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MICROPROCESSOR APPLICATION ENGINEERING PROGRAMME

DP/IND/84/03C

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

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**ABSTRACT**

This report describes the work of a UNDP expert who visited India between October and December 1987 to investigate the status of Microprocessor Applications in India at that time. The report contains a description of activities of three MAEP centres, New Delhi, Pune and Lucknow. For each of the centres the staff and equipment available are reviewed, a report is presented on current and where possible proposed projects and information about the short course program is included.

The report contains details of the recommendations of the expert for the future development of the Microprocessor Applications Engineering Programme along with his conclusions resulting from his mission.

## 1. RECOMMENDATIONS

These recommendations are based on the experiences of the expert who visited only three of the Microprocessor Application Engineering Programme Centres. It is possible that they do not apply equally to all six centres.

a. All centres should establish specific expertise in instrumentation. This would assist in the completion of projects, many of which are suffering due to difficulties in instrumentation.

b. Each centre has specific activities allocated to it, but staff experienced in that activity and having a development or research training are not always available in the centre. For the centres to be successful they must make serious efforts to recruit some staff whose previous experience is useful to the centre.

c. Centres should develop a methodical approach to all project work. At present this is not always done and in some cases the market for the product is not fully understood or even known to exist.

d. All problems regarding instrumentation, etc., should be resolved, at least in principle, before any development work is carried out and a feasibility study report should be prepared. The report may then form the basis of an agreement with customers.

e. There should be an increase in the use of CAD techniques in the centres. Many PCB's, for example, are designed using tapes which are laid out manually. If CAD techniques are applied then modifications become easier, full documentation for the design is readily available and considerable time savings result.

f. Centres should expand their contacts with industries relevant to their own allocated activities. Since the centres have largely non-overlapping expertise they should each work as national centres and be prepared to approach industries anywhere in India.

g. Centres should be free to assist any company in their own region which requires specific help, even though that company may be working on a different application of microelectronics to that allocated to the centre.

h. In many of the projects viewed by the expert, there were serious delays and compromises in design caused by the long delays in obtaining electronic components and instrumentation. In a subject which is changing as quickly as electronic applications these long delivery times are serious and there should be attempts to reduce them.

i. Visiting experts should be given more information about the centres they are to visit before they leave home. This would assist them in selecting information to take with them and would make their work more efficient.

## 2. INTRODUCTION

The objectives of the mission were detailed in job description DP/IND/84/030/11-07/J13315. They specified duty stations as New Delhi/Pune/Ranchi/Bangalore/Jabalpur, and stated:

" The expert will work under the guidance of the National Project Director and Chief Co-ordinator, and will specifically be expected to:

i. Appraise himself of the current status of microprocesor applications in Indian Industry.

ii. Appraise himself of the objectives, status and the results of various systems engineering development projects going on in various centres.

iii. Help project personnel in hardware and software development for various projects.

iv. Train project personnel, as well as centres, on new methodologies for microprocessor-based system engineering systems."

A report was to be prepared setting out the findings of the mission and making recommendations to the Indian Government on any further action which may be taken.

These objectives were very broad, and it was clearly accepted by UNIDO officers in Vienna that some modification may be required. This was, in fact the case. The centres to be visited were reduced in number to three, New Delhi, Pune and Lucknow, and it was not possible to arange sufficient visits to Industry for the expert to appraise himself of the current status of microprocessor applications in Indian Industry.

The mission took place between mid-October and mid-December 1987, with the itinerary described below.

| | |
|---|---|
| 18 October | Depart from home |
| 19 October | Briefing at UNIDO, Vienna |
| 21 October-2 November | New Delhi Centre<br>Reviewing projects in progress<br>Seminar presented - the Transputer<br>Briefed on the work of other centres in particular on Lucknow which is concerned with microprocessor development for Indian Railways.<br>Two days were lost due to a National Holiday (Diwali). |
| 22 November | Pune Centre.<br>Reviewing projects in progress.<br>Presented 5 x 2 hr. lectures in Optical Instrumentation. Visits to various departments of College of Engineering. Visits to a total of three industrial and research organisations in Pune.<br>Two days lost due to holidays, one local, one national. |

| | |
|---|---|
| 23 November | New Delhi reporting back to Chief Co-ordinator on the Pune Centre. |
| 24 November–7 December | Lucknow Centre.<br>Discussion with the management of RDSO and with staff of various divisions.<br>5 Seminars were presented, as follows:<br>i. Introduction to Microprocessors for managers<br>ii. Design<br>iii. Optical Instrumentation<br>iv. Data Loggers<br>v. General Discussion and Parallel Processors |
| 8–14 December | New Delhi Centre.<br>Further consideration of work of New Delhi Centre. Giving assistance with resolving problems in both hardware and software.<br>3 Seminars presented as follows:<br>i. Optical Instrumentation<br>ii. Designs<br>iii. Single chip processors |
| 16 December | De-briefing at UNIDO, Vienna |
| 17 December | Arrive home |

This report describes the work of the New Delhi, Pune and Lucknow MAEP centres and suggests action which needs to be taken to safeguard the long term future of the present application program.

## 3. WORK OF THE MAEP CENTRES

There are six MAEP Centres. They are located at important industrial centres within India, and each has a specific area of activity as described below:

| Centre | Location/Activity |
|---|---|
| New Delhi (Northern Region) | Central Government Offices, Department of Electronics. Industrial Process Control and the establishment of a National Software Library. |
| Bangalore (Southern Region) | Indian Telephone Industry. Communications. |
| Jabalpur (Central Region) | Jawahar Lal Nehra Agriculture University. Microprocessor Applications in Agriculture. |
| Pune (Western Region) | College of Engineering. Test and Measuring Instruments and Medical Electronics. |
| Ranchi (Eastern Region) | Steel Authority of India Ltd. Application of Microprocessors to the Steel Industry and Mining. |
| Lucknow | Research, Design and Standards Organisation (RDSO) of Indian Railways. Microprocessor application to Railways. |

The Lucknow centre is additional to those listed in the agreement between the Government of India and the United Nations in Project Document IND/84/030/A/01(37).

There is a co-ordinator at each of the centres, with the New Delhi co-ordinator also working as a chief co-ordinator for the entire programme. At the centres visited by the expert whose mission is reported here, the co-ordinator was an employee of the host institution and staff of the centre were on the same salary scales as the staff of the host institution.

This report covers the work of the New Delhi, Pune and Lucknow centres since these were the only centres visited by the expert on this particular mission.

### 3.1 New Delhi Centre

The New Delhi centre is under the direct control of Dr. Krishna Kant who serves as both the Chief Project Co-ordinator, Department of Electronics, at a national level and Project Co-ordinator, New Delhi centre. At present the centre is staffed by 9 officers and 5 technical assistants along with a few non-technical staff. The 9 officers are all very well qualified and are divided approximately as 5 hardware specialists and 4 software specialists.

