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DP/ID/SER.A/1000
15 April 1988
English

16802

MICROPROCESSOR APPLICATION ENGINEERING PROGRAMME

DP/IND/84/030

INDIA

Technical report: Microprocessor application in agriculture*

Prepared for the Government of India
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Harold R. Duke, expert in microprocessor application in agriculture

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United Nations Industrial Development Organization
Vienna

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V.88-23970

INTRODUCTION

Because plans for this trip were not finalized until 25 February 1988, the day before leaving my home post, this consultant received virtually no guidance from UNIDO or UNDP/INDIA as to recommendations for personal safety/comfort, the details of my mission (except for presenting a technical paper at the International Symposium on Electronic Measurement Techniques and Microprocessors in Agriculture), expected results or reporting requirements. I presumed that UNIDO/UNDP expects some evaluation of the efficacy of its programs in microprocessor applications at the Jabalpur MAEP center, therefore I assumed that I had authority to investigate the facilities, equipment, staff and technical progress of that program. Further, I have taken upon myself to develop a report format which shall be deemed acceptable to UNIDO/UNDP in lieu of prior instructions.

Circumstances of this visit resulted in major impediments to my efforts to conscientiously learn details of the program and evaluate its effectiveness. Firstly, my visit was during and immediately after the International Symposium on Electronic Measurement Techniques and Microprocessors in Agriculture held at Jabalpur 8-10 March 1988. As might be expected, Dr. J. H. Agarwal, Project Coordinator, had many details of post-symposium financial and administrative matters to complete following the symposium. Further, my visit corresponded to the end of a financial accounting period at the institution. These responsibilities limited the time for the Project Coordinator to devote to technical discussions. It was the intent of the Project Coordinator that I spend most of the period 11 March-24 March in technical discussions with staff member Dr. S. N. Murty. A serious accident in his family on 12 March resulted in Dr. Murty being called away for the duration of my visit, limiting my potential contribution to the program. The visit was subsequently shortened to the extent allowed by available airline schedules.

The Project Coordinator indicates that my expected contribution was fulfilled by my technical presentation, chairing a technical session, serving on a discussion panel and my advice and encouragement to attending scientists and to scientists at the Powarkheda research station I visited. From my own viewpoint, the time and effort of both UNIDO and myself could have been utilized more efficiently during an independent, well organized visit of about 3 weeks. Although my services were specifically requested by MAEP, and my credentials were offered in full, I sensed disappointment that my formal training is not in electronics, and a reluctance of MAEP personnel to discuss technical details of project developments. It was not until I had spent 10 days on site that this problem was mostly overcome.

ITINERARY

The following describes in brief my itinerary and contacts during the trip:

26 Feb - 0830 leave home duty station via personal vehicle to Denver. CO. UA168 to New York. PA66 to Frankfurt. PA150 to New Delhi. arrive 28 Feb. 0400 hrs
29 Feb - Report to UNDP/IND for briefing and advance of DSA. Report to UNDP/DOE/MAEP Chief Coordinator. Dr. Krishna Kant for briefing.
01 Mar - Report to U.S. Embassy. Agricultural Attache and USDA-OICD. Begin preparation of paper for Symposium.
2-3 Mar - MAEP. prepare symposium paper. Audience with Additional Secretary and Director General. National Informatics Center Dr. M. Seshagiri
04 Mar - National Holiday
5-6 Mar - Weekend
06 Mar - IC433 to Bhopal. IC 469 to Jabalpur
07 Mar - Visit Government College of Engineering with Dr. U. S. Bhatnagar. Principal. Attend opening of Workshop on Modern Trends. Developments and Practices in Geotechnical Engineering.
8-10 Mar - International Symposium on Electronic Measurement Techniques and Microprocessors in Agriculture. Jawaharlal Nehru Krishi Vishwa Vidyalaya. Jabalpur.
11 Mar - Technical discussions with MAEP staff. Visit MAEP facilities under renovation.
12-13 Mar- Weekend
14 Mar - Technical discussions with MAEP staff. Visit present MAEP facilities. Travel by train with Project Coordinator to Itarsi. M.P.
15-16 Mar- visit Zonal Agricultural Research Station. Powarkheda (Hoshangabad) and surrounding Tawa Irrigation District reservoir and command area. Return to Jabalpur via train.
17 Mar - Formal discussions with Project Director regarding objectives. progress. plans and problems of MAEP. Jabalpur.
18 Mar - National Holiday. Review equipment for MAEP with Project Coordinator.
19-20 Mar- Weekend
21 Mar - Visit College of Agricultural Engineering. JNKVV. IC470 to Bhopal. IC 434 to New Delhi.
22 Mar - UNDP/INDIA for debreifing. Arrange airline flights USDA-OICD at American Embassy.
23 Mar - Free
24 Mar - UNDP settle financial affairs. work on UNIDO report
25 Mar - UNDP/DOE/MAEP work on report. debriefing
26 Mar - PA73 to Frankfurt. LH1452 to Vienna
28 Mar - UNIDO/Vienna for debriefing. contract.
29 Mar - LH1471 to Munich. AA37 to Chicago. UA287 to Denver. Return to Ft Collins. Colorado via personal auto.

