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MONITORING BEHAVIOR AND SUPERVISORY CONTROL
International Symposium, Berchtesgaden, F.R. Germany
8-12 March 1976

Dr. JAMES W. MILLER

27 AUGUST 1976

UNITED STATES OF AMERICA

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(Paper summarizes) This was a five-day NATO-sponsored symposium which had as its objective the convening of scientists and engineers involved with the complex man-machine relationships in controlling vehicles and large scale processes. Thirty-eight presentations were given, covering the general topics of man-vehicle control, general models and process control. Much attention was given to the changing role of man from controller to system supervisor;

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to the impact of this change on training, selection, mathematical modeling of complex systems and human performance; and to the measurement of operator workload. Presentations included descriptions of newly developed models, individual display and control systems, and the interaction of man and his computer "slave". Proceedings of the symposium will be published.

This conference, described briefly in ESN (30)-6:252-4), was sponsored by the NATO Scientific Affairs Division (Human Factors) and was directed by Prof. Thomas B. Sheridan, Dept. of Mechanical Engineering, MA Institute of Technology and Dr. Gunnar Johannsen, Research for Human Engineering, Mechkenheim, FRG. The principal purpose of the Symposium was to discuss and analyze the changing role of the human operator in today's world of rapidly advancing technology. The meeting was attended by approximately 110 persons from 15 different countries with 38 presentations making up the five-day period. Complete lists of the participants and presentations are contained in Appendices A and B, respectively. The length of the papers varied from 15 minutes to invited 45-minute presentations. All sessions were conducted in English. Pre-prints of each talk were distributed at the outset which helped in overcoming language difficulties. The well-organized sessions, held in a modern conference center, reflected a lot of detailed advanced planning. As shown in Appendix B, the Symposium was divided among three major sessions: Man-Vehicle Control, General Models, and Process Control, each of which began with a 30-minute overview.

The Man-Vehicle Control session was opened by Johannsen, who did an excellent job of placing the papers into a general context relating to the changing role of the human from operator to controller to monitor to supervisor. He pointed out that many of the basic tasks of the human operator have changed from sensorimotor (physical skills) to mental skills and that the so-called unburdening of the human operator by automatic systems, perhaps more rightly should be referred to as a shift in task emphasis.

Johannsen placed the man-machine problems involved in vehicle control into two general categories, (1) ground-based and (2) on-board monitoring and control. Examples of the first category include air-traffic and spaceflight control, and central-dispatching control of trains, buses, ships in harbors, and central control of traffic in large cities. Examples of the second category included aircraft, spacecraft, ships and various land vehicles in which the human operators are pilots, helmsmen and drivers. A special case, which is really a combination of the two categories, is the control of remotely piloted vehicles from the ground. Although in principle, all controller functions could be performed by either a human or an automatic system, functional requirements and the need for flexibility usually dictates the need for task allocation between the two.

Because information for the human controller arrives from many sources, e.g., directly by looking out of a window or indirectly from visual or audio-displays, he must act as an integrator prior to arriving at a decision. As a consequence, the controller often develops an internal model of the vehicle in relation to the environment. A good example of this is the so-called car-image most of us have that assists us in parking and moving through traffic without constantly having to estimate time and distance at a conscious level. The concept of the internal model will be discussed in more detail later in this report.

Because designers more and more are incorporating new technology, i.e., electronic displays, weather-penetrating sensors, etc., the sensorimotor activities are becoming much less frequent, while vigilance and decision-making behavior is becoming more important. The combination of powerful digital computers and displays is creating a new world of vehicle management and control.

The papers which followed Johannsen's overview addressed several aspects of these developments with emphasis on the relation of hardware to the changing role of the human operator.

The first talk was given by Prof. Elwyn Edwards (Univ. of Technology, Loughborough, UK). He set the stage for his presentation by pointing out that "it is possible for a pilot, whilst on the ground at a European airport, to depress half a dozen key switches which activate a navigation programme to guide him to a destination in North America. Thereafter he may engage the autopilot at about 500 ft and function as a system monitor until his aircraft is on the runway four thousand miles away." Developments such as this bring in their wake both direct and indirect modifications in the nature of the piloting task. Edwards went on to postulate two rules which can be stated briefly: "automation has changed rather than reduced the workload on the operator," and "the requirement for ergonomics input is not diminished because of the introduction of automation." He went on to give several examples of systems which illustrate these two rules, including flight guidance, navigation, thrust management, and alarm. He re-emphasized a statement made by Johannsen, namely, that the change in the operator's role has far-reaching consequences with regard to selection and training procedures. Edwards also made a point, which came up repeatedly throughout the meeting, that a serious problem will be the requirement for an operator to perform tasks in an emergency situation on which he has very little practice and must perform from a "cold start."