The centre has achieved a reasonable degree of competence on both the hardware and software aspects of the 8085 microprocessor. It is expanding its activities into a wider range of processors including the 8051 and 8086, although the 8086 applications are generally via an IBM-PC clone or an Intel computer system.

Equipment at the centre includes Intel series III and series IV Microprocessor Development Systems having provision for 8051, 8085 and 8086 software development. In-circuit emulators are available for the 8051, 8085 and 8086 processors. There is also an Intel 86-310 computer having an 80286 processor and RMX-86 operating system and five IBM-PC compatibles of various types. The centre has produced its own 8085 development system and, in addition, has recently purchased Dynalog Micro Systems' equipment which has a floppy disc based assembler for the 8085 processor. The Dynalog equipment may be connected into a rack-and-card system developed at the centre to aid software and hardware development.

Although the centre is well provided for in terms of in-circuit emulators, there is little provision for more general hardware fault location. The centre does not have either storage oscilloscopes nor logic analysers, both of which are important for fault and error location in parallel interconnection systems, or when aperiodic signals are encountered.

#### 3.1.1 Work of the expert at New Delhi

The expert made two visits to New Delhi, reviewing projects in progress and giving advise when necessary, presenting seminars and assisting in fault location in hardware and software. Brief details of these activities follow:

i. a. Development of equipment for instrumented car. The equipment had been developed to the point at which it was awaiting field trials, but there were some outstanding problems. The instrumented car is to be used in a cost study for road usage.

The purpose of the instrumentation is to enable distance travelled, gradient, fuel consumption, direction of travel and road surface bumpiness to be measured, recorded and printed.

A major outstanding difficulty was the measurement of direction or change in direction. A gyrocompass had been donated for the project but was not capable of on-line connection and hence direction data must be entered manually each time a bend is reached. Ways of overcoming this problem were discussed. They include:

1. The purchase of a gyrocompass with digital outputs. Importing such an instrument would be very expensive.

2. The use of an accelermeter. The processor could then calculate radius of curvature from the acceleration, speed and mass of the car, and hence the change in direction could be found.

   The calculations to be performed should be within the capabilities of the existing microprocessor system.

3. The attachment of a device to the steering to enable the movements of the steering wheel to be monitored.

Methods 2 and 3 would result in a loss of absolute direction information, but if that is not important they are the simpler solutions. The preference of the expert would be for an attachment to the steering. It would be necessary to low-pass filter the signal corresponding to the steering wheel position but this could be done digitally using the microprocessor. However, before any such solution is accepted it would be necessary to investigate the tendency of the vehicle to oversteer or understeer.

An alternative possibility is to modify the existing gyrocompass by adding an optical detector which should be able to pick out the markings on the compass dial. Directional ambiguity could be removed if two detectors were provided and were spaced at 1/4 dial graduation width.

Other factors which were discussed include the removal of contact bounce and a re-design of the human interface. Contact bounce could be removed by treating the sensor reed relays as part of the keyboard and utilising the keyboard interface circuit, providing the contacts are closed one at a time and for a short time only, or by low-pass filtering combined with a Schmitt Treigger circuit.

b. Development of a cross assembler for the 8051. This work is over half complete. The purpose is to produce an 8051 assembler for the National Software Library. It is to run on the NEC1000 computers in the national information network. It was suggested that if a compiled version able to run on an IBM-PC compatible could be produced then a wider use may be possible.

   Software is written in Fortran 77 which should aid portability if this is found to be desirable in the future. Work is progressing well and the expert was not able to offer any useful suggestions for improvements. The software writer was a very able person who clearly understood the 8051 in detail and was well able to produce the assembler source code.

c. Hardware design for an 8051 board. A design had been carried out and was to be produced as a printed circuit board. Although the design of a general purpose 8051 printed circuit board is not in agreement with the original concept of the 8051, which was intended to be used as an embedded processor, the concept is interesting. By carrying out design work real experience is gained.

   The expert was able to offer specific advice on the circuit which contained a few errors. He also suggested ways in which provision could be made on the pcb for various options in the application of the system. The general concept of an 8051 board design was considered. It became evident that a second phase to the project

was under consideration, providing for a few simple boards in a rack system. This resulted in the presentation of a seminar by the expert, as described below.

On his return to New Delhi, after visiting Pune and Lucknow the expert was able to assist in debugging the hardware. At this time the centres' shortage of test equipment, described above, became evident.

d. Flow measurement system for Bhagirathi water treatment plant. This is a project which has been reported on in detail by a previous U.N. expert. It is now encountering serious problems in instrumentation, particularly for the measurement of water flow in open ducts.

Each duct is 1.85 metres wide, 1.25 metres high and normally contains water with a depth of one metre. The daily flow through a duct is about 1.5 million gallons with a water temperature of between 10 and 28 degrees Celsius.

The water contains a considerable amount of suspended solid most of which is river sand. Due to these solids the normal technique for measurement using a notched wier is not considered possible since there would be silting behind the notch. A flow method using ultrasound had been considered and does seem a possibility. The expert reviewed alternatives including a method using correlation (after the work of Prof. M.J. Beck, et al). However, it was evident that development facilities were non-existent and that only a tested and working system could be accepted. There had been proposals to use a radio-active tracer. It was suggested that this should not be applied due to possible difficulties in using even low-level radioactive sources.

The centre has details of a flow measuring system manufactured by Fischer and Porter. This utilises ultra-sound transmitted from above. A letter was drafted to the manufacturers asking if they have a version of the transducer able to operate in the large ducts at Bhagirathi. If necessary this can be followed up by the expert on his return home.

The overall problem is quite complex and measurements cannot produce a direct output of water volume flow. The best that can be hoped for, without a very large financial outlay, is a measurement of flow of water and solids over a small area of the duct. It would be necessary to estimate total flow of water over the entire duct from such measurements.

The overall project is very complex but systems of the type required do exist in some countries. The awarding of a study fellowship for a member of the staff of the centre to visit water treatment plants in other countries should be considered.

e. Interface cards for IBM-PC's. This work is at a very early stage. The proposal is for the development of a range of interface cards to enable processes to be controlled by an IBM-PC or a compatible computer. The work was at such an early stage that no detailed technical discussion was possible, but there was some discussion about the desirability of continuing the project. Cards

of the type proposed are readily available in India. The type of work undertaken by the centre is a matter of policy for the centre to decide upon but the expert was asked for his opinion on the proposed development. He replied that in general any development work must be justified and that in this particular case the development should be considered for progression under any one of three conditions:

i. When cards are required to perform functions not already available from Indian produced cards.

ii. When the centre will require a considerable number of cards, and costs could be reduced by development of its own cards.

iii. If the centre should be allowed to enter a commercial venture, selling interface cards in competition with existing vendors.

