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INDIA

Technical report: Present development status and proposals for future advancement of the application of microprocessor-based systems*

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 Dr Bruce G. Taylor, expert in microprocessor applications

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ABSTRACT

As part of the Microprocessor Application Engineering Programme (MAEP), Project DP/IND/84/030, the author visited MAEP Centres at New Delhi, Bangalore and Pune during Dec 1988 - Jan 1989 and contributed to an International Seminar on Microprocessor Applications for Productivity Improvement (INMAP'88) held at New Delhi on 6 - 8 Dec 1988.

The objectives of the assignment were to participate in hardware and software project discussions at various centres and to impart training on design methodology. These objectives were realized by delivering lectures on successful microprocessor applications, by reviews of MAEP projects in progress at the different centres, and by discussions with the management and staff about current techniques and future developments in the field.

This report presents a summary assessment of the INMAP'88 Seminar and the main projects in progress or proposed at each of the Centres visited. A number of recommendations are made for further action to improve the efficiency of the development methods used, to strengthen the infrastructure to support modern electronics design, to help the selection of more appropriate future projects, and to ensure a wider dissemination of the results of MAEP developments.

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INTRODUCTION

After the USA and USSR, India produces more scientists than any other country in the world. But in a recent in-depth review of science in India, the respected international publication 'Nature' concluded: 'excellence in the midst of poverty'. There is a vitally important requirement in the country to promote the appropriate application of modern technologies to serve the industrial development needs of the nation.

Launched in April 1985, the Microprocessor Application Engineering Programme (MAEP) is a joint project of the Department of Electronics (DoE) of the Government of India and the UNDP, with UNIDO as Executing Agency. Initially foreseen for a duration of 3½ years, the project has now been extended into 1990.

The consultant was assigned to the project during Dec 1988 - Jan 1989 with the objective of participating in hardware and software project discussions and imparting training in design methodology. He visited the Northern Regional MAEP Centre in New Delhi, specializing in the service sector, and participated in the International Seminar on Microprocessor Applications for Productivity Improvement (INMAP'88) held there from 6 - 8 Dec. He then visited the Southern Regional Centre at Bangalore (Karnataka), specializing in communications applications, and the Western Regional Centre at Pune (Maharashtra), specializing in test & measuring instruments.

At each Centre he presented lectures on microprocessor applications and new developments in the technology. He held discussions with the management staff and individual project reviews with the engineers concerned. He studied the working methods and equipment in use, and made proposals for the introduction of new methodologies to improve the efficiency of the work and add new capabilities.

This report presents a brief review of the status of current projects and future plans at each of the three Centres. It discusses a number of issues which appear important to the efficient operation of MAEP, and includes a list of the consultant's principal recommendations on further action which might be taken.

SUMMARY OF RECOMMENDATIONS

As a result of his work at the New Delhi, Bangalore and Pune MAEP Centres, the consultant formulated recommendations concerning various aspects of the programme which are discussed in detail later in this report. The principal recommendations are listed in summary form in the following.

A. Recommendations applicable to all three MAEP Centres

1. In collaboration with the DoE/UNDP ERNET (Education and Research Network) project, each MAEP Centre should establish a Usenet node to facilitate the exchange of technical expertise with the industrialized world, including Indian nationals working in the USA. High priority should be given to the implementation of this recommendation in view of its important impact on MAEP productivity.

2. In selecting development projects, the MAEP Centres should try to identify work which can contribute in an important way to the programme objectives of disseminating microprocessor technology in industrial operations having a significant impact on the Indian economy.

3. The organization of regular National and International MAEP seminars should be strongly encouraged. Each MAEP Centre should try to hold a seminar in its specialized field annually.

4. Closer contacts between MAEP Centres and industrial enterprises in the public and private sectors should be encouraged to lead to greater exploitation of the work done in MAEP and commercialization of the developments made.

5. The present formal 'Technology Transfer' procedure should be streamlined to permit more open access to MAEP work and freer industrial exploitation.

6. The MAEP Centres should procure CAE software (such as P-CAD for IBM PC-compatibles) with facilities for schematic capture, simulation and pcb layout with back-annotation. If possible, the selected package should be standardized for use at all MAEP Centres and a single staff member should be assigned responsibility for the maintenance and enhancement of the component libraries.

7. Programmable Logic Devices (PLDs) should be introduced for digital design at the MAEP Centres. The Data I/O ABEL software should be procured for the IBM PC-compatibles there, together with UniSys (or equivalent) programmers and an initial supply of modern PALs such as the Cypress C22V10.

8. Each Centre should procure at least one Macintosh II with LaserWriter NT for DTP, IEEE 1196 NuBus and 88000 RISC processor developments, and to gain experience with a powerful modern graphics toolbox and more advanced operating system than MS-DOS.

B. Additional recommendations for New Delhi MAEP Centre

9. The Centre should strengthen its links with other organizations in India and with other projects (such as ERNET and NICNET) within the DoE. Government research organizations, such as the Central Scientific Instruments Organization (CSIO) at Chandigarh and the Central Water and Power Research Station (CWPRS) at Pune have experience in measurement techniques and sensor technology which complements the expertise within MAEP, and the IIT's have much experience in this field also.

10. The efficiency of the microprocessor cross-software development procedures used at the Centre should be reviewed, and a direct host/target link implemented with the NEC S1000 computer in the National Informatics Centre.

11. The Delhi Centre should expand its coordination role by promoting the use of common standards by all MAEP Centres in such areas as CAE and PLD software, communications protocols, real-time O/S, microprocessor and bus types and development methods.

12. The MAEP staff should be equipped with precision hand tools appropriate for microelectronics work and the numerous but inexpensive sundries necessary to support hardware development. The administrative procedures for the procurement of such items should be streamlined.

13. The repair or replacement of items necessary for the proper use of the MAEP instrumentation should be carried out. Attention to maintenance should be considered an important aspect of the activity in an efficient Centre.

C. Additional recommendations for Bangalore MAEP Centre

14. As the MAEP Centre with special responsibility for communications applications, the Bangalore Centre should play a leading role in establishing MAEP Usenet nodes by liaising with NCST, ERNET, NICNET, VSN, DE(I)L and the Satellite Communications R&D Group of ITI's Transmission Division.

15. In the selection of future projects, greater emphasis should be given to MAEP objectives by disseminating microprocessor technology to organizations outside ITI which do not yet have this expertise. The accent should be on the development of new solutions to problems of special importance to the Indian economy. The duplication of existing microprocessor products by reverse engineering should generally be discouraged.

16. The release of MAEP funds linked to the new building completion should be expedited to permit urgent component purchases.

17. Current projects in the area of statistical multiplexer development and token bus interface design should be carried to the production prototype stage with a view to technology transfer to industry.

18. NIRMAN should be ported to the MAEP Centre's Omega Superstar V20 system and evaluated with direct use of the schematic capture package by designers. The staff should collaborate with other MAEP Centres on the selection of CAE software.

19. The MAEP staff should be equipped with remote access facilities to the ABEL language processor of the Digital Communications Section of ITI's Switching R&D

Department. Alternatively they should procure ABEL for their own IBM PC-compatibles and arrange to utilize only the DCS Data I/O UniSys programmer.

20. Editing equipment for U-matic video-tapes should be procured for the R&D Audio-Visual Group and their work in producing training tapes of relevance to MAEP should be encouraged.

D. Additional recommendations for Pune MAEP Centre

21. A meeting of MAEP and Maharashtra State Government representatives should be convened about the planned new building. A compromise lease term for the land should be formulated to allow construction to start.

22. Alignment of Pune MAEP staff contracts with DoE staff employment conditions should be sought to improve staffing stability.

23. Customer charging policy should be revised to facilitate project work for industry.

24. A precision pc board ATE fixture should be procured. A basic system should be demonstrated and user commitment ensured before any further development is undertaken in this field.

25. DoE authorization of image-processing work within the ATE framework should be sought. Any restrictions on this activity should be clarified and implemented.

26. A market study activity should be introduced before any autonomous product development is undertaken.

27. The Maratha Chamber of Commerce Industrial Directory should be obtained and local industrial activities studied. Target organizations should be identified which:

(a) are important to the economy

(b) are large enough to have the resources to invest in new technology

(c) do not at present have microprocessor expertise, or adequate expertise

(d) could obtain substantial productivity or quality improvements from a realistic MAEP input.

I. NEW DELHI MAEP CENTRE

The consultant visited the New Delhi MAEP Centre from 1 Dec - 25 Dec 1988 and, after his visits to the Bangalore and Pune Centres, from 17 Jan - 18 Jan 1989. During this period DoE Secretary Mr K.P.P. Nambiar entered retirement, and Mr Rajamani took office from 3 Jan 1989.

In view of this change, some uncertainty surrounded the details of various aspects of future MAEP policy, but the general view was that positive support for the programme could be expected from the DoE over the coming years. A new Memorandum of Understanding requires to be drawn up to provide the legal basis for future MAEP operation, and this should incorporate revisions based on experience so far.