The pilot, according to Edwards, must act largely as a systems monitor, a task for which he is not selected, little trained, and constitutionally ill-suited. Tasks demanding long-term vigilance tend to suffer most from the effects of fatigue. In the event of the unexpected, the pilot must instanteously assume manual control employing his out-of-practice skills whilst attempting simultaneously to diagnose and rectify the circumstances."

D. K. Bauerschmidt (Rockwell Intl., Anaheim, CA) presented a paper which discussed the integration of displays and controls. According to Bauerschmidt "the role of a complex monitoring system operator is to extract data from his environment, manipulate the data to provide system-operating direction, and input this direction as controls upon the system." The degree of display integration depends upon the amount of data conversion, manipulation and translation necessary, and it increases as the operator activity between receipt of the display-output and the required control-input is reduced. Bauerschmidt illustrated the use of integrated displays using both traditional and advanced display/control configurations. Examples included applications aboard nulear submarines and in electrical power stations.

A second paper pertaining to the integration of display and control systems was presented by S. N. Roscoe (University of Illinois, Urbana). He reviewed the status and relative advantages of head-up and head-down cockpit displays. The rapid advance in display and control technology has always discouraged the development of a standard system. While many feel that it would be a good idea to develop a standardized cockpit, "right now" never seems to be the time because "things are changing too fast." Roscoe suggests that now might be a good time to undertake the synthesis of a universal system in which changes could be made in the future involving only software rather than hardware. He presented a configuration of a future cockpit illustrating an integrated display and control system. Considering the vast amount of experience Roscoe has, perhaps his suggestions should be carefully considered. A few million dollars spent in this direction could have considerable payoff if a significant step towards the standardization of aircraft display and control systems were achieved.

The papers delivered by S. Bossi (Standard Electric Loreng AG (SEL) Stuttgart) and R. W. Allen (Systems Technology Inst. Hawthorne, CA) discussed problems associated with mass transit. The first was concerned with an automated rail-guided system in Germany, while the second dealt with driver decision-making under laboratory conditions. While the problems themselves are indeed important in today's world of mass-transit chaos, neither talk dealt with what, in this writer's opinion, are the main issues. This was particularly true in the Allen paper, where considerable effort, for example, was devoted to describing a detailed probability analysis of the likelihood of getting traffic tickets as a result of driver decisions.

An interesting paper, delivered by Johannsen, was concerned with pilot workload while landing an STOL (Short take-off and landing) aircraft under emergency conditions. Using a fixed-based simulator, they simulated manual, semi-automatic and automatic landing-approaches both with and without autopilot failures. The performance measures in this study were deviations from a prescribed glide-path, the time required to detect an autopilot failure by the pilot, and the secondary task of tapping a large key as regularly as possible during the failure mode. As would be expected, performance decreased and workload increased immediately following the detection of a system failure. It was the opinion of the authors that the failure-detection times of their subjects were too long and would, in some cases, not allow sufficient time to compensate properly for control errors in a real world situation.

A series of papers was given describing the measurement of workload under various real world situations. In addition to subjective measures, these studies employed the use of physiological parameters such as heart rate, blood pressure, respiration and skin resistance. These measures were usually correlated with subjective assessment and with various personality tests. The results of such efforts, while not conclusive, are encouraging in that measureable changes do occur when the workload is increased. The measurement of workload in real situations was felt to be one of the key issues by many participants at the conference. While no single measure can accurately reflect changes in workload, a profile of such measures, coupled with other methods of task analysis and operator evaluation, can provide such information.