INTERNATIONAL SYMPOSIUM ON ELECTRONIC MEASUREMENT TECHNIQUES AND MICROPROCESSORS IN AGRICULTURE. 8-10 MARCH 1988.

The symposium was opened Tuesday morning with greetings from the Project Coordinator. Dr. J. H. Agarwal: Dr. D. K. Sharma. Vice Chancellor of Jawarhalal Nehru Agricultural University. Jabalpur (JNKVV): Dr. Krishna Kant. Chief Coordinator. UNDP/DOE/MAEP. New Delhi: and Dr. Dixit. Vice Chancellor. GCE. These dignitaries encouraged the participants as to the potential impact of electronic technology on agricultural production in India. with several mentioning specifically the potential for improved management of irrigation water and of soil fertility. for forecasting and control of crop pests and for protection of stored produce.

The attention by the MAEP Program Coordinator to organizational details was obvious. A professionally prepared program with abstracts and participant's names and addresses was provided to registrants. Group meals and a recreational outing were planned to encourage discussions beyond the technical sessions.

Attendance exceeded 100 at times. with an estimated 40-60 scientists and engineers at each presentation. Representation was from throughout India. with both agricultural and industrial participants. Four engineers representing the international electronics community also attended.

Seven technical sessions were held. with an additional panel discussion relative to the challenge and opportunities in agricultural electronics. The presentations may be grouped into three general areas: hardware development. software development. and training of agricultural scientists in electronic fundamentals.

Most of the hardware developments reported by Indian scientists are still in the development stages at this time. Among those developments with most potential are electronic meteorologic stations for collecting water and pest management data. devices for in situ soil water measurement. electro-optical systems for determining crop status and the soil fertility testing device under development by MAEP. Jabalpur.

Software developments of significance include a program for management of an agricultural data base. which might include a register of specific scientific instruments available for use: inexpensive software for data analysis and a program to allow irrigation project managers to schedule water deliveries under a command area. In my opinion. it is these areas of agricultural data base management that will have the most immediate impact of microprocessors/microcomputers on Indian agriculture. Programs to schedule water deliveries will allow the manager to determine problem areas with the delivery system and provide data for better allocation of operation and maintenance funding. Data base programs available to Extension subject matter specialists in the districts will allow more accurate. authoritative analysis of

field problems from outside that person's area of specialization. Expert systems for planning and diagnostic evaluation by these Extension specialists may have particular utility if developed for personal computers, and I encourage efforts at such development by MAEP.

One of the most important aspects of electronics reported, so far as agriculture is concerned, is that of training. Worldwide, agriculturalists are very conservative and the potential application of electronic technology to agricultural problems is not widely recognized. Thus, awareness programs and training of these agricultural scientists is the necessary first step in widescale adoption of modern technology. Training programs described ranged from short term courses to develop awareness through formal instrumentation training as part of agricultural curricula and to degree programs in agricultural electronics.

FACILITIES AT MAEP, JABALPUR

Since its inception in April 1985, MAEP Jabalpur has been operating from substandard facilities on the campus of JNKVV. The initial period required development of the administrative and physical infrastructure necessary to support the technical program.

In the past, space for training programs has been borrowed as available from other campus units. Laboratory space available lacks the lighting, security or environmental protection necessary for quality electronics development. As of my visit, renovation of space to house MAEP is nearing completion. This project, at a cost of some RS 450,000, will result in modern quarters of about 550 square meters which will allow maintenance of a clean, controlled environment necessary for operation and development of electronic equipment. The space will include an environmentally controlled computer room, laboratory space, conference facilities and office space for a professional staff of about 20. At this time, the facility is being painted, electrical fixtures mounted and doors and hardware installed. Telephone requisitions have been processed and the facility is in que for telephone installation. There remains to make minor repairs to windows, install office and laboratory furnishings and install environmental controls for the computer room. It is anticipated that the renovated facility will be occupied in April or May 1988. An automobile has been recently acquired for program support.