It may be that a better use of centre resources would be the development of a new housing for IBM-PC compatibles for use in an industrial environment.

f. Development of a Data Acquisition System for the Gas Dispatch Station of Bhilai Steel Plant. This project is quite advanced. The expert congratulated the staff involved on their understanding of the RMX-86 operating system. To resolve the difficulties of getting started with this very complex system without the assistance of Intel or other consultants is commendable and indicates a high degree of competence.

On his second visit to Delhi the expert was asked for assistance with a specific problem in the driving of a printer. A variety of checks were carried out, indicating that the principles involved were correct. Time prevented a full resolution of the problem before the expert returned home, and the problem still exists. It is difficult to give advice over a distance, but the expert will attempt to obtain a working program listing which can be forwarded to the centre.

ii. The expert presented a number of seminars. These were:

a. The Transputer. The purpose of the seminar was to introduce the concepts of parallel operations in both hardware and software using a type of processor which will grow in importance in the future.

Individual transputers are RISC machines having a Van Neuman architecture. The novel features are the methods of interconnection and the development of a programming language allowing parallel processing without the programmer having to be concerned about the detail of message passing.

There was an extensive discussion of the transputer and consideration of how fast and novel it is.

b. Design. While in New Delhi the expert had been concerned that not all work employed good design principles, and he therefore requested approval to present a seminar on design. In the

subsequent discussion it became evident that some staff were aware of the principles of good design but that the particular problems of locating suitable instrumentation and of importing instrumentation, electronic components and systems made the application of good design principles difficult.

c. Single Chip Processors. This seminar was presented as a result of the interest, in the centre, in the development of systems based on single chip processors. Discussions of the basic design philosophy of the single ship processor as a device for embedded systems, with all computing facilities on a single chip were included. The single chip processor was compared to advanced 8 and 16 bit processors and the advantages/disadvantages of each were considered. In particular the limitation of the single chip processors' bus system were considered.

d. Non-Contact Instrumentation. This seminar was presented to illustrate to staff of the centre the ways in which non-contact instrumentation, in particular using optical systems, can be applied. It was a review of a number of systems currently available for quality control and real-time instrumentation in hostile environments.

3.1.2 Courses operated by the New Delhi Centre

The New Delhi centre has operated a number of courses and has proposals for new courses in 1988.

| | | |
|---|---|---|
| Workshop on the Microprocessor and its application in water treatment and sewage disposal. | 2 - 4 Dec.1986 | 30 participants |
| | 6 - 8 Oct.1987 | 30 participants |
| The Microprocessor and its applications. | 4 -14 May 1987 | 20 participants |
| Microprocessor based systems development for real-time data acquisition and control in water resource projects. | 24 June - 10 July 1987 | 25 participants |
| Industry meet on the Microprocessor and its applications. | 2 - 3 April 1987 | 60 participants |

The courses proposed for 1988 are:

The Microprocessor and its applications, 14 days from January 1988.

Industrial Seminar on the Microprocessor and its applications to Productivity Improvement. To be held in the Ashok Hotel, October 1988.

### 3.2 Pune Centre

The co-ordinator of the MAEP Centre, Pune, is Professor A.M. Dhake, who was away on study leave at the time of the visit of the expert. Professor Dhake is the Head of Electronic Engineering in the Pune College of Engineering and carries out the work of co-odinator as part of his Head of Department duties. In the absence of Professor Dhake, the expert was very competently briefed on the work of the centre by the consultant to the centre, Professor K.K. Rathod.

In November 1987 the centre had a staff of eight Engineers in addition to its co-ordinator and consultant. There are six engineering vacancies. Since the centre was formed there has been a considerable turn-over of engineering staff. Five people, who joined the centre between January and August 1986, resigned between June 1986 and July 1987. Of the staff availaole to the centre in November 1977, six had joined in the period since June 1987 and, of these, three were new graduates with no industrial experience.

The staff of the centre attribute .ne large turn-over of staff, and difficulty in recruiting experienced staff, to salaries in the centre which, it is claimed, are not competitive with industrial salaries. There can be no doubt that the staffing situation is causing problems for the centre. New staff need to be trained to use the complex equipment in the centre and only then are they .ble to undertake productive work. Also there is a reluctance in the centre to the accepting of major consultancy work having fixed delivery dates since future staffing is not predictable.

The centre is housed in two rooms of the Pune College of Engineering. It is to be re-housed in a new building which, it is proposed, will be built on land adjacent to the college. There is a delay in the construction of this building due, in part at least, to discussions between the Government of Maharashtra who as the state government own the land and operate the College of Engineering, and the Federal Government who, with UNIDO, fund the MAEP Centre. The work of the centre is seriously hampered by a shortage of accommodation, and it is vital that the new building be constructed shortly so that the centre is able to house its full complement of staff and has accommodation of a sufficient quality to operate training courses.

Equipment at the centre includes a range of development facilities for Intel processors, including one MDS Series IV, three PDS's, $I^2$ICE with pods for 8086, 8088 and 80286 processors, ICE for 8048, 8051 and 8085, PROM programming facilities including microcontrollers and software development tools for a wide range of processors. The centre also has four IBM-PC compatibles of various types along with a wide range of software including compilers, PROLOG, Word Processors, Data Bases and Spreadsheets. A cluster board for the series IV enables PC's to be connected to the series IV. An H.P. system for the developments of 68000 software was due for delivery before the end of 1987. The system will be able to operate a number of terminals and so will give multi-user access.

A number of kits are available for use on training courses, and small software packages exist for use with the kits. There are ten 8085 kits, two Z80 kits and two 68000 kits.

The location of the centre in the College of Engineering has the potential to create an excellent environment for the work of the centre to the benefit of both the centre and the college. Already the centre is co-operating with the college in the work of students near the end of their BE course, or on an ME

course. For example, staff of the centre have given lecture courses and students of the college have used the facilities of the centre for project work. One particularly interesting project seen by the expert was the use of an 8052 as an adaptive controller. The students had developed both hardware and software for the controller, and this is now available to the centre. There is a proposal for the centre to modify and slightly extend the PCB layouts after which a good general purpose circuit board, which will include a Basic interpreter. will be available and should be useful in a variety of applications.

3.2.1. Work of the expert at Pune

i. The expert considered a number of specific projects. These were:

a. Gas Turbine Monitoring System. This is contracted work for Meltron Electronics and has been given priority in the centre. Originally, the contract was for software development only, but there was an extension to carry out hardware design with Meltron constructing the hardware.