The final paper in the man-vehicle control session was presented by W. Veldhuyzen (Delft University of Technology, The Netherlands). He described the application of the internal model concept to a helmsman controlling a large ship. (The term "internal model" was used liberally during several presentations and in much of the discussion. This concept, which dates back to 1943, is that the human observer has in his head a model of the world about him consisting of relevant background information pertaining to a task to which he is giving attention. The model -- which includes the observer's value structure, a weighting system, an updating capability and an overall statistical representation of time and space -- determines the manner in which the individual responds to events occurring in the external world. The availability of powerful on-line computers has rejuvenated the internal model concept. Unfortunately, at least in the writer's opinion, this rejuvenation has also resulted in a maze of new jargon drawn from control and signal detection theory, mathematics, engineering and biotechnology which creates an aura of pseudo-sophistication and validity in an area which is still very heavily speculative.) Returning to Veldhuyzen, he felt that this was a particularly interesting application of the internal model because the time constants in ship control are long and thus more similar to those of supervisor control system than a classical manual system. It was stated that "all forms of human behavior involve some internal representation -- the internal model -- of the system being observed or controlled, or can be explained in such terms." Veldhuyzen and his colleagues studied the helmsman's behavior using a ship-simulator system. Generally speaking, they found relatively high correlation between the predictions made by the model and the behavior of the helmsmen. As would be expected, the internal model of the operator approaches the external model (the real world) as training progresses.

The General Models Session was opened by Sheridan, who reminded the audience that mathematical modelers have been challenged in the past for their audacity to suggest that human behavior can be reduced to mathematical equations. He said the usual reply is that man-machine interactions are utilitarian and mechanistic and therefore amenable to mathematical prediction. Sheridan pointed out, however, that because the computer is now gradually taking over the routine, predictable and definable tasks, leaving the more complex actions to the man, existing generalizations about modeling of human behavior may no longer be valid. Another rather interesting question raised by Sheridan which needs to be considered when developing models of human behavior, was, "When should the machine be given the power to decide what information to display to the man or what controls to allocate to him?"

The papers that followed covered a variety of topics. The first, by R. C. Williages (University of Illinois, Urbana) reviewed a series of research studies which attempted to evaluate the ideal observer hypothesis in terms of those factors that affect the observer's response criterion. Classical target-detection (vigilance) studies usually have concluded that target detection probability decreases as time on watch in the monitoring task increases, thereby representing a vigilance decrement. If, however, one assumes an "Ideal Observer" hypothesis, the decrease in response may, in fact, be an effort on the part of the observer to reduce his false alarm responses even though this results in his missing more targets as well. According to Williages, "Viewed in this way, the classical vigilance decrement expressed in terms of decreasing signal detections may actually represent a vigilance increment when considered from a decision-making point of view in which the human observer attempts to optimize his decision performance across the monitoring session."

Williage's experiments required the subjects to perform a rather difficult brightness-discrimination task over 60-minute monitoring sessions. His data support the "Ideal Observer" hypothesis which indicates that the observers are approaching optimal decision performance as time on task continues, even though the probability of signal detection in the 1/5 ratio condition is decreasing during the watch period. He points out that if artificial signals are introduced late in the monitoring sessions, the subject can maintain a constant response criterion throughout the sessions and thereby increase target detection at the price of more false-alarm errors. He concludes by saying that what may appear to be degraded detection performance at the end of a session may therefore actually be an approach to optimal decision performance.

The next paper, delivered by R. E. Curry (Department of Aeronautics, MIT), was concerned primarily with a comparison of failure detection between monitors and controllers. A series of experiments was conducted in which the failure detection performance of 15 professional airline pilots was tested on an aircraft simulator. Based on the predictions of the model and the experimental results, it was concluded that "in many instances: the controller will be better at detecting failures not readily noticeable or failures difficult to detect on the basis of error signal alone; the monitor will be better at detecting failures if the control task requires considerable attention to the steering displays, if there is slow adaptation on the part of the controller, or if there is a low signal-to-noise ratio in the control residual."

Curry presented a second paper in which he reviewed previous work related to human information processing of random processes and models describing human failure detection. While much work has been done involving discrete random processes in numerous vigilance studies, much less has been carried out towards furthering our understanding of human information-processing of continous-time random processes. Curry feels that modeling can play an important role in improving our understanding of these processes.