The New Delhi Centre is under the able leadership of Dr Krishna Kant, who is also MAEP Chief Coordinator. The Centre has built up a team of competent staff, has a fair range of microprocessor training and development equipment at its disposal, and is tackling several development projects. It is anticipated that new and much larger premises will be made available to the Centre by March 1990. Owing to a family bereavement, Dr Kant was called away during the consultant's final debriefing on 18 Jan. In his absence, the main observations presented in this report were discussed with Mr G.S. Varadhan, Chief Coordinator of AAPP, and with Mr S.N. Sardana of MAEP.

A. INMAP'88 Seminar

An International Seminar on 'Microprocessor Applications for Productivity Improvement' (INMAP'88) was organized by MAEP at New Delhi from 6 - 8 Dec 1988.

The Seminar was attended by over 350 delegates from all regions of India, including representatives from all the MAEP Centres, as well as by UNIDO experts C.A. Hobson (UK), A.M. Norton (Mexico), J.L. Peters (Netherlands), D. Popovic (FRG), B.G. Taylor (Switzerland) and E.J. Wightman (UK). There were numerous participants from public and private industries as well as from other Government organizations involved in microprocessor applications.

Some 45 papers were presented in sessions covering microprocessor architectural advancements and microprocessor applications in medecine, railways, the service sector, communications, process industries, agriculture and education, steel, test & measuring instruments, industrial control, manufacturing automation and standardization.

The consultant presented a paper entitled 'Real-time Control and Monitoring by Microcomputer' in the session on Microprocessor Applications in Industrial Control. He also chaired the session on 'Microprocessor Applications in Test & Measuring Instruments' and participated as a panel member in a concluding discussion session on 'Microprocessors and Productivity: Technology and Challenges'.

The topics of the papers presented ranged from technology reviews, tutorials and accounts of development projects at Government laboratories and other MAEP Centres to practical microprocessor applications in manufacturing and service industries. The Seminar was well

organized, ran very smoothly, and every facility was provided to encourage interaction among the participants between the formal presentations. The weakest areas were the inadequately sized projection screens, projector reliability and quality control of the printed proceedings volume. The consultant's paper appeared in the latter with numerous errors and most of the text missing.

One unfortunate result of the heavy organizational load on the New Delhi MAEP Centre staff was that they were left with little time to attend the paper presentations themselves. For the same reason, none of the staff appear to have attended the Seventh Biennial Technical Convention of the South East Asian Regional Computer Confederation (SEARC'88). This computer convention, the most important ever held in India, took place at the same venue in New Delhi from 28 Nov to 1 Dec 1988. It was attended by 1000 delegates, more than 300 from outside India, and included exhibitions covering 300 stalls and 40,000 ft^2 of space.

INMAP'88 indicates that the organization of important seminars is an effective component in achieving MAEP aims of promoting productive microprocessor applications. While microprocessor development projects themselves can be undertaken in many laboratory and industrial environments outside MAEP, few such other organizations would have the mission or resources to organize specialist meetings on this scale. UNIDO support enabled 6 international experts to share their experience with a much wider audience than would have been possible by individual travel within India. The Seminar is considered an important productive activity of MAEP, the Centre staff are to be commended on its success, and such activities should be strongly encouraged.

B. Bhagirathi water treatment plant

The Bhagirathi Plant, which is operated by the Delhi Water Supply and Sewage Disposal Undertaking, is located in trans Yamuna and draws raw water from the upper Ganga Canal. The plant is one of the 4 main sources for the city of Delhi (the other 3 being located on the Yamuna itself) and supplies 2.8 million people with about 100 million gallons per day.

The automation of the plant is currently the subject of studies by MAEP and by a US consortium, with systems planning by consulting engineers CH2M Inc and controller technology by Texas Instruments. The 'soft' approach which is being studied by MAEP envisages calibration and enhancement of the existing facilities, rather than extensive modernization re-work. It should prove considerably less expensive to implement than the Texas Instruments proposal, which is budgeted about $18M.

While this is not a consideration for the Bhagirathi Plant if US aid funds are provided to implement the Texas Instruments system, it does mean that the indigenous solution is potentially more suited to duplication at numerous water treatment plants throughout India. The future direction of this project depends essentially on whether or not the CH2M study leads to implementation approval by the US Government. In either case a certain reserve by the plant operation staff towards the introduction of unfamiliar automated controls will have to be overcome by a programme of information and re-training.

C. Integrated water flow measurement system

The progress of this project was reviewed with Mr S.S. Khichi. This microprocessor-based system is being developed at the MAEP Centre for first use at the Bhagirathi Water Treatment Plant, but it is hoped that it may be of more general utility. Since the input water flow at the

plant is in open flumes, it is proposed to measure the flow by the Parshall flume method. The flow rate is of the order of 15 million gallons per day per flume, which indicates a flume throat width of around 1 - 6 ft and an input throat length of about 4 - 9 ft.

It is intended to install float wells at the throat as well as upsteam to allow the pressure difference to be measured for calibration purposes. The water level measurement technique has not yet been chosen. In view of the high sediment content, it is proposed to utilize Fischer Porter ultrasonic sensors, and the Indian agents Harshaday Private Ltd at Bombay have been contacted, but procurement is not yet in progress.

The microprocessor electronics is to be based on an STD-based card system, supplied by Technics Ltd of New Delhi, which includes an 8085 CPU card, ADC, timer, RAM, printer and display drivers. For development purposes, the CPU is replaced by a buffered STD-bus extension to a Dynalog Micro-Systems 'Microfriend III' training kit which runs floppy-disk based CP/M 3.0. The Centre has 5 such kits. The resident CP/M macro-assembler is used, which is quite slow. There were reliability problems with the prototype system, but it is said that in view of the number of spares and availability of DMS service this is not a severe problem.

The lack of suitable sensors and uncertainty about the most appropriate water flow measurement system appear to be the main impediments to progress in this project. The consultant drew the attention of the staff to the fact that considerable expertise in the area of hydraulic instrumentation for microprocessor-based systems is available in India at the Government Central Water and Power Research Station, Pune. This world-renowned station, which was established over 70 years ago, benefited from UNDP support for the development of computer-based hydraulic instrumentation from 1975 to 1983. The station is typically engaged on several hundred projects for locations both in India and other countries in SE Asia.

The consultant recommends that contacts be established between the MAEP Centre staff engaged on the Bhagirathi project and CWPRS for an exchange of instrumentation expertise.

D. Route survey system project

The progress of this project for the Central Road Research Institute (CRRI) was reviewed with Mrs Sangita Arora and Mr Ravichandran. The system is implemented with an AAPP-designed microcomputer card system, connected to vehicle-mounted instruments for the digitization of distance travelled, road gradient and roughness, and fuel consumption. Horizonal curvature data and secondary route characteristics are currently entered manually. The system incorporates an 8085 CPU card which can accommodate 6x2K RAM or EPROM, with cards for additional memory, timer, ADC and printer interface.

Field trials are currently in progress, and apparently have highlighted reliability problems while the vehicle is in motion. If these are caused by mechanical shock it should not be difficult to provoke them in the laboratory and find the cause. The microcomputer is also disturbed when heavy transient loads, such as the vehicle horn or engine starter, are engaged and additional work is in progress to improve the filtering of input signals.

The system is conceived to print the acquired data every 500 metres travelled. Since the data are subsequently to be processed offline by the CRRI, a rugged cassette or other recorder should be evaluated to obviate the re-entering of the data manually.

E. Butt-welding monitor project

The progress of this project was reviewed with Ms Renu Malik. The system is intended to monitor the quality of the butt welds produced during the concatenation of 13 ft rail sections so that, in the case of an unsatisfactory weld, remedial action can be taken without delay. At present, only weld monitoring is being implemented, but if the system proves successful it could be extended to online control of the butt-welding machine.

The prototype system has been tried on-site at the welding facility at Meerut (some 73 km from Delhi). Reliability problems were experienced with the locally-built modular microcomputer system used, and the project is being transferred to a Professional Electronic Products 'Nucleus' modular microcomputer supplied through the RDSO.

Although the Nucleus system uses the same 8085 microprocessor, there are differences of detail in the memory map and type of timer used, requiring changes in the software. It is estimated that these should be completed in about 2 months. The code is prepared using the NEC S1000 cross-assembler, and is accommodated in one 2732 EPROM. The Nucleus system incorporates an EPROM card which can accept several 2764s and a battery-backed RAM card, of which some 16K are required by the application, so that the capacity of the hardware is adequate.

In view of the random nature of the problems encountered at Meerut, it is possible that the observed unreliability is not due entirely to factors internal to the microcomputer hardware. As the system must operate in the vicinity of the hostile electromagnetic field created by the welder (operating at a current of about 30,000 A), due consideration should be given to the filtering of all power and signal inputs and outputs to the microcomputer system.

F. Graphics for microprocessor systems

Video graphics is a powerful facility for modular microcomputers such as those used at the Delhi Centre. The consultant supplied 2 video RAM modules for use in an example project, together with interconnecting cable and connectors. The first is a Matrox MTX-256**2ES video graphics card generating a European-standard composite video signal (as used in India). The second is a module which incorporates a Matrox MTX-1632SL externally-synchronized alphanumeric video RAM together with some address decoding and control circuitry for both modules.

