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PAKISTAN

Technical Report: Introduction of Computer Aided Design to Heavy Mechanical Complex*

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

Based on the work of David Wadsworth, expert in
Computer Aided Design

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Vienna

* This document has not been edited.

EXECUTIVE SUMMARY

An initiative has been taken by HMC to introduce computer methods into their Design Office. As a consequence of this, the services of a UNIDO CAD consultant were obtained to :

- identify the hardware and software required
- assist in designing software for specific jobs
- train designers in CAD systems and procedures

FINDINGS

The project determined that the introduction of CAD into the HMC design office would produce many benefits. The major benefit would be that design specifications could be improved by :

- a more consistent method of approach
- a more thoroughly defined technical content
- better presentation, and a
- reduction of the required leadtime

These factors will, in time, produce additional benefits to the Comany in the form of improved :

- material and resource utilisation
- production efficiency
- quality assurance

These benefits can only be achieved by means of a determined investment and implementation programme as laid out below.

STRATEGY

The strategy for progress is

1 To develop a broad base of competent PC utilisation by vigorously pursuing a policy which includes computer education, staff training and project planning in order to acquire essential hands-on experience.

2 As a follow on from the previous stage, there must be a further investment programme of comparable size which builds on the experience gained in stage 1 and extends the design capability in terms of technical ability, volume throughput and database handling.

CONTENTS

ANNEXES

1 INTRODUCTION

This project was initiated in order to define the need for, and accelerate the progress of, the adoption of effective Computer Aided Design technology into the Design Department at HMC. Note: the abbreviation CAD is frequently used, but often misused, by various authors to mean different things. The "D" in CAD can be taken to mean Design or Draughting or sometimes both. The author of this paper has always adopted the view that CAD should be interpreted in the widest possible sense, that is "the use of computers to assist the Designer". Therefore any activity which the Designer undertakes in the process of defining a design specification, and which could well be improved upon by the application of computers, falls into the category of Computer Aided Design. CAD in this context is thus seen to embrace proposal preparation, analysis, modelling, visualisation, draughting, equipment listing, cost estimating, parts list preparation, and other relevant documentation used in the specification process.

This report provides the background to the use of computers in the Design Department at the start of the assignment. It then enlarges on the evolution of the strategy adopted during the the course of the assignment, the progressive accumulation of information and the identification of opportunities for further development.

The report provides observations on the state of the CAD supply industry in Pakistan and discusses those factors which are considered relevant in influencing the general adoption of CAD.

The report assesses the project achievements and makes recommendations which, if acted upon, will influence the future rate of progress.

2 RECOMMENDATIONS

The recommendations are that HMC initiate an investment programme in CAD. The investment should be in :

- hardware/software CAD systems
- people training and
- planning

Stage 1

The minimum investment in hardware/software should be to provide

5 CAD graphic workstations
3 non-graphic workstations
and supporting equipment

Total cost Rs. 1.90 million

The minimum investment in staff training should be

40 man-weeks CAD training for 10 staff.
40 man-weeks non-CAD training for 10 staff.
4 man-weeks hardware training for 2 staff.

Eighty percent of this training should be acquired from external sources. A minimum of 12 man-weeks should be allocated for sending two people to the UK for extensive practical CAD training.

Total cost Rs. 0.25 million

An investment should be made to purchase from the Engineering Industry Training Board (EITB), UK, their full suite of Engineering Design Open Learning Packages. See Annex 12

Total cost Rs. 0.05 million

Since there is a total absense of computer literature within HMC, It is recommended that an investment is made to purchase, on a regular basis, appropriate Trade literature including the following from the USA and UK

PC Magazine
PC Technical Journal
CADCAM International

Total cost Rs. 0.01 million

The minimum investment in planning during the first 12 months should be

30 man-weeks strategy and progressing.

100 man-weeks application program development.

200 man-weeks database creation and verification.

This investment is totally from HMC resources and will increase with each successive year in line with the rate of systems development.