Software design is now complete, full simulations have taken place and have been approved by Meltron. The completion of the work awaits the hardware from Meltron who are late in delivering. The project is regarded by the centre as a development of automatic test equipment.

b. Relay Parameter Tester. Pre-prototype systems were working and were demonstrated to the expert with the exception of coil and contact resistance measurements which need revision to conform to ISO standards. Revised resistance measuring circuits have been constructed on a patch board and it has been shown that they will work as required. A new printed circuit board is under development. The modified board includes all design revisions and provides for larger switches at the human interface.

Following the demonstration of the tester, the expert proposed some further design revisions for consideration by the centre:

i. A minor software change to enable multiple relays of the same type to be tested without the need to re-enter the relay type for each relay.

ii. The use of a four-wire system when measuring coil and contact resistance. The two additional wires would be used for measuring actual coil or contact voltage and would replace the present rather awkward system involving the manual insertion of links.

iii. The provision of a facility which would allow all expected relay parameters and their tolerances to be entered into the instrument before a sequence of tests (they may even be stored in ROM) and then simple pass-fail indications to be given, possibly with reasons for failure. At present there are 6k bytes of unused EPROM available and this should be sufficient for the proposed modification.

iv. The provision of a facility to enable parameter printing to be carried out.

c. CO Monitor. This is to be used to monitor the exhaust gas levels produced by road vehicles. A prototype system has been produced, but there has been no progress since 2 July 1987 when the person who had carried out the development resigned from the centre.

There have been problems in identifying a suitable transducer, and in transducer calibration. The expert will enquire about these matters and will send relevant information to the centre.

There is a possibility of extending the instrument to measure the concentrations of pollutants other than carbon monoxide. While this is probably desirable, particularly since emission from a diesel engine is best monitored by measuring the amount of exhaust soot, it is also desirable to ensure that any product has a potential market.

Before further development is carried out a survey of the potential market may prove valuable. Factors such as the impact of Government anti-pullution laws and the strengths of competing products (pollution monitoring is carried out in Delhi using equipment developed at IIT Delhi) should be considered.

d. ECG Unit: This is a project in two stages. The first stage was due to be completed by the end of November 1987, and was on schedule. It consists of the development of software to enable the various phases of an ECG trace to be identified. This is believed to have considerable potential value since doctors looking at ECG traces are not usually fully trained in the analysis of graphical data, a problem which may be overcome by the presentation of the results of an automatic analysis of ECG data. The second stage of the work is the possible development of an automatic diagnosis package using the data obtained from the first stage of the work.

The project has been discussed with members of the medical profession who support the first stage of the work, but not the second stage. It is hoped within the centre, that the involvement of members of the medical profession in the first stage of the project will convince them of the value of the proposed second stage.

First stage development has been carried out using an IBM-PC compatible with programming in 'C'. ('C' had not been used in the centre previously and its use has provided for in-service training of a member of the centre's staff) The work is to be presented to the medical profession at an international meeting to be held in Pune in January 1988.

It is the opinion of the expert that the method of presentation of the first stage work to the medical profession is critical to the eventual success of the second stage. He has discussed with staff of the centre the possibility of obtaining real ECG traces to test the algorithms rather than using only simulations and the possibility of carrying out actual clinical trials if at least one sympathetic doctor can be found. Clinical trials would allow real ECG data to be collected, rather than the present simulated data, and would allow the automatic phase identification to be compared with phase identification carried out by doctors.

The second stage of the work is complex and, in the opinion of the expert, should be viewed as a long-term research project. A project

of this nature would enhance the quality of work of the centre, and it is the opinion of the expert that it should be allowed to proceed. The work could be a suitable topic for a postgraduate student studying for a higher degree. Some international co-operation, possibly involving a study fellowship for the person carrying out the research, and short-term visits by international experts on expert systems may be needed. Overall the project would be a valuable and productive form of training within the centre.

e. Patient Monitoring System: This was scheduled to be completed in mid December 1987, but in the opinion of the expert the date would be overshot by a considerable amount. The basic difficulty is due to the staff changes in the centre, and the need for new staff to become familiar with both the medical aspects of the work and the microprocesso. levelopment facilities available to the centre.

The system is intended to monitor a patients temperature, blood pressure and heart rate while the patient is at home, and is to work automatically at pre-set time intervals, even though there may be no attendant to the patient.

It is proposed that a conventional pressure pad, as normally found in a blood pressure measuring system be used. The pad will require to be inflated to a maximum pressure of 250 mbar above atmospheric, with a continual monitoring of actual pressure. Suitable pressure transducers are known to exist. It is necessary to identify a small pump capable of producing a pressure of 250 mbar above atmospheric in the pressure pads over a period of about 20 seconds. The most serious difficulty in instrumentation is the identification of a suitable microphone to listen to blood flow. The microphone is to be located between the blood pressure pad and the patients skin. A suitable microphone was available to the centre, but the suppliers are not known. The expert will make enquiries about suppliers and will notify the centre of his findings.

In order to extract the required k-sound signals from the microphone output, frequency selective amplification is required. The use of digital filtering with a 25-125 Hz pass band was proposed. The filter was to be second order with a finite impulse response and having 21 stages. The filter was to be realised in the 8085 processor forming the main controller of the system. The filter was under development when the expert arrived in Pune, and he was able to discuss its design and various factors which may be expected to affect its performance. Eventually it was determined that the processing time available was too short for the arithmetic operation to be carried out by an 8085 and it was decided to develop simple analog filters.

The development of the analog filters was completed, with some assistance from the expert, but a considerable amount of work remained to be done at the time of the expert's departure.

ii. The expert presented a training course which covered various aspects of optical instrumentation. The course, which consisted of five lectures, each of two hours duration, was presented at the request of the centre consultant since it was believed that two medical projects involving the use of optical systems were available to the centre. Later it became evident that these two projects were no longer available but two new projects were identified as described below.

The subjects covered in the training course were as follows:

Day 1 Why use optical instrumentation?
Outline of an interferometer with a discussion on the problem of directional ambiguity.
Laser Beam geometry.
Beam deflection vibrometer.
Introduction to Holography and its application.

Day 2 Holographic image processing using:

a. Manual processing of photographic data
b. Image digitisation and computer processing

Dual frequency holography. Fringe formation and Moiré contouring.
Fringe projection contouring.

Day 3 Image processing. Basic theories and processing algorithms.
Wear analysis by image processing.

Day 4 Hardware systems. Time limitations and parallel processing.
The use of line scan cameras on moving targets.
Diffraction patterns analysis.

Day 5 Laser Doppler velocity measuring systems.
Theory and applications.

iii. While in Pune, the expert requested that arrangements be made for him to visit a number of industries. (The job description required him to appraise himself of the current status of microprocessor developments in Indian industry.) It was a matter of some regret to the expert that due to the incidence of holidays, and some other factors, it was only possible for three visits to be organised and only one of these was to a private company. The expert does not feel that this has given him a true impression of industry in the Pune area, but presents the information available.

a. National Informatics Centre, Western Region.