Neither the MAEP Nucleus-bus microcomputer nor the STD-bus Technics microcomputer had a graphics capability, and the feasibility of adding the graphics hardware to both systems was studied. This proved technically possible in both cases, and it was decided to implement the STD bus connection because, in conjunction with the Microfriend III, it can run CP/M with its resident assembler.

Several members of the MAEP staff, notably Mr Khichi, Mr Mani, Mr Ravichandran and Mr Sardana, participated in this work, which served as an illustration of several general principles in small microprocessor-based systems. For example, the economics of hardware/software tradeoffs were discussed, and a solution to the problem of synchronizing alphanumeric video RAM accesses with frame and line flyback periods was implemented which used software procedures to simplify the hardware required.

Bus characteristics, memory mapping, and development and debugging procedures were reviewed, and this simple exercise brought to light many of the difficulties under which the Centre staff work. The tools and sundries available proved to be very few in number and

inappropriate for microelectronics work. Basic materials like connectors and coaxial cable were lacking, and even solder was not in plentiful supply and had to be sent out for. Although the Centre had good Tektronix oscilloscopes, working probes were not available and open wires had to be used for connections, distorting the waveforms being observed.

Nevertheless the interfacing was successfully completed, and some basic routines were written to access both the alphanumeric and graphics RAMs. A library of more advanced routines was defined with the MAEP staff and then their implementation was assigned to a group of students from the Delhi College of Engineering, working under the guidance of Mr Sardana and Mr Ravichandran. They had made commendable progress when the consultant re-visited the Centre after 4 weeks.

G. Cross-software projects

The progress of these projects was reviewed with Mr Arun Babu, Mr Dvln Rao and Mr Rakesh Sinha, working under Mr R.S. Mani. This team is currently developing a suite of cross-assemblers (written in Fortran 77) for 8051, 8086 and 8096 microprocessors to run on IBM PC-compatibles.

In the past they have developed 8051 and 8096 simulators which run on the Cyber and NEC computers of the NIC. They were originally written in Pascal for the Cyber, and as a result of problems encountereed when porting to the NEC computer were converted to Fortran 77. They are now being ported to IBM PC-compatibles, which should make them more generally accessible. The simulators can be used to test and debug algorithms not requiring special I/O, or for writing modules of microprocessor code in assembler for training purposes.

The 8051 cross-assembler was considered by the staff to be essentially complete, while the 8086 and 8096 cross-assemblers were estimated to require a further 1 month and 3 month's development respectively.

The team was also considering the development of packages for such applications as stores and inventory control. In view of the wide choice of comprehensive packages already available for such applications, it is suggested that this work be limited to a comparative evaluation and implementation. In large organizations there is a tendency for a multitude of incompatible data-bases to proliferate, which results in multiple entries of the same data being required. An attempt should be made to avoid this by coordinating the future requirements of all concerned administrative services.

H. Software development procedures

A variety of facilities for the development of microprocessor software is available to the Delhi Centre. The Intel MDS systems appear to be rarely used. With their in-circuit emulators they are well-suited to the development of special-purpose boards incorporating microprocessors. But the infrastructure for the design and prototyping of such boards is lacking at present, so that most microprocessor projects are being tackled with ready-built microcomputer card systems.

One such system can be connected to an 8085 trainer kit which has additional memory and can run floppy-disk based CP/M. This provides an autonomous system for the development of code and its debugging using the trainer kit monitor but the assembler is slow and the hardware does not appear to be entirely reliable.

The cross-assemblers available on the NEC S1000 computer of the National Informatics Centre are faster, but the implementation procedure is quite cumbersome. While terminals were available in the MAEP Centre, they had been disconnected because of a shortage of I/O ports. Source code can be entered and edited using other terminals on the same floor of the building, but these do not have data recording facilities and an IBM PC-compatible on the first floor must be used to store the object file on floppy disk. This disk is then conveyed to an IBM PC-compatible connected to an EPROM programmer in the MAEP Centre on the 4th floor.

The programmer, a PP-81 Universal PROM Programmer from Professional Electronics Products, can handle 2716, 2732, 2764 and 27128 EPROMs with different personality modules, although in general 2732s have sufficient capacity for current projects. An EPROM is programmed from the floppy disk file and transferred to the target microprocessor system. Finally a utility of the target system monitor is used to transfer the code from EPROM to RAM in the system so that breakpoints can be set and debugging can commence.

This clumsy procedure could be greatly streamlined if the monitor were provided with a transparent mode of operation allowing the microprocessor terminal to access the remote NEC host directly. The assembled code could be downline-loaded directly from the host to microprocessor RAM, bypassing the intermediate floppy disk and EPROM-programming phases during software development. The source code of the Microfriend III monitor used is available at the Centre, and this development is well within the capability of the programmers there. In view of the greatly increased efficiency which would result from such direct host/target communication, the consultant suggests that this development be undertaken forthwith.

I. Future irrigation control projects

A new member, Mr N. Saratchandra Babu, joined the Delhi Centre staff during the consultant's visit. Mr Babu, who was formerly employed by ITI Bangalore, brings additional microprocessor electronics design experience to strengthen the MAEP team. He has been initially assigned to explore possible microprocessor applications in the field of irrigation control, and will develop contacts with the Government Water & Power Consultancy (WAPCO) in New Delhi, the Water & Land Management Institute (WALMI) in Aurangabad and the Central Water & Power Research Station (CWPRS) in Pune.

Water resource management is of crucial importance to the development of the Indian economy, and microprocessor technology has considerable potential for applying intelligent control in this field. The consultant commends both this choice of new project direction and the approach of establishing links with potential user organizations right at the start of the project definition phase.

J. Computer Aided Electronics (CAE) at the Delhi Centre

The Delhi MAEP Centre at present has no facilities for CAE. The consultant visited the CAD Group of the National Informatics Centre, which is accommodated in the same building at the CGO complex, and held a discussion with Mr Rajeev, Senior Systems Officer.

The Group is engaged on both developing CAD software for civil and mechanical engineering and cartography and solving projects in these areas, mainly for Government organizations or joint state/private enterprises. Typical applications include offshore

structural analysis, tower design for electricity distribution and All-India Radio, stress analysis in rolling stock and marine architecture, and CAD for building layout.

No CAE work is undertaken by the Group. The reason cited was that a Government CAD effort is justified by the requirements of the large indigenous enterprises active in civil and mechanical engineering. Electronic engineering, on the other hand, is largely the precinct of numerous smaller companies which operate jointly with an overseas partner in an industrialized country. Such partnerships allow the companies access to CAE technology without additional Government input.

In view of this, it is recommended that the MAEP Centre acquire its own CAE software, for use with its IBM PC-compatible computers. An on-site demonstration of the popular P-CAD package was made by the local representative Micronics, who support about half-a-dozen installations in the Delhi area; notably at the Telecommunications Research Centre, Jan Path. The demonstration was competently effected by Mr S. Venaik, suggesting that a good level of local support for P-CAD should be available.

P-CAD comprises a suite of programs for digital CAE suitable for small to medium-scale applications. The facilities range from schematic capture and logic simulation through pc board layout with autorouting, back annotation, and the production of artwork and drilling tapes for production. The software is protected by a hardware key system which permits the procurement of multiple keys for the inexpensive but frequently-used schematic capture function, while sharing the more expensive keys for pcb layout functions only when required. P-CAD offers less comprehensive simulation facilities than more expensive products such as Daisy stations, but it is a cost-effective entry-level system which has gained wide acceptance internationally. CAE software represents an investment of such general utility that standardisation among several MAEP Centres would be desirable.

A major support effort for any CAE package is the maintenance and enhancement of the libraries of logic devices and other components supported. To ensure a measure of standardisation, it is recommended that one person in the Centre take responsibility for this task, and that all requests for library changes be handled by this person. The pcb manufacturers whose services are available to the Centre should be contacted to ensure compatibility of photo-plotter and pcb drilling-machine formats. It was claimed that a service of pcb manufacture for P-CAD files is available from Micropack Ltd, who have a New Delhi office.

K. Digital design using Programmable Logic Devices (PLDs)

The New Delhi MAEP Centre at present has no facilities for modern digital electronics design using programmable logic devices such as PALs. In industrialized countries the use of these devices has superseded design with SSI and MSI circuits for several years. In addition to the features of more compact design and ease of implementing changes, modern PALs have characteristics which are particularly attractive in situations where resources are limited.

A device such as the Cypress PAL C 22V10, with individually programmable output macrocells, is so versatile that it can be used for a very wide range of logic functions, eliminating the need to stock a large number of different types of integrated circuits. In addition, since the device is UV-eraseable, it can be reprogrammed and re-utilized indefinitely.

The consultant provided data sheets for the 22V10 and discussed examples of its use in state machine and combinatorial logic applications. He supplied copies of the complete User's Guide, Language Reference Manual and Applications Guide for ABEL, the high-level PLD

design language which is available for IBM PC-compatibles. These documents include many additional applications examples.