Total cost Rs. 0.53 million

Total cost of stage 1 Rs. 2.74 million

Stage 2

The minimum investment in hardware/software should be to provide

2 Apollo based CAD graphic workstations

2 non-graphic workstations

and supporting networking equipment

Total cost Rs. 1.50 million

Staff training

Total cost Rs. 0.10 million

Trade literature

Total cost Rs. 0.01 million

Planning, data collection and verification.

Total cost Rs. 0.50 million

Total cost of stage 2 Rs. 2.11 million

3 BACKGROUND TO HMC DESIGN DEPARTMENT

HMC is part of the State Engineering Corporation, SEC, itself the largest group in Pakistan manufacturing engineering goods. It is located in Taxila some forty kilometers west of Islamabad. The turnover for the Company during 1986-87 was Rs 635 million, ie approximately $ 36 million. Some twenty percent of this income derived from the supply of cement plant and associated equipment, and thirtysix percent from the supply of oil field equipment. The complete distribution of revenue is shown in Annex 1. Some of the services supplied by HMC include turnkey projects which involve collaboration with leading national and international companies both within Pakistan and abroad. Those products where HMC provide a design, manufacturing and supply service include cement plant and equipment, sugar plant and equipment, boilers (including chemical plant and pressure vessels), cranes, steel structures of various types, water control gates and construction machinery.

An organisation chart for the Design Department is shown in Annex 2. This chart indicates the division of responsibilities. It should be noted that in many instances there is a high degree of interplay between the divisions where specialist design skills are mobilised to support composite plant or contractual requirements. This applies particularly in the area of boiler and structure design which always form an essential ingredient of sugar or cement plant requirements.

Two sections, that is, the electrical and the computer cell, act as service centres to the other sections as the need arises. In the context of this report, it is worth making a special note of the structure of the computer cell.

In January 1988 the computer department equipment consisted of one IBM PC computer, the full specification of which is shown in Annex 3. Certain software was also available and this is detailed in Annex 4. The computer cell staff consisted of one assistant manager and one junior programmer. These titles are slightly misleading, in that, neither of these staff had been trained in computer languages relevant to engineering applications. Both members of staff are of graduate status, one engineering, one arts, and have built up considerable experience from direct use of the available software.

4 STRATEGY FOR THE ASSIGNMENT

The terms of reference for the assignment are shown in Annex 5. The strategy adopted in order to achieve these terms of reference followed the following course:-

The project stages were identified and set out in the form of a Gantt, ie elapsed time, chart. A version of this chart is shown in Annex 6. It was appreciated from the commencement of the project that the elements within the chart, and the progress to be made against individual items would be modified both in the light of the information as it was accumulated and by the rate at which the information could be generated.

It should also be noted that the chart was modelled on the basis of experience gained in developed countries and therefore the rate of progress would be influenced by a series of indigenous factors which would reveal themselves progressively throughout the duration of the project.

The most significant influencing factors were seen to be :

- the degree of interest and motivation within the relevant staff
- the working cultures and practices
- the state of the supply industry
- the local procurement procedures

4.1 Interest and Motivation

It is not surprising to record that the degree of computer awareness encountered is lower than that which is prevalent in developed countries. The computer culture in Pakistan has only existed for approximately four years. For example, there is yet no indigenous Trade literature or magazine to promote the sale of computer equipment or the benefits of computerisation using illustrative case examples of successful implementation. The only case examples heard quoted in conversation refer to either bank applications or the PIA ticket/reservation system introduced some six months ago.

As a consequence, staff do not consider that the use of computers in Pakistan is sufficiently advanced to be relevant to their requirements.

4.2 Working Cultures and Practices

Pakistan has been the recipient of much foreign aid in variety of guises ie manufacturing plant has been erected by foreign personnel and much of the technology that is manufactured within the country has been imported. Therefore, there is little tradition within companies such as HMC to establish standards and procedures in their own house style. Designs and methods have been adopted from a wide variety of external sources and there is therefore less sense of ownership or cohesion about working practices than one would expect to find in a design organisation and supplier of original equipment. Maybe because of this staff are not used to making their own initiatives. There is a preference to be told what to do rather than to determine a solution for themselves.