The Government of India is establishing a national network of computers. These are to be at four main centres, one of which is Pune. Each centre is to have one or two NEC S-1000 computers, each capable of executing 15 million instructions per second. There will be 25 smaller NEC computers each located in a state capital and forming part of the network. Provision exists for a total of 625 outstations to have terminals which will consist of an IBM compatible 386 based personal computers.

The network will operate using a satellite data communications network known as NICNET.

It is intended that the network will be used for both information processing and exchange throughout India. It will be of considerable benefit to users of the network to have an efficient form of communication available to them. In addition the network will be available for the monitoring of various socioeconomic activities and projects.

The National Software Library, for which the New Delhi centre is producing software, will make use of the network.

Extensive documentation was made available to the expert, but it does not seem relevant for any of it to be reproduced here. The visit was not generally relevant to the work of the expert, except that it provided some background information about data communication systems in India, and had some interest in relation to the work of the New Delhi centre.

b. National Institute of Virology

The National Institute of Virology was visited because the MAEP centre had been asked to undertake a project involving the recognition of the Malaria virus in blood samples. In fact the Institute has completed its research project and the recognition system is no longer required.
The National Institute carries out high quality research and has a worldwide reputation. Staff work in difficult conditions due to overcrowding, but it is hoped to move to a new building in the fairly near future.

The expert was surprised to find only two computers in the Institute, both of which are used mainly for administrative work, and not in connection with research.

Two possible projects for the MAEP centre were identified. They are:

1. The automatic counting of plaques on a culture. At present this is done manually, a process which takes time and can be quite difficult. It should be possible to automate the counting using a vision system. Such a project would be quite simple and would give the centre experience of vision systems.

2. Automation of DNA fingerprinting. This would be a complex pattern matching project which would involve a considerable amount of research and development work. At present the Institute carries out the pattern matching manually. As the number of DNA fingerprints to be compared increases, then the amount of work will increase and some automation will become essential.

These two projects are related to medical applications of computers. One of the projects should be quite simple but the other is far from simple. The centre should try to accept both. Should it do so and need further advice on vision systems and their applications then the expert confirms his willingness to accept a member of the centre staff into his research group for training under a U.N. Fellowship and his own willingness to make further short-term visits to Pune. The centre will need to purchase a suitable vision system, along with a computer and software if the projects are accepted. Ideally the equipment purchased should be available for staff on a fellowship.

c. Laval Automation.

Laval Automation is part of the multi-national Laval group of companies. It was established in India about April 1986 (the same time as the MAEP Centres!). Its products have been developed by its own staff of 30 without any reference to the parent company.

The company compares well with the best in the world. The products are of high quality and are in considerable demand throughout Indian industry. To achieve this situation in a short time the company has attracted and retained high calibre staff by offering very competitive salaries.

Two specific examples of the work carried out by the company are:

1. A process control computer. This is built as a modular system so that it can be configured to meet the needs of a customer by board selection and software. The software design is modular and a variety of modules are available, so minimising the time required to produce a working system. The front panel is a keyboard and display system. The legend on the panel is customised by using a keyboard of the membrane type.

2. Operator training system for the process industry. This is based on two P.C. compatibles, one of which models the plant operation and simulates the operator's display. The other computer is used by the instructor who is able to adjust parameters in the model of the plant through his keyboard and a system of communication between the two computers. Thus it is possible for the instructor to adjust the conditions existing in the plant model and to create emergency or fault conditions and for the operator to have to detect the condition and take remedial action.

3.2.2. Courses operated by the Pune Centre

The courses operated by the centre were discussed by the expert and members of the centres' staff.

At present the centre operates some general courses three times a year, and some specialist courses once per year. Details are as follows:

| | |
|---|---|
| Digital System Design | - 3 courses per year |
| Introduction to Microprocessors | - 3 courses per year |
| Advanced Microprocessors and their application | - 3 courses per year |
| Programming in 'C' | - 1 course per year |
| Prolog | - 1 course per year |

The centre expressed a wish to introduce new courses. Various possibilities, including the following, were considered:

Process control
Numerical Control
PLC's
Digital Signal Processing
Instrumentation
Microcontrollers
Robotics
EPLD's

It would not be realistic for the centre to operate more than two or three new courses in a year, and those selected should be the courses most urgently required in the regional industries. It is possible that a questionnaire to industry listing possible courses and asking which are of interest, would assist the centre in designing courses. In any questionnaire space should be included for industry to specify its own requirements. The possibility of an incentive for industry to return questionnaire by offering a fee reduction for those replying was discussed.

Possibly the most useful new courses would be:

| | | | |
|---|---|---|---|
| i. | Process Control | : | To include Control Theory, digital control techniques. Control algoritms (e.g. 3-term). A review of microprocessors may be required. If the course could be extended to two weeks then digital control theory could be included. |
| ii. | PLC's | : | To include a review of hardware elements, and program writing using various techniques including ladder logic. |
| iii. | Microcontrollers | : | To include an introduction to control systems and microcontrollers along with a software and hardware design in a typical application (e.g. A Case study). |

### 3.3 Lucknow Centre

The MAEP Centre at Lucknow is located within the Research, Design and Standards Organisation (RDSO) of Indian Railways. Its work is totally devoted to the promotion of Microelectronic Applications on Indian Railways. In practise the MAEP centre operates as a division of RDSO and is staffed by railway personnel.

The Lucknow Centre was not in the original agreements between the Government of India and UNIDO who act as executing agents for the UNDP (see project document, UNDP project number IND/84/030/A/01(37) which lists five centres and does not include Lucknow). The centre is located in an environment where a specific microelectronic engineering input is required, and has developed from an organisation first esablished at RDSO in the second quarter of 1982.

The centre co-ordinator Mr. Desh Deepak. was instrumental in establishing the original organisation. He continues to be an employee of RDSO rather than MAEP, thus indicating a long-term commitment to the work of the centre by RDSO. In practice the funding available through MAEP is being used to enhance the work of the centre and to ensure its long-term success.

It is unfortunate for the centre that Mr. Deepak was seconded from the centre between May 1985 and September 1987. In this time there was little development of the work of the centre so that no advantage was gained from the early start. The centre is the worst equipped of those visited by the expert. No UNDP provided equipment is yet available, all existing facilities having been supplied by RDSO. Some UNDP equipment has been ordered and some UNDP funding remains to be spent.

The present equipment position is as follows:

One MDS (Indian made) having an 8085 assembler, Compiled Pascal which produces 8085 object code and a Basic interpreter. A PROM programme which will interface to the MDS, is available.
Two 8085 training kits, each having PROM programming facilities.
One Z80 and one 8086 training kit.
One General Purpose computer used for word processing etc.
One small personal computer.
Various training aids including power supplies and patch boards.