ABEL allows logic to be described with Boolean equations, truth tables, state diagrams, or with any combination of these. The ABEL processor has powerful logic reduction algorithms, extensive syntax and logic error-checking, and simulation of designs before PALs are programmed.

The procurement of reprogrammable PAL devices, ABEL software and a universal PLD programmer such as Data I/O's UniSys should be given high priority at the main MAEP Centres. MAEP staff should be encouraged to make the maximum use of this versatile modern technology in their microprocessor work, and training in digital design using PLDs should be included in the microprocessor courses organised by MAEP Centres.

L. Appropriate Automation Promotion Programme (AAPP)

The AAPP shares premises and some facilities with the Delhi MAEP Centre, and the progress of this programme was reviewed with its Chief Coordinator Mr G.S. Varadhan.

MAEP could possibly profit from a number of experiences in AAPP. For example, AAPP has achieved very satisfactory results by a function of bringing together industry and established centres of expertise (such as IIT Bombay). It would have been much more difficult to build the AAPP Centres themselves up to the level of expertise available in the IITs.

AAPP has also successfully pursued a policy of selecting a particular facility, such as the Bhilai Steel Plant, as a model for its work (in this case, industrial automation). Other companies are then encouraged to emulate the procedures which have been proven in the model. Both the systems implementations and the approaches to training have been duplicated in this way. Here again the IITs have cooperated in producing courses for consultants which are then widely disseminated.

Project staff have also made good use of the monthly DoE publication 'Electronic Information and Planning', now in its 15th year, to disseminate the results of their studies and analyses. This publication is of good quality and merits wider circulation (only 1000 copies per month are printed).

Another effective tool for encouraging industrial modernisation is the vetting by the DoE of requests for equipment import licences. For example, if a request to import a traditional pneumatic control system is received, the applicant would be asked to consider the possible benefits of installing a more modern electronic DDC system instead.

Altogether, AAPP is assessed as benefitting from a capable leadership under Mr Varadhan. The programme has successfully undertaken major projects and is having a significant impact on the Indian industrial scene.

M. Library

A comprehensive, well-organized and up-to-date technical library is a pre-requisite for good work in a fast-moving field like microprocessor applications. The consultant reviewed the library facilities available to the Delhi MAEP Centre staff. The library, which is administered

by the NIC, is located close to the MAEP premises. While the physical stocking conditions appeared to be less than ideal the range of publications available was considered satisfactory.

Numerous good periodicals in the field are taken regularly by air mail and bound locally as volumes are completed. A fair selection of books is stocked although, possibly because the library reflects NIC activities, modern electronics design was poorly represented compared with computer software texts.

A modern microfiche reader is available for publications in that form, and there is even a teleprinter online to the Indian News Agency. The MAEP staff should be encouraged to regularly request new library acquisitions in the fields of microprocessor applications and electronics design, and to make the fullest use of this resource to keep their working methods up-to-date.

II. BANGALORE MAEP CENTRE

The consultant visited the Southern Regional MAEP Centre (SRC-MAEP), located in the Indian Telephone Industries (ITI) complex at Bangalore, from 26 Dec 1988 to 6 Jan 1989. He reviewed MAEP projects in progress there, held discussions with MAEP and ITI staff and management, lectured on microprocessor applications, and offered recommendations about introducing new technology and selecting future projects.

At the time of the consultant's visit, the Centre was without a Project Coordinator owing to the departure of Mr S. Rajaram. Until the vacancy is filled, the responsibilities are being carried by Dr A. Prabhakar, Executive Director of the Microelectronics & Computer Division of ITI with which SRC-MAEP is associated. The day-to-day running of the Centre was being managed by Executive Engineers M.S. Mohan and M.V. Roopchandar. One Senior Engineer and two Assistant Executive Engineers were in the USA on fellowships at this time. The Centre had 3 vacancies for Apprentice Assistant Executive Engineers.

Without exception, the SRC MAEP and ITI staff proved most cooperative and enthusiastic about new developments. They demonstrated a high level of competence in the field of microprocessor applications in communications, and afforded the consultant every convenience in the accomplishment of his duties. While this report highlights current and future project issues, it should be noted that the Centre has an established record of successfully completed past projects in fields as diverse as satellite communications and CAD for LSI circuits.

A. Statistical multiplexer project

The status of this on-going project was reviewed with Mr M.S. Mohan. The objective is to develop an 8-channel multiplexer for RS-232C terminals (up to 9600 Bauds) which can be produced at lower cost than functionally equivalent imported ones, such as the Intelligent Network Processors from Codex Corporation. One development model has been solder-wired on two breadboards. One of the breadboards, developed by a student, contains the LSI octal UART and RS-232C driver/receivers. This board can be tested by connecting it via a short ribbon cable to the bus of an IBM PC-compatible. The PC was also used for developing the software in C.

The second breadboard contains the 8088 microprocessor with its EPROM and RAM, timer, synchronous channel driver, and an EEPROM for storing the terminal parameters. These parameters are loaded via one master terminal or can be read from DIP switches. Software for this card was developed using an Intel MDS system. Since a second card is not yet built, it has been tested by exchanging data with an HP 4995 protocol analyser.

The CAD Division of Intelligent Computer Systems is now preparing a pcb layout which merges the circuitry developed on the two breadboards. Library additions are required for the LSI devices used, and it was estimated that this work would be completed by 15 Jan 1989. Subsequently, pc boards will be produced by ITI's internal facility. At present, the requisition for about Rs 2300 components to populate these boards is held up by the delay in the release of DoE funds, pending official inauguration of the new MAEP building. The MAEP Centre has been funded during the current financial year by an ITI loan, to be repayed

when the DoE funds are released, but this could not be extended to the purchase of the required components.

The deadline set for the completion of the statistical multiplexer project is 31 March 1989. Since, in addition to testing the new pc boards and completing the software, many aspects of packaging, production testing, user and maintenance documentation have yet to be tackled, it is urged that formalities for the release of the component funds be made as soon as possible.

B. IBM PC-compatible LAN projects

The status of these projects was reviewed with Mr M.V. Roopchandar. One objective is to develop an Arcnet-compatible 2.5 MBaud token-bus LAN card for IBM PC-compatibles at lower cost than functionally equivalent imported ones. Two prototype cards have been solder-wired on large breadboards, which can be connected to the IBM PC bus by ribbon cables. Software has been written to allow the exchange of e-mail, interactive chat, and the transfer of files between these 2 nodes.

A pcb layout for an IBM PC-format card has been produced by the CAD Group, and was being checked before the production of an initial batch of prototype cards. Only then will it be possible to check multi-node operation over a long bus. In view of the complexity of the task of developing a full library of LAN software for their token-bus card, the Group is considering porting the 10net software to their token-bus LAN environment.

In parallel with this development, CSMA/CD LAN work is being considered. This is spurred by the fact that an Ethernet LAN is being installed for the ITI MIS Group IBM PC-compatibles by Integrated Data Systems (IDS), the Indian agents for DCA Products, using Fox LAN cards and 10net software. While cards for 50 nodes have been ordered, the potential exceeds 300 nodes, and the MAEP Group feels that the requirement could be met by a functionally equivalent card of their own design.

Discussions were held with a representative of IDS and the MAEP staff. It appears that IDS could be interested in exploiting the MAEP Centre development by commercialising the token-bus LAN card, especially if it were supported by 10net software. If the technology transfer procedure is implemented for this device the company should be considered.

Ethernet systems are currently in much more widespread use than token-bus LANs, and the installed base is expanding so rapidly that the usage gap is widening continuously. Non-proprietary virtual terminal and file transfer software is readily available. On the other hand, token-bus networks guarantee a deterministic transport time for messages, which can be calculated by multiplying the number of nodes by the maximum token-ownership time, and IEEE 802.4 has therefore been chosen as the basis for Manufacturing Automation Protocol (MAP). But at present only IEEE 802.3 Ethernet is used extensively by industry, and market predictions do not expect major industrial acceptance of MAP until the 1990s.

The Bangalore MAEP Centre has already invested many man-hours in its token-bus card development. This project has provided the staff with an opportunity to gain direct experience in the computer LAN field, and they should be encouraged to take it to a successful conclusion, including commercialisation through technology transfer. However, it would not seem prudent to make an unlimited commitment to the development and on-going support of complex LAN software packages paralleling products which are already available, in some cases (eg. NCSA Telnet with FTP) in the public domain at no cost.

C. Project directions at the Bangalore Centre

While the development of indigenous products which save imports is laudible, the consultant believes that the MAEP objectives are better achieved by a concentration on tasks which are unique to the Indian environment. In particular, the straight duplication of imported products by reverse engineering should generally be discouraged.

ITI is a large and well-equipped plant with extensive experience of applying microprocessor technology in communication systems. While developing microprocessor products in MAEP for ITI manufacture or internal use is of course constructive, it should be considered secondary to the principal project aims of disseminating this technology to other Indian organizations who require assistance in its application. The work of the Bangalore Centre in organizing training courses and seminars is very valuable in achieving this aim, but it should also be more strongly reflected in the choice of MAEP R&D projects, and the consultant made some suggestions in this direction.