4.3 State of Supply Industry

The state of the supply industry in Pakistan is far from satisfactory. A separate and parallel project, undertaken by the author, which surveyed software availability in Pakistan, identified less than ten different types of named engineering software. This compares unfavorably with developed countries where typically one would find lists of software extending into the hundreds or even the thousands. This aspect will be dealt with in greater detail in section 9.

4.4 Procurement Procedures

In a situation where the supply market is not well co-ordinated or defined and in which the software is developing rapidly on a world-wide basis, it is difficult to ensure that all reasonable sources of available software have been identified. The method chosen for this project was the Invitation to Tender, ITT, coupled with the proviso that HMC was not obliged to give reasons should a decision not to purchase subsequently be made. No apology need be made for adopting this approach, but it is quite at variance with methods used in countries where a structured supply industry exists.

The difference between the two methods of approach is shown below :

Method 1 Structured Market	Method 2 Unstructured Market - limited budget and - limited supply market
1 assess needs	1 draw up tentative requirements
2 identify opportunities and benefits	2 issue invitation to tender, ITT
3 assess budgetary requirements and potential return on investment	3 review and discuss with vendors
4 draw up specification of reqts.	4 benchmark likely suppliers
5 review and discuss with vendors	5 assess achievable benefits within financial restraints and supply market capability
6 benchmark likely suppliers	6 draw up specification and financial justification
7 issue ITT to shortlisted companies	7 make final selection
8 assess financial justification	8 instigate purchase
9 make final selection	
10 instigate purchase	

4.5 Evolution of the Strategy

It was against the background of the factors referred to above that the strategy for the project developed. In addition, a frequently quoted criticism of using international consultants is that there is little long term gain to the recipient company unless a satisfactory method is derived which enables a transfer of technological insight and understanding. Therefore, whilst the earlier weeks of the project were characterised by lectures, workshops and semi-formalised data collection exercises of existing activities and procedures, the latter stages of the project were characterised by 'one-to-one' discussions with senior managers. The objective was to identify small and achievable projects which could be implemented in a relatively short timescale making use of the computer facilities and staff already available. In this context the most valuable pieces of software proved to be Lotus 1-2-3, a spreadsheet package, and the Multimate word processing package.

In addition to this, other activities also concentrated on the establishment of basic drawing office management controls and the control and utilisation of computer and staff resources.

Hence, by these means, several advantages were achieved :

- the individual projects were recognised as being relevant and valuable
- they were achieved in a relatively short period of time
- they promoted enthusiasm amongst the design managers
- the computer staff were also more motivated since they were now being used in a creative role rather than just operators

In this context it should be noted that, a decision was taken to ensure that all application programs developed must be operated by staff from the user department concerned and not by the central computer staff.

The central computer staff would be retained :

- to train other staff in the use of the available software
- to develop application programs in line with departmental managers needs
- to maintain and develop the existing computer facilities in line with the organisational and administrative requirements

These initial steps were designed therefore to lay the foundations for a better educated staff which, as a result, would more readily appreciate the value of, and the management of, the more complex aspects involved in introducing computer graphics when these facilities were ultimately acquired.

5 IDENTIFICATION OF REQUIREMENTS

In order to establish those areas within the Design Department where opportunities for the effective use of computers could be identified, it was necessary to gather a wide variety of background information.
The information gathered was organised under two main headings :

- Company information
- Engineering organisation information

Company information

This information consisted of the following elements :

- Product catalogues
- Company income by product type
- Product policy and business objectives
- Market characteristics and penetration
- Investment criteria

Engineering organisation information

- Organisational structure and policy for engineering functions
- Design / manufacturing policy
- Numbers of staff involved in design, draughting and other engineering functions.
- Location and distribution of staff

Within each product group or organisational cell it was necessary to collect the following more detailed information.