In addition the equipment listed below has now been ordered through UNDP.

One Intel Series IV MDS having a wide range of software and in-circuit emulators.
One single board, Indian made, 8086 training kit with monitor firmware.
Four data logger.
Five cardcage systems along with a total of 40 different cards, providing each system with a CPU, RAM, ROM, Analog and Digital I/O, etc.
Two IBM-PC compatibles.
Ten kits for training purposes. 8085 based.

The report to the Technical Advisory Committee meeting on 21 May 1987 stated that the staff in post at that time were one Joint Director, one Junior Scale Officer and four Research Assistants plus some non-technical support staff. The meeting agreed that the Professional Engineer complement of the centre should be increased to the centre Co-ordinator, two Joint Directors, two Deputy Directors, two Junior Scale Oficers and four Chief Research Assistants. By early December 1987 all but the Chief Research Assistants had been appointed.

The expertise of staff in the centre is as follows:

| | | |
|---|---|---|
| Co-ordinator | - | Civil Engineer with a knowledge of Software, Systems and Signal Processing. |
| Joint Director | - | Electrical Engineer |
| Joint Director | - | Telecommunications/Electronic Engineer |
| Deputy Director | - | Electrical Engineer |
| Deputy Director | - | Analog Electronics/Instrumentation Engineer |
| Assistant Research Engineer | - | Electrical Engineer |
| Assistant Research Engineer | - | Software/Computing |
| Chief Research Assistants | - | 4 vacancies |

(Note: Assistant Research Engineer is the centre designation for a Junior Scale Officer)

The present (December 1987) staffing does not include any specific expertise in Digital Electronics and Computer hardware. This was discussed by the Co-ordinator and the UNDP expert. It was the opinion of the expert that this is potentially a problem for the centre and that the Chief Research Assistants should all have specific Microelectronic expertise and that in the future an experienced digital systems engineer should be recruited to a senior position in the centre.

The centre co-ordinator provided the expert with the following statement of the philosophy and management approach of the centre.

" It is proposed that all effort should be directed towards system and software development work. Transducers and hardware are to be purchased from private manufacturers as they are required according to specifications fixed during system development. Existing transducers shall be used as far as possible. It is also proposed that the centre shall help various wings of RDSO in developing prototypes and in proving them in the field. Logistic support for all field trials shall be provided by the concerned wing of RDSO.

The system so proved in field trials shall be manufactured for regular use by the Railway Board or the Zonal Railways as the case may be. The centre shall make available specifications and details of suppliers or manufacturers and shall help in the evaluation of tenders.

The centre is not envisaging any hardware development work since it does not have the necessary infrastructure for doing this.

The centre shall impart training in System Development and Software to at least one or two staff from each wing of RDSO. The necessary courses are being organised. In addition, some courses are to be orientated towards general exposure to microprocessors, their use and operation by other staff of RDSO and zonal railways.

The centre has a strength of 6 officers and 4 staff. These posts are being filled. It is proposed to take up 12 projects in the centre, 4 having first priority and the remainder second or third priority. It is expected that the centre will be able to complete 12 projects per year in addition to the training programme, providing all projects are of a small or medium nature. Should the centre be required to take up large projects then the number of projects should be reduced accordingly".

In the subsequent discussion it became clear that one aspect of the statement is not realistic. The centre must be prepared to undertake hardware development and must establish the infrastructure to do so. In a number of cases it is necessary to develop instrumentation with signal conditioning and processing and the centre must be prepared to accept the associated hardware development.

3.3.1 Work of the Expert at Lucknow

The expert was presented with a very full programme of lectures and discussions as can be seen from the details below:

| Date | Time | Activity/Topic |
|---|---|---|
| 24.11.87. | 10.00 to 12.30 | Meeting with Directors |
| 24.11.87. | 14.00 to 17.30 | Discussion in MAEP Centre |
| 25.11.87. | 10.00 to 12.30 | Lecture - General Introduction to Microprocessors |
| | 14.00 to 17.30 | Discussion in MAEP Centre |
| 26.11.87. | 10.00 to 12.30 | Lecture - Optical Instrumentation |
| | 14.00 to 17.30 | Discussion with DR/DRT |
| 27.11.787. | 10.00 to 12.30 | Lecture - Realtime Monitors |
| | 14.00 to 17.30 | Discussion in TI directorate |
| 30.11.87. | 10.00 to 12.30 | Discussion in DEDO |
| | 14.00 to 17.30 | Discussion in E.Lab. |
| 01.12.87. | 10.00 to 12.30 | Discussion with TRRC group/DR |
| | 14.00 to 17.30 | Discussion with RM group/DR |
| 02.12.87. | 10.00 to 12.30 | Lecture - Design |
| | 14.00 to 17.30 | Library |
| 03.12.87. | 10.00 to 12.30 | Lecture - General |
| | 14.00 to 17.30 | Further meetings with TI and DEDO directorates |
| 04.12.87. | 10.00 to 12.30 | Discussion in MAEP Centre |
| | 14.00 to 17.30 | Meeting with director of DEDO. Initial work on report. |
| 07.12.87. | 10.00 to 12.30 | Further meeting with TRRL group |
| | 14.00 to 17.30 | Concluding session |

where DR = Director of Research
DRT = Director of Research, Track
TI = Traction Installation
DEDO = Diesel Engine Development Organisation
E.Lab = Electrical Lab. (Instrumentation)
TRRC = Track Recording and Research Car
RM = Research, Mechanical.

Indian Railways are to extend electrification so that the major cities of Delhi, Bombay, Calcutta and Madras are fully interlinked, and to utilise only diesel traction on non-electrified lines. The present locomotive stock is approximately:

| | |
|---|---|
| Electric | 1,000 |
| Diesel | 3,000 |
| Steam | 7,000 |
| Total | 11,000 |

These figures indicate that a considerable amount of work is to be done.

It is planned that the maximum running speeds should be increased to 160 $kmh^{-1}$ initially, and that a future increase to 200 $kmh^{-1}$ should be catered for.

The work of the expert in discussions and lecture presentation was concerned with the implications of this programme. It is necessary to measure and record the performance of track, overhead line equipment and bridges for safety, research and maintenance reasons and to improve the efficiency of traction for economic reasons. In the following sections there is an overall summary of the discussions. There were almost parallel discussions with various directorates, and no attempt has been made to identify particular directorates interests in this report, with one exception. It should be noted that the Signal and Telecommunications Directorate did not respond to an invitation to take part in discussions.

The short preliminary meetings between the expert and the various directorates was very helpful to the expert, and a fairly detailed report of those meetings is presented before the report of the more general meetings.

a. Preliminary Meetings.