D. Usenet communications node

As an example of such a project, the consultant has proposed that SRC-MAEP study the possibility of establishing a Usenet communications node at ITI Bangalore and in due course extending the facility to other MAEP Centres, and indeed to other organizations in India. The Bangalore Centre has access to all the required communications expertise and a satellite data communications project, the development of an intelligent Demand Assigned Multiple Access (DAMA) controller, was successfully completed within the MAEP context in Jan 1988.

Usenet news provides a world-wide forum for the exchange of technical information, including program files, among all sites connected to the network. The net traffic is heavily biassed towards computer and microprocessor applications, and includes specialist newsgroups for every type of microprocessor, personal computer, operating system and language etc. New product announcements may also be posted. MAEP Centre access to Usenet would provide the project staff with access to a vast resource of international expertise in all relevant fields and direct communication with many compatriots in industrialized countries who are already on the network and eager to contact India.

The consultant furnished hard-copy of some recent Usenet messages including information about current work at the National Centre for Software Technology (NCST) at Bombay. Additional Usenet messages received after his return to Geneva indicate that this is part of the Education and Research Network Project (ERNET), funded by the DoE and assisted by the UNDP. The NCST node 'shakti' is a VAX 8600 running Ultrix. It has an info server (uunet!shakti!infoserv) which gives directory information to other Indian sites reachable through 'shakti'. The project is headed by Mr S. Ramakrishnan at DoE. The following nodes are now believed to be active for mail (but not yet for news):

shakti	NCST, Bombay	uunet!shakti!postmaster
agni	IGIDR, Bombay	uunet!shakti!agni!root
tifr	TIFR, Bombay	uunet!shakti!tifr!root
betaal	IIT Bombay, Computer Centre	uunet!shakti!betaal!root
vikram	DoE, Delhi	uunet!shakti!vikram!root
netearth	IIT Delhi, Dept of Computer Science	uunet!shakti!vikram!netearth!root

The ERNET team at NCST comprises A.G. Joshi, Anil Garg, H. Shrikumar, J.S. Sidhu, P. Jain, S. Ramani and Vinod Kumar. Mail names (all on uunet!shakti): ncernet (for the ERNET team), agj, anil, shri, jss, pradeep, ramani and vinod. An e-mail message relayed through North Carolina State University, Raleigh, indicates that the Indian Institute of Science (IISc) at Bangalore is also very interested in Usenet access.

Usenet read news (rn) software is in the public domain but was not installed on the small Unix systems running on CAD workstations at ITI. The only VAX computer at ITI is running VMS instead of Ultrix. To make full use of Usenet news, Unix should be implemented on a multi-user system with adequate disk capacity to store messages in the important newsgroups for a period of several days at least. In Europe, Digital Equipment Corp provide some support of important Usenet backbone nodes such as mcvax in the Netherlands. Digital Equipment (India) Ltd, who are established in Bangalore, have recently announced the indigenous manufacture of the micro VAX as the 'deil VAX II'. DE(I)L, which has about 400 employees in Bangalore, is a joint venture of DEC (40%), Hinditron (30%) and the Indian Government (30%). Discussions should be opened with them about possible support of the introduction of Usenet in India.

The consultant discussed the communications aspects of a Usenet connection at ITI with Mr G.K. Srecnivasa Gopalan, Senior Engineer in Satellite Communications R&D (Transmission Division), who received the proposal with enthusiasm. ITI Bangalore currently employ an INSAT 1C channel for voice and data communications with a factory in a remote part of Uttar Pradesh. There appears to be no technical difficulty in establishing a satellite data link either directly to the nearest Usenet feed (possibly Singapore), or to NCST at Bombay if they start handling news traffic in addition to mail. Communication costs can be minimised by restricting the newsgroups taken to those of very specific interest to the first users, but it will soon be found that the facility is of such value to so many R&D projects that the acceptance of more traffic will be justified.

E. CAE facilities at the Bangalore Centre

The consultant visited the CAD Group which is also part of ITI's Intelligent Computer Systems Department in the Microelectronics & Computer Division. The Group has developed a CAE software package (NIRMAN) for different platforms, the latest of which are 80386-based IBM PC-compatibles running Xenix. Facilities for schematic capture and pcb layout with autorouting are available, and colour graphics is supported.

MAEP had also used the schematic capture package OR-CAD, but no hard-copy could be produced due to the lack of a plotter driver. DP, a drafting package supplied by OMC, had been used to prepare schematic diagrams, and a library of electronic symbols is available, but as this is a general-purpose drawing tool it does not interface directly with pcb layout software.

As NIRMAN appears to be the only complete CAE software suite available, and as it benefits from the availability of local expertise, it is the natural choice for the Bangalore MAEP Centre. NIRMAN is currently being used for the pcb layout of the IBM PC-compatible token-bus LAN card. The current procedure is to supply the engineer's development schematic to a CAD operator, who re-enters it using NIRMAN. This is time-consuming and error-prone.

It is suggested that OR-CAD and DP be abandoned and the schematic capture facility of NIRMAN be made available to the MAEP staff so that they can use it directly from the start of their development work. It was agreed that this should be possible by implementing NIRMAN on the MAEP OMC Omega Superstar V20 VME-based system when it is installed

in the new building. This is one of two such systems, supplied through MAEP, which were used successfully for the development of its VINYAS CAD system for LSI.

The present Deputy Chief Manager of the CAD Group, Mr Visvesvara, formerly acted as Project Coordinator of the Bangalore MAEP Centre. This should facilitate a maximum of cooperation between the two groups, and it is recommended that, as far as possible, barriers between MAEP and the CAD service should be removed. For example, designers should have the possibility of studying photoplotter masters before they are used for production, as well as verifying the pen-plots as at present. Some freedom of choice should be allowed for the placement of MAEP pcb orders, so that prototype boards can be made by outside manufacturers on occasions when ITI's internal facility is too heavily loaded to provide a rapid service.

F. PLD design at the Bangalore Centre

Modern digital electronics design using state machines implemented with programmable logic devices (PLDs) was discussed with the Centre staff, and design examples using PALs and ABEL were reviewed. It was agreed that the MAEP Centre should seek PLD facilities. Enquiries revealed that a complete system existed in the ITI Digital Communications Section (Mr Gangadariah) of the Switching R&D Department. ABEL is available on an IBM PC-compatible and the JEDEC-format programmer load file produced there can be transferred by floppy disk to another PC connected to a Data I/O UniSys programmer.

The Digital Communications Section selects PLD devices only at the start of each new project, and has not yet used 2nd-generation PALs such as the 22V10. No procurement problems are foreseen however. A second UniSys programmer is believed to be on-site at ITI so that, while the local availability of Data I/O maintenance is uncertain, a back-up is available. The system inspected has performed reliably during the 12 months since its installation, and software updates have been received regularly.

There is a close collaboration between SRC-MAEP and Switching Division R&D staff (a fault-tolerant systems project was completed by H.V. Nagaraja on a 50/50 assignment in early 1988). On discussion with Mr Gangadariah, there appeared to be no problem of principle in MAEP staff sharing the PLD facility, subject to the priorities of current users. They should be encouraged to do so in future design work.

G. Audio-visual training aids

UNIDO support had allowed the procurement of a complete system for the production of U-Matic video-tapes for training purposes. In particular, a Sony DXC-1820 PKA camera, VO-5630 recorder and VO-6800 PS field recorder were available, together with large-screen colour monitors of Sony and indigenous manufacture.

The consultant visited the R&D Audio-Visual Group led by Mr Sridhar to review the use being made of this equipment. The Group has set up a studio-cum-demonstration room with adequate lighting facilities and has produced numerous video-tapes for the Switching Division. These range from scripted training films concerning the operation and maintenance of telephone equipment to records of complete lecture courses given in the classroom by ITI engineers. From the master U-Matic tapes, VHS cassettes are prepared which can be sent out to field centres and played on recorders readily available there.

The Group staff includes specialists with both electrical engineering and photographic-art skills, and the tapes produced demonstrated skilful programming, sound and lighting. The main equipment limitation is in the area of editing, which must be done rather clumsily using the two recorders since no dedicated editing facility is available. There is also a shortage of colour monitors.

SRC-MAEP organizes regular courses of training in the application of microprocessors, some of which are given by experienced ITI engineers who cannot be made available regularly. It is suggested that the facilities supplied be used to prepare more VHS cassettes of these presentations, for distribution to other MAEP centres and interested organizations in India. It is possible that space may be available in the new MAEP building to accommodate the Audio-Visual Group studio which would facilitate such cooperative projects.

H. National Seminar on Microprocessors and Communications Systems

The Bangalore MAEP Centre plans to hold a seminar under the above title on 23 - 24 Feb 1989. The proposed topics are switching systems, data communications systems, satellite communications systems, digital transmission, telemetry systems, fiber optics transmission systems and advanced communication systems. Participants' attendance costs are borne by their own organizations, and a small registration fee is charged to non-speakers.