- Sample documentation of drawings and product specification material
  - Proposals
  - General arrangement
  - Component details
  - Schematics, process flow and circuit diagrams
  - Technical illustrations
  - Parts list

- Volume of new drawings produced per annum
  - By size and type

- Volume of drawings modified per annum
  - Characterised by reason for change

- Time-based activity analysis for each functional group involved in engineering

- Total volume of drawings stored

- Part numbering system used

- Control documentation and procedures

The request for the above information was structured in such a way that the 'generation sequence' and 'the flow of design information from the proposal to commissioning stage' could be charted.

6. ANALYSIS OF DATA

In making the request for data, it was appreciated that few records were available which would enable definitive information to be provided. Most of the information regarding throughput volumes and activity analysis had to be estimated by individual managers. The results therefore can only be interpreted as indicative of the situation prevailing.

The purpose of collecting the data was to demonstrate the key activity areas so that a more detailed examination could be undertaken into situations where the application of computer resources showed promise, bearing in mind the markets ability to supply suitable tools.

The activity analysis showed that for the department as a whole, the activities that occupied eighty percent of the time utilised was as follows :-

Activity	Percent
New drawings	31.8
Modifications	12.7
Parts list preparation	10.6
Estimating	9.5
Information retrieval	9.2
Calculations	6.2
	80.0

A fuller analysis, showing the activities as they applied to each individual section is shown in Annex 7.

One of the more significant factors highlighted by the data collection exercise was the absence of any consistent part numbering system from section to section. Neither was there a formal method of recording and storing information. As a consequence, the retrieval of information proved to be a significant and time consuming problem.

An additional analysis of activities concerned the data flow through each of the departments, or sections, and the generation of specific working documents. Typically, the preparation of a specification, with sufficient detail to enable a design proposal to be submitted to a customer, would consist of the following:

Descriptive specification
Calculations
Cost estimate by equipment type
Layout

Thereafter, if an order was placed by the client, a full design specification would be generated and, in addition to the above, would include many of the following elements:-

Equipment sheets
Calculation sheets
Layouts
Layout drawings
Manufacturing drawings
Parts list
Installation drawings
Manuals
Foundation drawings
Piping drawings
Motors list

An example of a data flow diagram for one section is shown in Annex 8.

7 ANALYSIS OF OPPORTUNITIES AND BENEFITS - GENERAL

7.1 General requirements

The data collection exercise showed up many of the difficulties currently associated with information retrieval. Significant improvements could be made by the introduction of an all embracing part numbering system. The benefits of introducing a system in which the part number contains meaningful associative data has many advantages which would be evidenced in a number of ways :

- drawings could be associated with the section generating them
- drawings could be associated with the relevant equipment or service type
- design sequences could be established
- the status of drawings would be immediately evident. For example, a drawing might be associated with a proposal, an installation or a production requirement.

7.2 Retrieval of information

The time activity analysis indicated that nearly ten percent of staff time was spent on information retrieval. Much of this time was used in searching for information associated with specific projects. The current system relies on peoples memories and the ability to persevere with a search through relevant records. Where a search is not conclusive, "new" components may be designed unnecessarily leading to wasted effort.

In addition to having associative information represented within the drawing number, it is also possible to incorporate, within the computer database, other attribute data which further facilitates the search for information. Typically, this attribute data would define some performance criteria such as equipment power, size, weight, etc.

Using such a system would further enhance the retrieval of design information for specific purposes. This feature would be particularly useful in situations where different sections within the design department have to design equipment of a similar type. For instance, conveyors, tanks, vessels and fans are designed in different sections, eg sugar and cement, and the present method of accumulating data does not always guarantee a sufficient interchange of knowledge about these products.

7.3 Equipment classification

There is a need to maintain records for all similar equipment designed in HMC regardless of which functional group designs it. In the longer term it is anticipated that the new part numbering system will satisfy this requirement. In the short term it will be beneficial to create a single independent database for each type of equipment making use of the new part numbering system enhanced by further attribute data which will facilitate the cross-checking of equipment designed in other sections. Once all the equipment has been categorised, a further exercise should be initiated to rationalise and modularise the design assemblies and subassemblies. This would be a valuable pre-requisite prior to committing designs to a CAD system. The advantages to the company would be many and would include the following:

7.3.1 The retrieval of information would be smooth and efficient

7.3.2 Design time would be saved by the elimination of replication within the various departments

7.3.3 Special designs would only be authorised where seen to be essential, but in any case would be reviewed in the light of the new specification fitting into a preferred range of performance criteria

7.3.4 Procurement and manufacturing resources would be simplified and this would further impact on production leadtimes and stock holding requirements

7.4 Formalised letters

There are a number of standard formal letters which could readily be formatted onto a word processor. Work has already commenced and it is expected to be completed within the next few weeks. The benefits to be gained by using computers in this context is to ensure that all essential factors have been given due consideration and that information is presented in a structured and consistent manner.

7.5 Comparative supplier analysis

All sections within the design office are involved in preparing comparative statements which assist in the analysis of supplier responses to invitations to tender. Spreadsheet software can be used very

effectively to layout this information in a consistent format on a single sheet of paper. This formalised presentation enables immediate and more meaningful comparisons to be made and allows managers to make more effective decisions more quickly.

7.6 Cost estimates

At present there is no formalised record of sales contracts and prices. It is recommended that the each section liaise with the Sales department in order to agree a mutually satisfactory contents and format for a localised database for these products.

The advantage of such a system will be that :

7.6.1 Information retrieval of previous sales history will be accessible in a predetermined format

7.6.2 Much of the information required for future contracts will be readily generated in the form of check lists and trend analysis

7.6.3 Staff in separate departments will be working to the same rules and expectations

7.7 Purchase records

There is a need to develop and maintain records of purchased items to assist with the preparation of cost estimates. Such records would indicate the item cost, the source of purchase, the project destination and the date of purchase, together with other information considered relevant. The first requirement is for materials to be treated in this manner. However the number of records involved is extensive and would not present a suitable application for a design based computer. It would be a practical application for a commercial computer since it would tie in with the inventory and production management systems.

The second requirement is for equipment to be treated in this manner. Work should be actioned now to determine the extent of the lists involved and to agree between Purchase, Design and Production departments the requirement for the format, the maintenance and the access to information needs before determining the most appropriate treatment for such a system.

8 ANALYSIS OF OPPORTUNITIES AND BENEFITS - BY DEPARTMENT

Following the generalised data collection exercise, it became possible to investigate in some detail the individual requirements of each section. Each section will now be dealt with in turn.

8.1 Cement

The Cement department has already made a useful start on the road to computerisation, in that the cost estimates are now being processed. This has dramatically reduced the preparation time from as much as one month down to a few days. The next stage is to prepare process flow diagrams as soon as a system becomes available. The preparation of process flow sheets is time consuming and typically takes thirty to forty days to execute. Some considerable effort would need to be expended to prepare the necessary library of equipment symbols to agreed international standards. However, once this has been accomplished, the preparation time for proposals will be as dramatically reduced as that demonstrated in the preparation of cost estimates.

A further development would be to link this information, in a suitable form, to generate mimic diagrams for use in the cement plant control room.

An opportunity exists to simplify the preparation of equipment lists within the specification of requirements. These lists consist of a large number of standard formatted data sheets for different types of equipment including motors and controllers. This would be an ideal application for database software and a start could be made on this right away.

8.2 Sugar

The Sugar department commenced the use of computers by using the word processing package to prepare descriptive equipment specifications for proposals. This has been highly successful and has reduced the preparation time has been significantly reduced.

A proforma for the preparation of cost estimates has also been prepared and currently a data collection exercise is in progress in order that estimates may be compiled using database software. It is anticipated that the use of this software will make equally dramatic savings as that indicated above.

The other two elements of the proposal are the site layout and the process flow diagram. Both these require CAD, and AutoCAD software would supply the necessary tools. This process would provide valuable savings once the necessary standard equipment symbol library, compiled to agreed international standards, has been prepared.

Following receipt of an order, the design requirements increase in magnitude. The first requirement is to produce voluminous manufacturing drawings. A PC computer based system would not be suitable for this application. A much larger configuration, such as an Apollo workstation system networked with intelligent PC's would be required for this purpose.