STAFFING AT MAEP, JABALPUR

Because of lack of adequate facilities and the necessity to develop program infrastructure first, only a very limited technical staff has been assembled. In addition to the Project Coordinator, the project has but two scientists of an expected staff of about 20. Dr. S. N. Murty provides agricultural

expertise (analytical chemistry) and Mr. Rai that for electronics design (electrical engineering). These three have made much needed progress in developing and presenting electronic awareness programs and training for agricultural scientists and have a working prototype device.

Past efforts at recruitment have been hindered by lack of suitable facilities and lack of interest in agricultural applications by potential staff. The new facility should help attract staff to MAEP. However, it appears unlikely that the program can attract experienced engineers with a proven record. Therefore, it is important that people with intellectual ability and initiative be identified and that the Project Coordinator be given latitude for developing these people by offering a variety of professional growth opportunities.

EQUIPMENT AVAILABLE, MAEP, JABALPUR

Initial equipment acquisitions have been in the area of commercially available agricultural instruments, including a photosynthesis measuring device, a leaf area meter, digital pH meter, infrared analyzer, grain moisture meter, infrared thermometer and one MS/DOS personal computer. These instruments have been used in numerous electronic awareness programs and specific instrument training workshops for agricultural scientists.

Requisitions were placed in April 1987 for modern equipment necessary for design, prototyping, programming, testing and debugging of electronic and microprocessor circuits. Only a very small portion of this equipment has been delivered to date. As the new facility is nearing completion, expedited delivery of the remainder of this equipment will assure technical developments can proceed.

Further equipment needs include additional commercial data loggers, climatic instruments, remote control telemetry equipment and commercial software packages for use in agricultural scientist awareness programs as well as development programs. Portable, battery powered ("briefcase") computers would expedite prototype development by allowing the scientists to concentrate on the agricultural interface rather than having to redevelop a microprocessor system for each device to be developed. Use of microcomputers for emulation of what will eventually be a dedicated microprocessor is a proven effective development technique which allows software development and debugging in a high level language. The portability offered by the briefcase computer will allow systems under development to be tested under field conditions.

The program Coordinator has no immediate desire to acquire equipment with special regulatory controls, such as radioactive moisture and density devices. This appears to be a sound

decision in terms of overall resource allocation considering the additional infrastructure necessary for regulation and control.

A major future need is for sensors, components and devices for use in both training and instrument development programs. I cannot make specific recommendations at this time, but sensors may include those for displacement, force and pressure as well as other environmental measurements.

It is planned that additional personal computers will be acquired soon after the new facility is occupied. I suggest that these be accompanied by appropriate software and be incorporated into the awareness and training programs.

In future acquisitions, it is imperative that bids received for items requested be reviewed directly by the Project Coordinator to assure that procurements are modern equipment that will fulfill project needs. The time required for procurement of even small items seems to delay progress of the project. Some system of limited, preauthorized procurement would increase the continuity and efficacy of product development by minimizing these delays.

PROGRESS TO DATE, MAEP, JABALPUR

Other than facility and infrastructural development discussed elsewhere, progress through the MAEP has focused on three areas: awareness programs, training of agricultural scientists and product development.

The key to development of devices which will prove useful in increased agricultural productivity is feedback from those agricultural scientists who are in daily contact with the farmer regarding the important problems to be solved. At present, these scientists in general have little concept of the kinds of problems that can be effectively addressed by electronic and microprocessor systems. Thus, an effective program to develop awareness of the potential of such devices is the absolute first step in obtaining meaningful ideas and cooperation from these intended users. Such awareness programs have been very successfully presented throughout the three years of the MAEP program and are well received.

The second level necessary for utilization of modern technology for increased production is to train these scientists in use of presently available electronic devices. An average of about two such instrument specific programs, each of 2 to 6 days duration, has been conducted each year, reaching 20 to 40 scientists each. Programs have included measurement of soil water, fertility testing, grain moisture testing and several others.

Finally, development of new devices which can be easily and accurately used by these field scientists is needed. The Project Director has taken the view that these agricultural scientists,

not the farmers themselves. should be the intended user of such devices. Considering both the economics of small farm holdings and the training necessary to insure accuracy of testing and interpretation of results. I fully concur in that judgment. Further. even though considerable accuracy may be achievable through microprocessor based instruments. it has been decided to provide output in rather crude increments. corresponding to achievable levels of carrying out the recommendations provided by the instrument. In the example of the soil fertility testing device. it makes no sense to confuse both the farmer and the agricultural scientist/advisor by recommending fertilizer application to four significant figures knowing full well that both field variability and application uniformity may contribute to errors of 25% or more. With microprocessor based devices. improving the recommendation as additional information becomes available is readily accomplished without redesign of the device.