By end-December 1988, 55 applications for participation had been received and some 30 papers had been submitted, 20 from organizations in Bangalore (including ITI contributions) and 10 from engineering colleges, Government research organizations and private and public companies in other parts of India. The abstracts received indicate that the seminar should be very successful, and the Centre plans to organize events of this kind annually.

SRC-MAEP staff should also be encouraged to present their work at major events such as the IEEE TENCON'89 Conference, to be held in Bombay 22 - 24 Nov 1989, which will include a full session on Software Technologies for Communication Systems.

I. Software projects for export

A topic which was frequently raised in discussions with the consultant was the possibility of encouraging microprocessor projects which could lead to software exports from India. Good software products can be created with a competent team of programmers and a reliable computer facility. The development and marketing of internationally-competitive hardware products, on the other hand, requires a very diverse and sophisticated infrastructure. There are already several successful software projects of this kind in India, including the activities of the Software Technology Parks in Bangalore, Pune and Bhubaneshwar.

The DoE has established a Software Development Agency which is 'entrusted with the responsibility of development of software, promotion of software exports, and creation of policy framework etc'. Software export value increased from $22M in 1984, through $54M in 1987, to about $100M (estimated) in 1988. India hopes to achieve a target of $230M by 1989 - 1990.

The subject was discussed in the MAEP/ITI context with Mr H. Sivaramakrishnan, Senior Engineer in the Microelectronics & Computer Division, who had supervised earlier advanced software work on a knowledge shell with possible applications to communication systems. As a public company marketing in India, ITI as a whole cannot enjoy the same privileges as

certified '100% export-oriented companies'. The legal requirements for such certification should be examined with the DoE to determine whether it could be granted to a restricted unit within the company, or whether MAEP developments can be exploited by such companies under the technology transfer procedure.

Collaboration with established vendors in the market countries would be essential for projects of this kind, as complex software products require strong local support. Reliable direct electronic mail, including file transfer facilities, is required between the Indian development centre and overseas vendors. ITI have the satellite communication facilities necessary to implement such links and should be encouraged to establish them.

Once the legal and communications aspects have been studied, suitable partners can be sought at international trade events. ITI is regularly present at major exhibitions such as Telecom (Geneva) and CeBIT (Hanover). It is suggested that at least one member of the ITI team at such events should be briefed on this topic, or even that a team member be sent with the specific task of initiating such collaborations. In Germany alone, there is an annual demand for about 6000 software writers, whereas the educational institutions produce only about 800 a year. Europe will readily look to India to fill such a gap.

India will participate as a partner company at CeBIT 1989, and a 'Business with India' forum has been organized by the Trade Fair Authority of India (TFAI), the Indo-German Chamber of Commerce, and the Deutsche Messe AG, Hanover. TFAI has reserved some 1300 m^2 of stand space - 900 m^2 for hardware exhibitors and 400 m^2 specifically to present Indian software expertise. A 5-day workshop will bring together policy-makers and experts from both countries to deliberate on joint Indo-German projects.

J. Library

SRC-MAEP staff have access to three ITI library facilities - the main library and those in the Switching and Transmission Divisions. In addition, it is planned to establish a local library in the new MAEP building, and an initial small procurement catalogue for this had been drawn up. The Transmission Division library was inspected.

Although books were being marked with their UDC classifications, they were not shelved in corresponding order and there was some mixing of subject matter. A card index system helps to locate publications. A fair range of periodicals is taken and there are numerous books, but few of recent date. In particular, no texts on modern digital design could be found. A few texts on this subject should be procured for the new MAEP library and funds should be allocated for regular future acquisitions.

Sections should be allocated for MAEP reports from both the Southern Regional Centre and other Centres, and shelves should be set aside for the technical documentation, such as component catalogues, system manuals and data books, which must be consulted during product design.

While it may be premature to propose the use of computerized library data-base systems such as UNESCO's ISIS, it should be noted that if ITI procures a modern mainframe or supermini computer at some future date their introduction should be considered. The search facilities supported by such systems are much more comprehensive than what is possible with any card index.

K. Bangalore Centre new building

Up to the present, SRC-MAEP has operated from the basement of ITI Building F-87 by sharing premises with the ITI Intelligent Computer Systems Division. In late 1985 it was proposed to construct a new building for MAEP in Hosur Road (Keonics Area) at ITI, and this was essentially completed during the consultant's visit.

The building, of which MAEP will occupy the entire ground floor, has been erected by ITI with DoE funding of Rs 3.2M. It provides over 400 m^2 of usable surface, divided into a laboratory area, seminar hall, computer room, staff area, library, and offices for the Project Coordinator and clerical staff. The laboratory area, seminar hall and computer room are air-conditioned, with air distribution via diffusers in a false ceiling.

Two unitized split-system air conditioners are mounted in the computer room itself. The noise level is quite high, and such equipment is normally housed only in unoccupied machine rooms. Any staff working regularly in the computer room should have periodic audiometric tests to detect any premature loss of hearing.

A building dedication ceremony and official hand-over from ITI to the DoE, represented by Dr Krishna Kant, was held on 5 Jan 1989. It was planned to start the removal of equipment to the new premises immediately. SRC-MAEP should be fully operational from the new building before the National Seminar on Microprocessors and Communication Systems in February.

L. UNDP Fellowships

Supporting UNDP Fellowships in industrial countries for MAEP staff is a valuable method of introducing them to the techniques and working methods used in other organizations. The fellowship programme complements the expertise provided by visiting consultants from other countries.

At the time of the consultant's visit, Senior Engineer Mr Chidambara and Assistant Executive Engineers K.J. Somashekak and K. Nalinakshan were terminating fellowships in the USA, while Executive Engineers M.S. Mohan and M.V. Roopchandar had received 2 out of 3 month's planned fellowship training. As fellowships cannot normally be authorized on a split basis, it was proposed to apply for two new fellowships of 3 month's duration for the Executive Engineers. Letters had been sent to the University of Bremen (Prof D. Popovic), Capricorn Systems International Inc (Mr V.S. Sripathy) and the University of Southern California, Los Angeles, (Dr Prasanna Kumar) requesting a 1 month period with each organization.

Bangalore Centre staff have been experiencing difficulty in identifying organizations prepared to accept UNDP Fellows for such periods. Academic organizations generally prefer to enrol students for complete courses, of minimum duration 12 months, while industrial enterprises generally link training with future employment.

A large number of Indian nationals working with computer-oriented educational and industrial organizations in the USA are regularly active in the 'soc.culture.indian' newsgroup of Usenet. It is suggested that, as soon as MAEP establishes its Usenet node, a query concerning fellowship possibilities should be posted to this group. The consultant feels certain that this will secure numerous responses, and the staff can discuss their interests by e-mail with the potential hosts before selecting the most appropriate organizations to visit.

III. PUNE MAEP CENTRE

The consultant visited the Western Regional Centre of MAEP at Pune from 9 Jan to 17 Jan 1989. The Project Coordinator is Prof A.M. Dhake, who combines this responsibity with his work as a Professor at the Pune College of Engineering which hosts the Centre. He discussed current problems at the Centre with administrative and engineering management and staff, reviewed current and proposed projects there, discussed new developments in microprocessor technology, and lectured on the real-time control and monitoring of multiprocessor systems.

This MAEP Centre has encountered a numbering of teething troubles in coming up to full productivity. Major problems have been the delay in starting the construction of an MAEP building (and the cramped nature of the present quarters), a false start in the area of microprocessor applications in medecine (which did not find successful acceptance by the medical profession), a high staff turnover rate, and an inadequate follow-through from initial project conception to industrial production or even final utilization.

On the credit side, the Centre has recruited a small but well-qualified group of engineers, has tackled a diverse range of work which has added to their experience, and has conducted quite an extensive series of training courses as one approach to the MAEP objective of disseminating microprocessor technology. The consultant made specific recommendations about procedures to identify appropriate target organizations for future project work, to ensure that the developments undertaken by MAEP are properly exploited by industries having a significant impact on the economy.

The Pune Centre staff are conscious of present project weaknesses and have a positive attitude to their rectification. The senior staff showed a full commitment to the goal of establishing a viable Centre, but are handicapped by a number of administrative hurdles which are discussed in more detail in the following.

A. Pune MAEP building

From April 1986 it was planned to erect an MAEP building within the Pune College of Engineering campus. A site of 3320 m^2 was identified and plans for a 2-storey building of total surface area 1082 m^2 were drawn up. Construction cost is estimated to be about Rs 2000/m^2. The erection of this building, which would take about 18 months, has not yet commenced as agreement has not been reached between the State Government of Maharashtra, who own the Pune College of Engineering and the land, and the Central Government of India, who would finance the building through the DoE.