The second requirement is for the visualisation of the complete plant design and the preparation of all pipe routing and pipework details. This is a specialist requirement which demands expensive software and significant computing power. It is not recommended that these two requirements are contemplated in the initial phases of introducing CAD. Experience should first be built up in relatively simpler applications and provide time for the supply market in Pakistan to become more sophisticated.

8.3 Boiler Section

The following notes indicate those areas most suited to assist in the design of boilers.

8.3.1 As with other sections, there is great value to be obtained by creating cost estimates on the computer. This would complement the proposal specification, the preparation of which is already being processed on the computer. A proposal specification can now be created much more rapidly.

8.3.2 The processing of boiler production drawings on a CAD system is not considered to be a first priority. It is recommended that experience be gained in other areas and in the preparation of proposal layouts as a first step. Proposal layouts could readily be handled using AutoCAD software in the initial stages once a suitable library of symbols had been established.

8.3.5 There is a need to locate suitable specialist software to assist with processing design calculations, such as thermal analysis, for

pressure vessels
piping
boilers
storage tanks
heat exchangers, etc

Unfortunately, software of this type is not available in Pakistan at the present time.

8.4 Crane section

The crane section had had a previous attempt to place proposal specification sheets on the computer. For a variety of reasons their use had been suspended. With a more critical appraisal of requirements it has been possible to reassess the usefulness and the benefits to be gained by adopting a more disciplined approach. In parallel with this, a format for the price estimation sheet was developed which not only acts as an effective check list, but also carries out the necessary extension to the figurework. This development has produced immediate benefits. Additionally, as data begins to accumulate from this proposal work it will be possible to build up composite data files of sales information and to analyse the data for different design criteria and customers. There are a number of standard proformas which can be developed to cover a variety of requirements, including

- standard terms and conditions
- general product descriptions

In line with the experience of other sections, each proposal is accompanied by a drawing. These general layout drawings could readily be effected using AutoCAD software and would reflect the build-up of modular sections into a functional and purpose-built design. The library of modules would take some time to establish and would need to cater for approximately eighty percent of the requirements before being of practical use.

8.5 Structures section

The structure section prepares designs for a wide variety of unique designs. There are two areas of interest where computers might be used effectively. The first area where computer assistance can be provided is in the use of frame analysis and finite element analysis programs. Such programs are available, they require a sound understanding of structural analysis techniques and a thorough training in the use of the software. Exploratory action has been initiated to acquire this training.

The advantages in using such analytical tools are not to found directly in terms of design office productivity. Any time "saved" in the design office is likely to be reallocated to exploring further design conditions in the pursuit of the creation of a more optimal design. The reward for this effort should evidence itself as a more cost effective design solution in terms of:

- material utilisation
- production efficiency
- quality assurance criteria.

A second application area for structures is the use of graphics for proposal layouts. Here AutoCAD could be used to great effect in illustrating:

- Typical foundation details and anchorage systems
- Typical bracing details
- Important joint details
- Typical trusses and roof designs
- Stairways, walkways, handrailing, etc.
- General notes

A library of representative symbols should be developed progressively. After creating the standard library of typical details, AutoCAD could be very effectively used to produce the following drawings :

- main assemblies of steel frame structures
- individual member detail drawings
- foundation layouts
- part lists

8.6 Electrical

The Electrical section works as service department to the other departments and receives detailed requirements appropriately. The nature and variety of the work undertaken by this department lends itself admirably to the use of CAD. CAD could be used on all elements of the design process. The basic elements of each design consist of:

8.6.1 Circuit diagram - which is typically a single line diagram as per the functional requirement of the contract.

8.6.2 Wiring diagram - developed from the circuit diagram, following the best engineering practice, to provide easy handling of documents to satisfy both the customer and the erection engineer. The symbology used is dictated by the owner of the technology, but must present an unambiguous representation for interpretation by different agencies.

8.6.3 Assembly layout diagrams - to satisfy the mechanical design and planning requirements.

8.6.4 Tender specification of equipment - used to analyse local bought out components and reference technical brochures and literature.