W. T. Singleton (Applied Psychology Department, University of Aston, Birmingham, UK) gave a most interesting paper in which he discussed the methodological problems involved in using mathematical models for studying monitoring and supervisory behavior. He points out that although we feel more secure in using a rigorous mathematical approach, such approaches, as yet, are unable to describe and predict supervisory performance adequately. On the other hand, the use of purely verbal methods "invites ambiguity and difficulties of communication." Singleton went on to say that although reasonable precision is desirable, we must not attempt to be too exact in describing human behavior. He presented a few practical case studies of supervisory and monitoring behavior, pointing out that gestalt models of supervisor behavior are a better fit to the real world than are stimulus-response models. He feels that a system designed such that a man, presented with a stimulus, is expected to produce an appropriate unique response will be headed for disaster. Successful supervisors will, by the very nature of their jobs, have to react in terms of concepts, not in terms of pure stimulus-response.

Sheridan's paper can best be summarized in his own words. He categorized supervisory operator's behavior into four rather distinct modes: "planner, teacher, monitor and intervener. He goes on to outline a "brute force" expected-value maximizer which can be used to model a supervisor. Fast-time internal "thought experiments" are run using an optimal selection procedure to decide what sensory measure of the environment is used and what are the motor responses contingent on what is sensed; the results are input to an internalized process model and utility function. Comparison of the process to a Kalman-Bucy control system reveals apparent similarity in structure with a major difference being in "off-line tuning" in the successive fast-time trials approach vs. "on-line tuning" through use of the Kalman filter's residual (which played a major role in the Curry-Gai model)."

R. J. Wherry, Jr. (US Naval Air Development Center, Warminster, PA) presented an interesting paper describing a Human Operator Simulator (HOS). This is a "digital computer program capable of simulating the performance of a goal-oriented, adaptive, trained human operator in a complex weapon system down to the level of hand reaches, control device manipulations, eye shifts, absorptions of visual information, and internal information processing and decision-making." Basically this program creates a situation and then simulates the performance of the human operator by inputing his short-term memory, decision-making, anatomical movement, and other pertinent parameters. Various equations are used which were derived, in part, from human performance data reported in the literature. While functions which are predominently mental are not as readily simulated, body movements and response-times to specific stimuli are well known and can be simulated accurately. Thus, the simulator approach, as described by Wherry, can be used advantageously in developing human engineering crew procedures and in crew station design, test and evaluation endeavors even in its present state. Currently, Wherry is attempting to validate the system by simulating an airborne tactical officer performing an ASW mission. In this case the displays, symbols and controls are in the hundreds and the number of different operator procedures exceeds fifty.

W. B. Rouse (University of Illinois, Urbana) addressed the problem of determining how responsibility should be divided between human and computer. He pointed out that while some tasks are best performed by one or the other, many tasks can be performed by either. Further, the assignment of these tasks should be dynamic and not fixed on an *a priori* basis. With dynamic allocation of responsibility, the human would have supervisory responsibility for all tasks, and would perform only those which he felt were appropriate and which were not being performed by the computer. Rouse's second reason for this approach is that there would be less queuing because tasks would be performed as they arose rather than waiting for either the man In accordance with these ideas Rouse developed a mathematical formulation of the human-computer multi-task situation. He discussed how this approach could handle false alarms, missed events, and incorrect actions. He concludes that while this approach has many obvious practical applications, much work needs to be done in the laboratory first, particularly with regard to devising a reliable method of letting human and computer know what each other is doing.

The same general problem of man/computer task allocation was discussed in the next paper by G. Weltman (Perceptronics, Inc., Woodland Hills, CA). His presentation included a description of a series of experimental investigations of adaptive computer-aided control. The experimental system consisted of "a learning control system, an adaptive decision model of operator behavior, a variety of means of allocation of control between man and machine, and software for assessment of performance and behavior." Specifically there were two tasks involved, the first required the subjects to move a single dot through an invisible path on a cathode-ray-tube hitting the boundaries as little as possible, while the second task required that the operator control a simulated remotely-piloted vehicle through a "hostile terrain." In the first case the operator used a two-dimensional variable-rate joystick, and in the second task he used a one-dimensional, single-speed velocity stick. It was concluded that the factors of greatest importance in shared-control were control allocation and feedback of machine state. More specifically, automatic allocation of control, based on the estimated utilities or on objectively defined values, appeared to be a major advantage. It tended to reduce the required communications and reduce the load on the operator thus putting him more in the role of a supervisor.

The Process Control Session was introduced by Dr. Elwyn Edwards (University of Technology, Loughborough, UK). He placed control systems into four categories: Software, Hardware, Environment, and Liveware. The concept of a system described in terms of these four component types and emphasizing their interactions has been called the SHEL model. Edwards feels that such a model can provide a framework for revealing and structuring the problems associated with highly interactive man-machine systems. His point is that a piece-by-piece analysis of operators' tasks will provide only part of the answers needed for systems development. It is necessary to put the individual tasks into a broader context, such as the SHEL model, where operator strategy and general performance can be assessed more adequately.