The problem is being actively pursued by Prof Dhake and Mr A.C. Kulkarni, MAEP Administrative Officer. Since the State Government is reluctant to transfer the title of the land to the DoE, a lease arrangement is being negotiated. Since the long-term duration of the MAEP project is unspecified, the State authorities are unwilling to consider a 99-year lease. On the other hand, the DoE cannot consider the construction of a building for which they might lose the rights shortly after its completion. The accommodation available to the MAEP staff in the College of Engineering is minimal for the present staffing level, and this is one reason why active steps are not currently being taken to recruit staff for the 9 posts currently

vacant. At present it is necessary to clear away all project material to provide space for students when training courses are given.

A meeting of all the concerned authorities (MAEP National Project Coordinator, Education and Employment Department, Revenue and Forest Department, and the Director of Technical Education for Maharashtra) should be convened as soon as possible with the aim of concluding an appropriate compromise for the leasing of the required land, so that the building construction can start without delay. In the event that it proves impossible to resolve the land problem, alternative solutions such as the addition of a floor to an existing college building should be considered.

B. Pune Centre staffing

The Pune MAEP Centre has experienced a high staff turnover. In particular, there were many resignations in mid-1987 by staff who were actively working on projects at the Centre. As a result, the projects had to be taken up by other staff members, some of them new to the Centre, which considerably delayed their completion. This staffing problem was discussed with the administrative and management staff and a number of reasons for the high turnover rate were identified.

A root problem is the uncertain duration of the MAEP project and the insecurity of employment which results. At MAEP Centres where the host organization is a Central Government one (eg. the state-owned ITI), MAEP staff could remain in Government employment with the host organization on termination of the programme. This does not apply at the Pune Centre, where the host (the College of Engineering) is an organization of Maharashtra State rather than the Central Government of India. While the initial Memorandum of Understanding states that the staff should be considered employees of the Government of Maharashtra, it is understood that the Director of Technical Education cannot agree to guarantee posts for MAEP staff on termination of the programme, since the normal rules for competitive selection for College appointments must apply.

At present the MAEP programme, initially foreseen to terminate in Sept 1988, has been extended into 1990. The staff contracts specify that they can be terminated without notice. In these circumstances the staff do not see a future career path within MAEP and tend to opt for alternative possibilities which present themselves. In view of the potentially short-term nature of the employment the staff cannot join the full pension programmes and must contribute to provident funds with less attractive benefits.

Finally, as they are not considered to be Government employees, MAEP staff receive salaries based on the University Grants Commission scales for academic staff, which are not yet aligned with those of the Central Government, and which are the subject of strike action by professors at present. In view of these problems it is surprising that the Pune Centre has succeeded in attracting such high-calibre engineering staff. Everything possible should be done to retain their services for a productive period by offering competitive salaries, security and other benefits.

C. Current project areas

Following the cessation of work on medical applications, the Centre has decided to concentrate its future efforts in two main fields: Automatic Test Equipment (ATE), by a team headed by Mr S.Y. Watve, and PC-based instruments, by a team headed by Mr S.V. Gunaji.

Work is already in progress in ATE, while the PC-based instruments were in a definition phase at the time of the consultant's visit.

Three older projects, which are considered completed, are currently offered by the DoE for technology transfer. These are the Relay Parameter Tester, the ECG Analyser, and the Vehicle Emission Monitor. As the latter monitors only CO concentration, and more comprehensive instruments are readily available, its utility is considered to be limited.

The reduction of CO emission from vehicles was to be stressed at the third Symposium on Indian Automotive Technology (SIAT 89) held at Pune from 18 - 22 Jan 1989. Although some 200 delegates from the automotive and ancillary industries were expected to attend this seminar, the Pune MAEP Centre had no plans to be represented. The Centre should grasp any such ideal opportunity to present its work and establish industrial contacts.

A portable CMOS microprocessor-based controller project is considered to be complete, but documentation for technology transfer has not yet been prepared. The patient-monitoring system project is considered complete, but as a solution to the problem of blood pressure measurement was not found it is not thought worthwhile to seek technology transfer for this.

In addition three 1-year projects, executed by students supervised by MAEP staff, have been completed but no future applications are foreseen. These are an 8085-based test jig for multi-module power supplies, which is in use by Digitronics Ltd, and an 8052-based adaptive controller and stepper-motor driven artificial limb, which have not so far been applied.

Finally two student projects are currently in progress. These are the development of a 256 x 256 x 6 bit video frame-grabber for IBM PC-compatibles, possibly for use in an industrial vision system for gear inspection, and the development of a 2-card IBM PC-compatible PAL programmer for internal MAEP use.

The video frame-grabber card development was initially foreseen as a component of a more extensive programme of work in image-processing. While an image-processing expert has recommended that this work should continue, the staff were advised at the September 1988 Project Coordinators' Meeting that this activity clashes with that of another Government research organization. The current situation is that image-processing work is proceeding at a reduced level as a background task, with a view to applications within the ATE project related to parts inspection. This programme should be clarified as soon as possible with the DoE, so that it can proceed with full support if it is properly authorised.

D. ATE projects

The ATE projects at the Pune MAEP Centre were reviewed with Mr S.Y. Watve and staff. Steps are being taken to procure an imported bed-of-nails fixture which can be used for the testing of bare and assembled pc boards. One IBM PC-compatible interface card has been produced which provides 64 programmable TTL I/O lines. It is proposed to use multiple cards of this type to connect to selected contacts of the bed-of-nails, and also to develop a variant with other I/O drive specifications. In the case of the testing of boards produced by CAE, the ATE software would use the netlist produced by the CAE system. It is hoped to demonstrate bare pcb testing in about 2 months.

Bare board testing of this type is normally carried out (as an optional service at extra charge) by pcb manufacturers themselves, who are relatively few in number in India at present. In many cases netlists for the tester would have to be prepared for manually-produced pcb layouts, since CAE systems have only recently been introduced in the country.

A more ambitious ATE project (estimated 18 months) envisages the development of a general-purpose knowledge-based ATE system for the functional and in-circuit testing of electronic modules. The MAEP Centre initially proposed to design an expert system shell which provides for knowledge acquisition, knowledge base maintenance and an inference engine structure. The work was to be carried out jointly with Algorhythms Computer Software Consultants, and would have been used by MAEP for the development of an expert system for ATE. Subsequently Algorhythms withdrew their support of this work, but the Centre has procured an existing shell which can be applied to the ATE development.

In the absence of a bed-of-nails fixture or automatic probe positioner, it is proposed to commence the work with a manually-guided probe approach. Programmable excitation would be provided by PC-driven pods connected to the test module's I/O connectors.

In the case of a card with a socketed microprocessor, the processor would be replaced by a connector from a pod which would emulate the microprocessor bus signals under PC-program control. It is proposed to implement the pod with a RAM, wide enough to generate all the microprocessor address, data and control signals, fast enough to be clocked at a rate which allows a finely quantized emulation of the microprocessor cycle timing, and deep enough to store the data for sequences of several pseudo-instructions. The data would be generated manually from the timing diagrams of each type of microprocessor to be emulated.

The feature of this proposal is that, with good software, it could direct a relatively unskilled operator to locate a pcb or IC fault of a nature which would prevent a microprocessor-based system from booting. On the other hand, as long as the microprocessor can execute code from on-board EPROM, it does not appear to offer important advantages over the much simpler procedure of having it execute a test program which can be accommodated there. Nor does it eliminate the need for such a program for functional tests with the microprocessor present and interrupt handling etc active.

In the consultant's view, the cost-effectiveness of the microprocessor emulation ATE approach is sufficiently questionable that this project should be pursued only if a firm commitment is forthcoming from a potential industrial user. Meltron Electronics, who collaborated with the Pune Centre in the past on the successful marine gas turbine monitoring project, are developing a microprocessor-based EPABX which is a possible candidate.

E. PC card-based instruments

The Pune Centre staff proposed the development of the following series of PC card-based instruments in a $2^1/_2$ - year programme:

(1) Signal analyser (processing workstation)

(2) Data acquisition system

(3) Logic analyser

(4) Digital storage oscilloscope

(5) DVM/Frequency counter - Timer

(6) Programmable signal generator

In addition, the development of an extension card cage for IBM PC-compatibles was being considered.

The conception of the signal analyser card was the most advanced. The analyser would use the TMS 32020 DSP and 8085/8 microprocessor with dual-ported RAM and two 12-bit ADC channels using Analog Devices AD578 hybrids. PC cross-assemblers for the 8085 and 32020 are available, the latter from Beltronix in Bombay. The facilities proposed were:

(1) Basic functions - Spectral analysis - FFT, IDFT
Digital filtering - FIR, IIR
Auto- and cross-correlation

(2) CAD of digital filters

(3) Post-processing - Data smoothing
Filtering of random and periodic data
Power/noise calculations

(4) Graphics display

The duration of this project was estimated as 9 months, which the consultant considers very optimistic in view of the range of facilities proposed and the fact that two members of the team (S.P. Dixit and C. Buzruk) will be absent on fellowships for 3 months of this period.

Potential users of the signal analyser card were considered to be:

Central Water & Power Research Station (CWPRS), for the analysis of structural vibrations produced by a random wave generator.

Automotive Research Association of India (ARAI), for vibration analysis in mechanical design of vehicles.

Deccan College (Prof Sampat), for work on the analysis and synthesis of Hindi speech.