8.6.5 Bills of material and parts - to be extracted directly from the site layout plans which detail cable routes, cable tray routes, service line routes,etc.

8.6.6 Extended assembly details - arising from the finalisation of the BO materials and parts for fabrication, installation, commissioning and maintenance.

8.6.7 Operating / maintenance manuals - detailing the normal operational procedures and the demands for periodic and preventative maintenance.

All the above requirements present ideal opportunities for the application of CAD and a simple 2D system such as AutoCAD would satisfy the requirements. It is recommended that the Electrical section is specifically targeted for the introduction of CAD. Work has already started on the specification of a program whose purpose is to act as a check list within the original specification. It will then be developed to provide a comparative analysis of supplier responses to the requirements.

8.7 Control Gates

This section is already using computer for design calculations and has carried out one project. They have now started a second project using the same techniques. The time saving achieved so far for the computational requirements is more than seventy percent, inspite of the fact that a considerable amount of iterative calculation work has to be undertaken to arrive at an optimal design and that all the work carried out by this section is associated with one-of designs. Word processing can be used to assist with preparation of bills of quantity.

In the future the use of finite element modelling would enable even more optimal designs to be derived and could be associated with solid modelling techniques to provide better visualisation and analysis.

9 EXTERNAL FACTORS INFLUENCING THE ADOPTION OF CAD

The external factors influencing the adoption of CAD consist of :

- Market support and
- Market motivation

9.1 Market Support Characteristics

Various aspects of the market support will be discussed under the following headings:

9.1.1 Hardware

In general, PC hardware is easy enough to obtain - most of it is IBM compatible, manufactured in the Far East and "dumped" without properly structured outlets or support. Several small companies are being created who are prepared to maintain hardware, although their preference is to support only what they sell.

Processors larger than PC's are difficult to acquire and it is even more difficult to obtain appropriate maintenance support for them. For instance, American companies do not export directly, therefore equipment arrives in Pakistan via third party agents who basically just operate as shipping agents.

The larger computer manufacturers such as IBM, ICL and Wang direct their activities towards the commercial market.

Therefore, any computer aided engineering activity has to be carried out on PC's apart from a few exceptions where the demand for sophisticated engineering analysis has been established. Access to these facilities tends to be highly priced.

9.1.2 Software

It is notable that the selection of demonstrable software for engineering design is minimal. It appears that less than ten named packages are available for sale or are being used within industry. This list includes four named computer aided drafting, CAD, systems and no computer aided manufacturing, CAM, systems. This should be compared with directories of several hundred packages to be found in European countries and America.

There are no Pakistan based computer magazines which promote the sales of software and describe successful applications. Magazines are used in other countries to identify sales outlets and to publish articles describing user achievements or the advantages and disadvantages of various systems.

Software that is sold in Pakistan can only be acquired after reading sales literature. It is not normally possible to see software demonstrated prior to purchase. In one exceptional example that has been noted, the company concerned had sent two of their staff to England to see software demonstrated prior to placing an order. In Europe and America it would be considered standard practice to attend a demonstration of software prior to its purchase.

With the exception of two CADCAM vendors, namely PAFEC and NORSK DATA, the majority of engineering software in Pakistan has been pirated. As a consequence, the effective use of software is heavily dependent on personal motivation since there are few training schools and few software manuals available. However it should be noted that even where software manuals are available, their use is not always effective since many staff do not possess the requisite understanding of the English language.

Most of the software used in Pakistan has been pirated from abroad, brought by people who may or may not have received adequate training. As a result, the software is frequently out-of-date with the latest release.

Many companies develop their own software, which gives rise to a wide range of small undocumented programs of doubtful quality which may or may not be capable of providing an adequate service to the user population.

9.1.3 Training

Since the majority of software in use has been pirated, personnel have to teach themselves how to use the software. Some commercial organisations have sprung up to try to fill the vacuum of knowledge, but their knowledge is scant and not directed to any particular technical sector of the market. Neither is their knowledge directed towards any particular application or professional group.

Doubt has been expressed as to the ability of universities or colleges to fill this gap - there seemed to be too few of them with too few facilities.