Director of Structures, Track.
Requires the following developments:

i. A system for the dynamic measurement of track parameters. The system must use non-contact sensing techniques, and the sensors must be mounted on a running vehicle.

ii. Software for the planning and management of all relaying and maintenance work by suitably upgrading the existing track recording and automatic data collection system.

iii. A continuous track-force measuring system.

iv. A real-time system to clear three blocks ahead of the Rajdhani Express using real-time charting.

Director of Structures - Bridges
The following are required:

i. Vibration monitoring of steel girders and piers on older bridges, to give a continuous watch over their structural integrity.

ii. Automatic water level recording and future trend prediction for the forecasting of a possible occurrence of flood conditions. A telemetry system is required since the monitoring will be done at remote localities which are not manned.

Director, Formation Engineering.
Requires the following:

i. Automatic triaxial testing

ii. Development of data loggers

Director of Research and Director of Research-Track.
Require the development of contactless transducers for the measurement of lateral geometrics.

b. Follow-up meetings.
From the follow up meetings it emerged that data logging and associated instrumentation systems present many problems at RDSO. The following summary represents the problems which were discussed many times by the expert with different people.

i. Track Recording and Research Car (TRRC). In the past various instruments have been developed for track recording purposes. These use contact measurement techniques which will not be suitable with the higher speeds to be achieved in the future.

A particular problem relates to the measurement of the wheel position relative to the inside edge of the rail. A capacitive transducer has been tried but found unsuitable due to the debris and dust often encountered, and their effect on capacitance.

Two basic proposals were considered, one optical and the other inductive. Both methods have been used by other railway systems. RDSO has experimented with an inductive transducer and the expert recommended that they should continue with this development since they have no electro-optic expertise or equipment available at present.

The measurement of other track parameters such as gradient and curvative was also considered.

The proposed data logging system was discussed. To the expert it seemed very complex and he was able to demonstrate by me calculations that the required data rates could not be achieved under worst case conditions. Alternatives involving less data movement and distributed processing of data were discussed.

ii. Lateral and Vertical wheel stress measurements. It is required to make these measurements on a rotating locomotive wheel and to log their values. The ratio of the measurements can be used to predict the probability of a derailment.

An existing system takes transducer signals from the wheel using a rotary transformer. This technique is not desirable since it requires drilling of axles and wheel hubs as well as modifications to axle boxes. Possible solutions to the problem were discussed. These generally involved optics or radio telemetry to take signals from the wheel.

iii. Overhead Equipment Recording Car. The development of this recording car has been put out to tender twice, but with little success. The proposal is very ambitious involving the

instrumentation of pantagraphs on both the locomotive and recording car, and was rather confusing in its presentation as an invitation to tender. There is an additional complication since the tender document also requires the locomotive performance to be monitored.

As a result of discussions, the expert recommended that there should be three phases in the work.

1. Development of a coach with an instrumented pantagraph.There should be provision for logging coach parameters such as vertical acceleration and for a telemetry link to the locomotive.

2. Instrumentation of a locomotive pantagraph.

3. Instrumentation of the locomotive so that its performance may be monitored.

The expert believes that the data logging system for the TRRC should be suitable for inclusion in the overhead equipment recording car, and that the instrumentation of the pantagraph should not be difficult. He can see no engineering reason why the coach needs to be imported and believes it to be feasible for RDSO to instrument a coach modified by Indian Railways. The experience gained in doing this would be very valuable. The MAEP Centre should be able to act as overall managers for the development of the instrumentation if this is acceptable within RDSO.

iv. Structure Monitoring. The basic problems are that a bridge moves and vibrates under the weight of a moving train and that it experiences longitudinal stress and deflection under conditions of acceleration.

The movements of the bridge are generally small and must, in many cases, be measured at considerable distances above the ground. Some optical measurement techniques were discussed.

v. Diesel Engine Development (Specific to the Diesel Engine Development Organisation, DEDO). DEDO is a new facility which has been established with world bank assistance. It occupies new and high quality buildings within RDSO and makes good use of available technologies. Its primary objective is to improve the efficiency of diesel locomotives.

The facility has a VAX-750 computer with, in November 1987, eight terminals. There are proposals to upgrade the computer system by provision of more terminals, including graphics, a plotter and CAD software. The computer is to be networked with RDSO's VAX-780 when it is commissioned.

The DEDO computer is used for a variety of management functions utilising word processing and data bases. Typical data bases are for the storing of a cross reference record, details of books in the library, equipment on order and an index of drawings.

There are four engine test beds each having comprehensive instrumentation facilities and high speed data recording. The test beds are organised in two pairs with each pair having a PDP11-23

computer for data monitoring and some control facilities. A spare PDP11-23 is to be obtained. The PDP11's and VAX-750 are to be networked. DEDO has an instrumentation laboratory under development.

Within DEDO there is an awareness of possible applications of microprocessors in a Diesel Locomotive, particularly for data logging and the monitoring of performance. One project was seen by the expert. It was the development of a system to monitor the performance of a locomotive and to log the conditions and time when any abnormal operation occurs. While discussions were in progress it was proposed that the MAEP Centre should be involved in the software development of the system.

c. From the programme given above, it can be seen that a total of 5 seminars were presented. Each involved a total of $1\frac{3}{4}$-2 hours of lecture and discussion. Brief details are as follows:

i. General Introduction to Microprocessors.
There are very few microprocessor or computer applications either in use or under development at RDSO. Consequently managers, most of whom completed formal study several years ago, often have little concept of computing or microelectronics. The seminar was intended as an introduction to the subject for management and was intended to help answer the question "Can I use a microprocessor?"

ii Optical Instrumentation.
Many of the instrumentation problems at Lucknow are caused by the need for non-contact measurement. The seminar was intended to show what may be possible using optical systems.

The expert was asked if he could arrange for practical training of a member of staff of the MAEP Centre through a fellowship or some other scheme. He was able to confirm that he could make such arrangements, and that should it be necessary he could make a short follow-up visit to India to assist in development work.

iii. Real-Time Monitors.
An introduction to data logging with some discussion of real-time control included.

Problems such as sampling rate and memory capacity were considered in some detail. At all times cost considerations were included in the discussion.

iv. Design.
The seminar was intended to introduce the general principles of design methodology and project management. In the course of the seminar both reliability and maintainability were discussed.

It became evident to the expert that Indian Railways currently use equipment which has integrated circuits in sockets as well as plug-in cards and that there were problems due to poor reliability as a result. It was suggested that the quantity of electro-mechanical connections should always be minimised and that, for train borne equipment, the quality of necessary connectors should be high. Possibly military specification connectors would give less trouble.

v. General.
This was intended as a general session in which participants could raise any point they wished. The questions were few and were largely based on discussions which had been started earlier in the expert's mission at Lucknow.

Two points were raised at the request of the expert - these were:

Library usage: It had come as a surprise to the expert that little use is made of the Library at RDSO. The need for library use was discussed, and the importance of consulting literature at the start of any project, and periodically within the project was considered.