Pune Engineering College (Prof Chikte), for vibration analysis in mechanical engineering.

ARAI had not so far been contacted about this development, while CWPRS were interested in using some of the Centre's 2-D graphics software but had not made a definite commitment to the signal analyser as such. No potential users had so far been contacted for any of the other five proposed card instruments.

The consultant suggests that potential users must be identified before launching upon such an ambitious programme of hardware and software development. It should be established that such users are prepared to wait 12 months or more for the indigenous development rather than import equivalent instruments today, and their active collaboration should be sollicited during the phases of product specfication and development. As far as possible individual requirements should be catered for to give the products some specific advantages over general-purpose instruments.

In considering PC-based instruments attention should also be given to alternative platforms such as the Macintosh, which is already being introduced at CWPRS. Instrumentation software (such as LabVIEW) is readily available for the Macintosh with comprehensive signal-processing libraries, graphical programming capability and very advanced features compared with MS-DOS machines.

F. Future project directions

Extensive discussions were held with all the Pune Centre project and senior staff about the realisation of MAEP aims and choice of future project directions. These served to highlight the reasons why earlier MAEP development work did not always lead to full industrial exploitation. The staff are resolved to correct this in future by seeking the collaboration of potential users at the project specification phase.

The consultant emphasized that an important aim of MAEP was to disseminate microprocessor technology in industrial applications where it can lead to higher productivity and improved product quality. He encouraged project staff to seek contacts with local industrial enterprises which are large enough to be important to the Indian economy, but are not currently expert in microprocessor applications. The Maharashtra Industrial Development Corporation (MIDC) area spread along the Bombay-Pune road, Chinchwad-Pimpri and Akurdi, comprises over 1000 companies. Many others are located in the Gultekdi, Parvati, Hadapsar and Pune-Nagar road industrial areas.

An Industrial Directory published by the Maratha Chamber of Commerce and Industries gives detailed information about the companies including capital, annual turnover, workers employed, products, production capacity etc. The Directory should be procured by the Pune Centre and used to compile a list of potential candidates, but it is essential that MAEP staff actually visit the plants in question to review the level of technology currently applied and identify the areas where microprocessor-based instrumentation could be productively introduced.

During these discussions the staff demonstrated an awareness of numerous important local industrial activities in which microprocessor technology could play a valuable role, ranging from two-wheeled vehicle production to the control of milk fat content in dairy product plants. Developing technical solutions for such specific processes, which are required widely elsewhere in India, could prove a productive use of the Pune Centre resources. This activity should be given higher priority than attempting, with much less comprehensive facilities, to emulate the high-technology products of foreign instrumentation manufacturers, which are required only in small numbers for specialist activities.

The means for initiating industrial contacts were discussed. The Pune Centre staff preferred the sending of introductory letters to telephone contacts. While a descriptive document of the MAEP Centre exists, it lists all the equipment facilities and is much too long for this purpose. It was decided to produce a single-sheet presentation of the MAEP Centre and its objectives, which could be sent to industrial organizations which are potential customers of its services.

G. Usenet at the Pune Centre

As for the other MAEP Centres visited, the consultant suggests that high priority be given to providing access to Usenet. The Pune Centre is the closest to the National Centre for Software Technology (Juhu, Bombay) which has established the 'shakti' node, and it is recommended that NCST be contacted to determine whether they would be prepared to provide a news feed as well as Usenet mail. The news feed is required to participate in the forum activity which is the unique feature of Usenet.

The Pune Centre is equipped with a full multi-user HP 9000 Series 300 computer configuration for which no projects are planned, and this should make an excellent Usenet

node. The system already has HP-UX, and it is suggested that Blue Star be contacted for the appropriate public-domain read news (rn) software and installation assistance.

The Pune Centre is also close to the Intelsat satellite earth station being operated at Arvi by the public sector international communications centre Videsh Sanchar Nigam (VSN), and to the NICNET terminal at Pune. A NICNET earth station is almost co-sited with the New Delhi MAEP Centre in the Central Government Office complex. VSN currently provides a link to the Intelsat Business System (IBS) for Texas Instruments' Bangalore operation, and they have requests from customers in nine more cities for a similar facility.

Invitations to tender have been launched for a nation-wide public packet-switched network, which will provide access from most major cities to international nets through a gateway in Bombay. The Telecommunications Research Centre (TRC) is currently engaged in extending packet switching from the four metropolitan cities - Bombay, Delhi, Madras and Calcutta - to Bangalore, Hyderabad, Pune and Ahmedabad. The consultant is ready to cooperate in electronic mail and file transfer tests between Geneva and MAEP Centre Usenet nodes in India.

H. CAE at the Pune Centre

At the time of the consultant's visit, the Pune Centre was evaluating the results of an invitation to tender for CAE software and hardware. The choice of platform had been restricted to 80386/387-based PC/AT-compatibles with 80 Mbyte hard disk and 14" EGA monitor. The most competitive offers received were for EE Designer (via International Data Management), P-CAD (via Micronic Devices) and Red-CAD (via WIPRO Information Technology).

WIPRO gave a technical presentation of all the Racal-Redac products. The company stated that they would shortly be starting production in India of Sun workstations which can support the more powerful Visula/CADSTAR packages. The future support of their more limited IBM PC-compatible packages appeared less certain.

The consultant recommends that, before a final selection is made, the Pune Centre should arrange to use the more promising CAE systems for a short period for their own work. Hands-on experience is necessary to evaluate large packages of this kind, to reveal the strengths and weaknesses of the software and its local support.

Collaboration between the Pune and New Delhi MAEP Centres is also suggested since both are at the same phase of CAE system procurement and a joint decision could have financial as well as operational advantages. Both Centres should also contact the CAD Group at ITI Bangalore to ascertain whether the NIRMAN package could be made available generally within MAEP.

I. Project funding at the Pune Centre

During 1987 and 1988, the Pune MAEP Centre offered product development services to several companies against payment of a fee. The projects included the development of a microprocessor-based wind data logger (Adept Recording Instruments), test equipment for a receive-only terminal (Datapro), multibus cards (Chaitanya Electronics) and a modular large-screen LED display processor (Tekmen Systems). Although the development charges quoted were relatively modest, they were considered too high by all the companies cited

because the number of systems required in each case was very low and the companies' resources limited.

In the long term, it would of course be highly desirable that MAEP operations be auto-financing. But the above experience suggests that until the Centre has an established reputation for rapid product development, it will not be possible to charge commercial rates for work undertaken. As a UNDP and Government of India supported project, it may be considered reasonable to carry out initial developments on an 'at-cost' basis, or even the dissemination of the results on a non-exclusive basis for the price of the technology transfer itself (disk or tape media, listings, pcb masters, model cards and production documentation etc).

It is therefore suggested that the customer charging policy be reviewed in order to facilitate developments for enterprises of limited resources, providing the work done can be of more widespread interest in India. While the rates applied may vary with the customer's means and the wider potential of the product, the policy itself must of course be applied in a rigorously uniform way with visible fairness.

CONCLUSION

The electronics industry in India has witnessed a four-fold increase in the last five years and is expected to achieve a turnover of Rs 10 billion by the end of this decade. Over 750 joint ventures with the USA (about 250), UK, Japan, West Germany, France, Switzerland, Sweden and other nations have been cleared by the Government of India since 1985. Nevertheless India is commonly perceived as an over-regulated country and she has failed to achieve the spectacular growth in this sector realized by Taiwan, South Korea and Hong Kong, and now spreading to Thailand, Malaysia and China.

Indian analysts attribute this lag to two causes:

> The Janata government's decision (in 1977) to limit foreign equity in Indian companies to 40%, which virtually excluded Japanese enterprises and caused the withdrawal of other major foreign investors such as IBM.
>
> A certain emphasis on achieving world-class stature in scientific and technological research, rather than on the more vital but less spectacular application of technology to improve productivity and quality control in national industry.

Both factors may be considered the result of a commendable desire to reinforce self-reliance, understandable in the first few decades of the nation's independence. But self-reliance must not lead to self-isolation, and in a shrinking world India must strengthen her communication links with industrialized and developing countries and learn how best to apply the results of her scientific work to improve the living conditions of her vast population.

In his inaugural address at the INMAP'88 Seminar, Mr Sam Pitroda, Adviser to the Prime Minister on Technology Missions, called upon Indian microelectronics engineers to look in new and uniquely Indian directions when selecting projects for development. This should prove more effective in strengthening the economy than simply following the routes taken in other lands with an inevitable lag in time.

By reason of her long-established educational and cultural institutions and high level of scientific expertise, India occupies a unique position among the developing countries of the world. International aid is required more to directly promote her industrial development than for the institution-building required in less advanced nations.

The Microprocessor Application Engineering Programme is a joint project with commendable objectives and undoubted topical value. At the three MAEP Centres visited by the consultant, it has attracted well-qualified staff who are dedicated to its aims and determined to improve its efficiency. With renewed attention to the two areas cited, external communications and internal project relevance, it should play an increasing role in the industrial development of the nation.

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