The MAEP has designed and constructed a prototype device for microprocessor aided colorimetric determination of soil fertility. Utilization of the microprocessor allows simplification of test procedures (narrow band light source and detector can be substituted for a range of colored optical filters) while maintaining sensitivity and providing direct fertility recommendations based on the test as well as other relevant factors (crop. irrigated or rainfed. soil type. etc). Software has been developed for the device and it has been compared to standard laboratory techniques for one nutrient. phosphorous. Further software development. hardware refinements and testing. in both laboratory and field. are required for nitrogen. potassium. sulfur and possibly trace elements.

Other product developments in the planning stages are devices for grain moisture measurement. to be used for harvest timing and storage monitoring. and low cost infrared sensing devices for use in plant water stress detection and timing of irrigations.

OTHER CONSIDERATIONS RELATIVE TO MAEP. JABALPUR

Before I could make informed judgments about the program. I felt it necessary to learn a little about the agricultural problems faced in India and about the people available for consultation to MAEP. The Project Coordinator arranged a trip to the Powarkheda Zonal Agricultural Research Station near Hoshangabad. I was escorted by the Associate Director of Research. Dr. Khan. the Chief Scientist in Water Management. Dr. Sharan and other staff scientists to see problems of cropping pattern modification. waterlogging. irrigation application. land shaping and pest management in the Tawa irrigation project command area. From this visit. I am convinced that the target user for electronic devices and the degree of sophistication sought are appropriate for the foreseeable future of Indian agriculture.

Close collaboration of agricultural scientists with electronic specialists is mandatory. The competence and interest of

agricultural scientists to cooperate is apparent. I have been assured by the Project Director that institutional barriers will not prevent adequate input from these agricultural scientists. Other administrators at JNKVV tell me that little time is available by agricultural scientists for assisting MAEP engineers. If such scientists are not available with firm commitment. I recommend that about one third of the professional staff to be hired be agricultural scientists. one third professional computer programmers. and the remainder electronic engineers. All devices developed must be thoroughly tested in both laboratory and field. with scientifically sound data collected to verify their performance.

The contacts made at the symposium appeared to instill enthusiasm in the participants through the encouragement and ideas of other attendees. In my opinion. one of the major benefits of such meetings is the informal exchange of ideas. Participation of all MAEP professional staff in international meetings and symposia should be encouraged as a means of keeping program scientists abreast of latest technology and avoiding duplication of efforts. I encourage conversion of some of the overseas fellowships to allow more staff to obtain more frequent exposure at professional meetings. While a well organized fellowship opportunity may be invaluable to the trainee. development of a meaningful program requires considerable effort on the part of both host and participant. In the same light. short term assignment of several UNIDO experts for specific topic areas is more likely to infuse new ideas than longer term assignment of fewer experts.

SUMMARY OF FINDINGS

- The project has made significant progress during its three years existance. particularly in training programs.

- The International Symposium on Electronic Measurement Techniques and Microprocessors in Agriculture was well organized and successfully carried out.

- Awareness programs and training of agricultural scientists are important aspects of developing feedback from the field that will likely result in development of useful microprocessor devices.

- Availability of suitable physical facilities is imminent. I expect them to be occupied by May 1988. Telephone service has been requested. but the timing and quality of service remains to be seen. No telex facility is available. An automobile has been procured for project support.

- A series of developmental projects has been identified for future work. The first. currently under development. is for field testing of soil nutrient content. Subsequent projects for devices to measure moisture content of grains and to determine water stress of crops will be initiated when additional staff are hired.

- The center has not made use of opportunities for overseas training of the staff.

- The Project Coordinator has made an extensive study tour to study agricultural applications of microprocessors in other areas.

- The center has been able to organize and conduct a large number of training courses to teach the use of specific scientific instruments to agricultural scientists. in spite of long delays in procurement of instruments.

- Delayed procurements can be expected to significantly impede the progress of device development.

- The center has not yet solved its recruitment problems.

SUMMARY OF RECOMMENDATIONS

- Recruit capable scientists and develop through further training as it is unlikely that those with proven record can be recruited.

- Commitments must be obtained for the services of agricultural scientists and programmers. as well as electronic engineers. for device development. If such committment cannot be made by the University. then MAEP staff should be recruited in about equal proportion in these three areas.

- Continue awareness and training programs for so long as interest continues or until such time as a widely dispersed network of scientists with such training and willingness to cooperate with MAEP exists.

- Support the development of the devices planned. soil fertility testing. grain moisture testing and plant water stress devices as discussed elsewhere.

- Allow conversion of some overseas training fellowships to support attendance at professional meetings to obtain a broader spectrum of exposure of staff to other professionals.

- Attempt to develop a small item procurement procedure that will not place undue impediments to progress of device development.