Concurrent Processing Systems: There is a considerable need for high speed operation at RDSO. One solution to the problem is to use parallel systems, and these were considered.

3.3.2. Other Activities of the Lucknow Centre

The technical advisory committee meeting held on 21 May 1987 contains a full report of work completed up to that date. They are listed as:

Track recording system
Ride quality meter
Vibration-cum-speedometer
Correlation Analyser
Real-time wheel force analyser
Automatic data processor
Random block generator
Microprocessor system for braking field trials.

In reviewing this list it should be remembered that the centre was started before the MAEP started and that some of these projects date back to the early days of the centre.

The report lists two projects in hand.

Development of a weld monitor
Development of a measuring wheel analyser

The first of these has been largely completed at the New Delhi centre and is now undergoing trials at the flat-bottom welding plant, Meerut. The second of the projects has worked using rotary transformers to extract useful signals, but a considerable amount of work remains if the rotary transformers are to be eliminated. The project will not be completed for several months. Some additional projects are now in hand:

Automatic recorder for weld geometry.

This, also, has been largely completed at New Delhi and is undergoing trials at Meerut.

Traction Station Monitoring Equipment.

This project is at a very early stage. It is intended to develop a microprocessor based relay to monitor the traction feeder current and voltage and to interrupt the supply if a fault condition is detected.

Feeder Station Power Factor Control.

This project is also at a very early stage. The purpose is to monitor the feeder current and voltage and then to calculate the reactive power. The processor is then to switch capacitors into or out of the circuit to minimise the power factor of the supply to the feeder station. It is necessary to investigate the switching of high current reactive loads using thyristors before this project can proceed far.

### 3.3.3 Courses operated by the Lucknow Centre

Since the Lucknow MAEP Centre was formed it has operated a number of taining courses. Details follow:

| Period | No. of participants | | | | Course Contents |
|---|---|---|---|---|---|
| | Rly | RDSO | Others | Total | |
| 24.10.85<br>4.11.85 | | 26 | | 26 | FORTRAN and 8085 Assembly Language |
| 18.11.85<br>3.12.85 | | 18 | | 18 | Microprocessor Basics and Applications |
| 30.12.85<br>3. 1.86 | | 7 | | 7 | Microprocessors - Practical Applications |
| 5. 2.86<br>11. 2.86 | | 6 | | 6 | Microprocessors - Peripheral and Controllers |
| 31. 3.86<br>4. 4.86 | | 9 | | 9 | Microprocessor-based TRS |
| 16. 6.86<br>27. 6.86 | | 7 | | 7 | Microprocessor-based Systems |
| 14. 7.86<br>25. 7.86 | 25 | | | 25 | Microprocesor Basics and applications |
| 16. 9.86<br>26. 9.86 | 9 | 3 | | 12 | Microprocessor Basics and Applications |
| 17. 3.87 | | 12 | | 12 | Microprocessor Basics and Applications |
| 22. 6.87<br>26. 6.87 | | 20 | | 20 | FORTRAN programming |
| 12.10.87<br>20.10.87 | 11 | | | 11 | Microprocessor Basics and Applications |
| 28. 1.87<br>29. 1.87 | | | | 200+ | Seminar-Microprocessors on Indian Railways. Held in New Delhi. |

The centre is planning the following courses to take it through 1988.

| Period | Participants | Course Contents |
|---|---|---|
| Dec.87 | C.Rly and W.Rly | Microprocessor Basics and Applications |
| Feb.88 | RDSO | Advance Course in Microprocessors |
| Apr.88 | S.Rly and SE Rly | Advance Course in Microprocessors |
| Aug.88 | NR and NER | Microprocessor Basics and Applications |
| Nov.88 | RDSO | Advance Course in Microprocessors |

## 4. CONCLUSIONS

In the relatively short time since the Microprocessor Application Engineering Programme was started very good progress has been made at some centres but other centres have developed more slowly. The reasons for the differences in the rate of progress are not easy to identify in a single short visit, but it is evident that there are many differences between the centres.

At the New Delhi centre, which has made very good progress, the following conditions apply:

i. Fairly good accommodation with ample space for equipment and people.

ii. Good equipment, except for hardware test facilities.

iii. A co-ordinator whose work is fully for the MAEP.

iv. Staff who are well qualified, usually with higher degrees which include training in research methods.

v. Staff who are reasonably content in their work and not likely to seek alternative employment in significant numbers.

vi. Staff whose training and experience is closely related to the work of the centre.

Not all of these conditions apply to other centres and consequently they cannot be expected to develop at the same rate as the Delhi centre.

The extent to which microprocessors and computers have penetrated Indian industry was difficult to gauge. Evidence of both good and less good features was seen, indicating a mixture of application standards as exists in many other countries.

Centres are not always able to assist industry in their region as they feel they should be able to. This is because they have specific activities allocated and they are unable to accept work not related to their specified activity. Considering the size of India, and the distane between the MAEP centres, now may be the time to allow centres to take on a wider range of activities. This applies particularly to centres where there is difficulty in obtaining staff whose expertise is related to the allocated activity.

The range of courses and training material available at the MAEP centre is commendable. There is co-operation between the centres in the operation of courses, but this could be increased. Centres are interested in extending the range of courses they offer. Co-operation in this could reduce the work involved. If each centre was to develop one new course and make full details of the course available to all centres then the total amount of work involved would be reduced. Detailed design work would be required and would involve handouts, tutor notes and experiments. There would need to be agreement between the centres about the courses to be produced and centres should continue to be free to develop courses involving their specified activity.

All centres visited had difficulties with instrumentation. These can only be overcome by recruiting staff with a specific expertise in instrumentation methods and by provision of development facilities so that novel instrumentation can be produced at the MAEP centres. Possibly the designation of one of the centres as a centre for instrumentation would provide initial experience in this work, which could then be used at all other centres. Until

the instrumentation problems are overcome there will continue to be delays in project work.

The work undertaken by some of the centres is at elementary levels and could be undertaken by most electronics undergraduates nearing the end of a degree course. Perhaps the development of closer links with higher education could be of benefit. Students could undertake the simpler designs, with some supervision from the centres, freeing the centres to undertake more advanced work. There would be a considerable benefit to the students if this could be done since they would be undertaking work with industrial relevance and so would be widening their own experience.

In many instances the staff of centres believe that they must use microprocessors in their designs. This is because the project is for Microprocessor Applications Engineering. In some cases the Microprocessor is not a cost effective device to use in a design and staff should be instructed that their designs do not have to involve microprocessors. With the development of Indian technology it is probable that new devices, such as the Application Specific Integrated Circuit (ASIC) will become available in India and that the scope of the programme will need to be widened. Perhaps a renaming to Microelectronic Application Engineering Programme would be of benefit.