Reliability Data Bank."

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12-16. Executive Secretary, Advisory Committee on Reactor Safeguards, NRC, Wash.
17. L. S. Tong, Assistant Director, Water Reactor Safety Research, NRC, Wash.
18. W. S. Farmer, Research Support Branch, NRC, Wash.
19-20. Director of International Programs, NRC, Wash.
21-22. Division of Technical Information and Document Control, NRC, Wash.
23-24. Technical Information Center, P. O. Box 62, Oak Ridge, Tn.
25. C. Michaelson, Director, Office for Analysis and Evaluation of Operational Data, NRC, Wash.
26. F. X. Gavigan, Chief, Safety and Physics Branch, RRT/DOE, Wash.
27. H. Alter, Chief, Safety Section, RRT/DOE, Wash.
28. R. Di Salvo, Probabilistic Analysis Staff, NRC, Wash.
29. W. E. Vesely, Probabilistic Analysis Staff, NRC, Wash.
30. J. A. Lenhard, DOE/ORO
31. J. S. Denton, DOE/ORO
32. H. Postma
33. W. B. Cottrell
34. G. W. Cunningham
35. G. F. Flanagan
36. N. M. Greene
37-41. P. M. Haas
42. S. D. Hudson
43. H. E. Knee
44. F. C. Maienschein
45. J. J. Manning
46. F. R. Mynatt
47. D. B. Trauger
48. A. Zucker
49. EPIC
50. Laboratory Records Department
51-52. Laboratory Records Department - RC
53. Laboratory Protection Division
54. ORNL Patent Section
55. ORNL Public Relations Office