A series of 12 papers followed which described a number of practical situations, primarily in industrial settings, in which operator tasks were analyzed both experimentally and by observing on-the-job performance in emergencies in a nuclear power plant, man-robot interfaces on assembly lines, performance in aircraft display and control systems, and laboratory experiments in which various man-computer interface relationships were investigated.

A very interesting paper was presented by D. Sayers (Dept. of Chemical Engineering, University of Technology, Loughborough, UK) relating to operator behavior under emergency conditions. The setting was a nuclear power plant where the task of the process operator is to keep the plant running if he can but to shut it down if he must. This situation tends to create a conflict. Usually the operator under such conditions tends to keep the plant running if he possibly can and thus may tend to take necessary shutdown action too late. The paper dealt both with specific fault detection, as such, and with fault administration, a more complex process. The experimental parameters included response time, appropriateness of corrective action, false alarms, plus the effect of boredom and related parameters. Sayers showed a fascinating film in which two experienced nuclear power plant operators were compared in a real but simulated failure situation. When given the identical emergency conditions, one responded with a shutdown almost instantly while the other essentially froze and never did take the correct action even after having it called to his attention. The contrast in response was indeed striking.

A related paper was delivered by R. W. Pack (Electric Power Research Institute, Palo Alto, CA) in which he reviewed a study of human engineering standards (or lack of) in the control rooms of nuclear power plants which have recently become operational. The study included the use of interviews, evaluations of procedures, and analysis of operator performance.

Pack showed an incredible series of slides of the layouts of control rooms of the five US nuclear power plants studied. The arrangements were so bad as to be almost unbelievable. There were displays where the operator had to climb a ladder or lie on his stomach to read emergency data, where two operators were shouting to one another from one end of a control room to the other because the information they were supposed to coordinate appeared on displays over 50 feet apart, where switches having the same general functions located next to each other moved in exactly the opposite direction, etc. There was no standardization whatsoever. In most cases, the operators had rigged their own display and control coding system so they would not get mixed up. The results could well be disastrous if a real emergency ever developed in some of these plants. Situations such as these exist because the systems are designed and layed out with little, if any, consideration for the user or operator.

The following paper by P. McLeod (Applied Psychology Unit, Cambridge, UK) compared the strategies of naive and experienced operators in nuclear power plant control. While he questions the efficacy of the selection of the three experienced operators used as subjects, McLeod's data show that the naive operators not only were as good in their responses after one week as the experienced (six years), but that they also seem to have adopted the same strategies.

Whenever automation is being considered or being introduced, the question of the man-automated-device relationship arises. The increased use of industrial robots is no exception to this and, as a matter of fact, is raising new questions. There are now about 3,000 "blue collar" industrial robots installed throughout the world according to D. A. Thompson (Stanford University). While some tasks are fully automated, man-machine cooperation will continue to be required for the forseeable future. Although the man-robot relationship is different than the man-computer relationship discussed earlier, function allocation remains a critical problem. A major role of the human for the immediate future is the programming and/or teaching of robots. As robots become more sophisticated, so can the teaching techniques. A meeting addressing these problems was held in Nottingham, UK, 24-26 March 1976, entitled Third Conference on Industrial Robot Technology and the Sixth International Symposium on Industrial Robots. This meeting was described briefly by P. Walsh in European Scientific Notes (30-5:218).

A problem of considerable concern to the participants was the measurement of operator workload. As discussed earlier in this report, this can be done in terms of error rate, failure detection, control strategy, etc., as well as by a number of physiological measures. A. Rault (Andersa/Gerbios, France) described experiments in which the performance of helicoptor pilots was tested both in a simulator and in actual flight. In addition to measuring their ability to "fly," a number of physiological measures were taken including: cardiac rhythym, electromyography of the neck muscles, pulmonary ventilation, and eye movements. The author felt that the simulation phase of the study showed promise in the capability to predict performance in actual flying.

Towards the end of the meeting the participants were divided randomly into four working groups for two, one-half day periods. The mandate for these groups was "What do we tell our governments and colleagues about research priorities, implementation of results, integration of various disciplines, and institutional arrangements?", with respect to the development of complex man-machine systems. Although the group discussions were informal, each group leader was asked to summarize the opinions of his group and to make specific recommendations as to what lines of research should be undertaken relating to the questions raised and priorities established.

In keeping with the theme of the Symposium, one working group defined supervision and monitoring as follows: "Supervision encompasses monitoring and implies action and/or control as well as the capability of dealing with new situations. Monitoring, on the other hand, is concerned primarily with three questions; what is the present state of the system; what will it be in the near future according to the operator's internal model; and are there any hardware failures?"

Another working group oriented their discussion around the internal model concept. They felt that we are now in the second generation of man-machine problems. The first generation was devoted to measuring physical parameters, straightforward data-processing capabilities, and to applying proper ergonomic principles in display and control layout. While much remains to be done in each of these areas, advanced automation techniques have relieved some of the routine burden. Therefore, the second generation can concern itself with the more complex and subtle functions of man-computer interaction, job satisfaction and cognitive functioning.

With regard to the latter, the group felt that efforts in the immediate future should concentrate on general models which are less complex as compared to specific models which, in additon to their complicated mathematics, are less generally applicable.

Most groups agreed that a multi-disciplinary approach to improving our ability to match men and machines was absolutely essential. Along these lines, Prof. J. W. Sanders (University of Toronto) suggested that micro-miniaturization of processing and control equipment could completely change the concept of human engineering by allowing for individualized design for operators and supervisors. His question was, "How do we begin to explore this possibility?".

The effect of the changes in the human role from operator to supervisor on selection and training procedures, and the anticipated reluctance on the part of existing organizations to make such changes because of vested interests, were discussed at some length. An interesting point made along these lines was that it is now becoming less expensive to change hardware than to change software. This is due to many reasons, such as the increasing use of the modular approach in equipment design and the increasing costs of programmers and related specialists.

The working groups agreed on several areas which in their collective opinion, needed considerable attention. One such problem was a definition of optimum workload such that system effectiveness, reliability, and job satisfaction are properly considered. More specifically, we need to refine and develop our methods of assessing workload and task performance further. In addition, we need to obtain the data necessary for properly allocating tasks between man and machine. Another area that cuts across all the others is the development of standards and standard methods of presenting human factors/ergonomics data so that they can be understood and implemented by the non-specialist. This problem has always existed and receives lots of lip-service, but too few real efforts are made to remedy the situation.

Finally, the more amorphous area of job satisfaction was discussed at length. In this age of automation, the replacement of man by machine may indeed be more efficient and inescapable, but it must be considered in the overall context of the man, his job, his family and his life. How do we maintain skills that are used only in an emergency? How do we keep people happy and feeling that they are contributing, even remotely, in an altruistic sense? Many at the meeting felt that such questions are important and should not be ignored. Our "improved" working conditions may, in fact, be viewed as a reduction in the quality of life by the average worker. Sheridan stated the case well at the end of his presentation.

"As supervisory control becomes more commonplace, certain undignifying human tasks will be replaced by computer operation and supervisory operators may delight in their new power. On the other hand, the operators may suffer from isolation and remoteness from the actual work. They may find their skills degraded when called upon to take over in emergencies. While they marvel at -- or become alienated by -- their powerful computer-slaves, they may abandon to the computer responsibilities which they as people should retain. And they may become even more confused between mechanical productivity and human fulfillment."

In my opinion, there needs to be a major re-assessment of the direction of ergonomic research if we are to be responsive to advancing technology. While there were many excellent papers presented, the writer was disappointed in the poor quality and nit-pickiness of others. Many of us occasionally need to step back from our individual research interests and re-assess the context into which we think they will fit so that we do not spend our valuable time studying an insignificant piece of a problem that generated our initial interest. In conclusion, this writer feels that the Symposium was a valuable one in that it afforded an opportunity to exchange ideas on the changing role of human endeavor in response to advancing technology. If this point sunk in to the other participants, as well, the efforts on the part of the organizers were well spent. This changing role is critical and should seriously influence the research performed in the name of ergonomics in the immediate future.

APPENDIX A

LIST OF PRESENTATIONS

APPENDIX B

Belgium

1	P.K. Verhaegen Prof.	Katholieke Universiteit te Leuven Schoonzichtlaan 21, 3009 Winksele

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