The most significant training has been acquired from abroad. However, there seems to be a general consensus of opinion that of the many who went abroad for training, too few have come back to use and disseminate the knowledge so gained.

9.1.4 Financial

Although there are many institutions willing to invest money in high technology, the majority of finance is directed towards creating plants to manufacture products not previously manufactured in Pakistan. Little demand is made for money to invest in "enabling technologies" and what demand there is, faces stiff competition from other investment programmes.

9.2 Market Motivation

In order to have a strong vibrant technological thrust, certain factors need to be at work within the market to stimulate the process. These stimulating factors would include the following:

9.2.1 Customer Demands

From the information collected there is little evidence to suggest that either the private customer or the Government procurement authorities are placing demands on consultants, designers or manufacturers to demonstrate their use of advanced enabling technologies in an effective manner.

9.2.2 Indigenous Design

HMC is one of only a few companies located in Pakistan who undertake original design. Most products manufactured in Pakistan are either of a repetitive nature with little new associative design technology or are manufactured under some licencing agreement whereby the original design is imported and only minor changes are made to products for either the home market or for re-export.

Therefore the stimulus for the application of advanced technology systems stems from major capital expenditure programmes as evidenced by highway, civil construction and energy resource development. This process has so far failed to attract vendors of sophisticated technological aids such as CAD.

9.2.3 Foreign Aid Programmes

Although Pakistan has been the beneficiary of many foreign aid programmes, too little of the associated technology has been assimilated within the fabric of Pakistan's skills profile. This has been due to a lack of simultaneous indigenous development. The only positive motivation arises when foreign consultants, working in conjunction with indigenous expertise, insist on the use of technologically based skills or, when local consultants are used in their entirety.

9.2.4 Standardisation Authorities

There appeared to be scant evidence that authorities were being established in Pakistan to provide appropriate Quality Assurance Standards either within the consumer market or in the supply industries which would impact upon the need to implement enabling technologies such as CADCAM.

9.3 Market response to ITT.

An invitation to tender for hardware and software was published in the national press. The closing date was 2nd May 1988 and a summary of the market response is given below.

9.3.1 Hardware

Of the eleven companies who responded to the ITT for hardware, only eight satisfied the contractual requirements, and of these only six companies provided a comprehensive range of equipment for consideration. A comparative statement arising from the ITT is shown in Annex 9.

9.3.2 Software

The response to the ITT for software was extremely disappointing and is shown in Annex 10. Only four companies responded, and only two types of 2D drafting software were offered. Since the price variation between the two differed by a factor of seven, the only viable offering appeared to be AutoCAD. It was noted that insufficient literature was made available with the tenders to enable a satisfactory judgement to be made regarding the attributes of the software offered.

9.3.3 Benchmarking

Prior to the purchase of any hardware or software, it is recommended that the system is demonstrated in a representative environment using representative company data. An approach to benchmarking is shown in Annex II.

10 FUTURE STRATEGY

In arriving at a satisfactory basis for future action the following considerations have been taken into account :

- The type of work processed and procedural methods used by HMC
- The budgetary restraints
- The state of the supply market
- The rate at which experience is likely to be assimilated

These factors will be discussed in the following paragraphs

10.1 Work and procedures

The nature of the work undertaken by HMC indicates that significant benefits can be obtained in all sections by using the following type of software :

Word processing
Spread sheets
Database
AutoCAD

for many applications including the following :

Project specifications
Cost estimates and specification check lists
Formalised letters
Equipment classification lists
Project history records
Comparative analyses
Equipment purchase records
Electrical schematics, circuit diagrams, etc
Equipment and site layout diagrams
Proposal layouts
Standard construction and foundation details

10.2 Budgetary constraints

Within the monetary restraints it has been possible to rationalise the proposed equipment in such a way that they match the initiatives which would be most fruitful for HMC to pursue both in the short and in the long term. The objective in deriving the equipment configuration is to :

- encourage a more systematic procedural approach towards the production of proposal specifications which will lead to :
  - greater consistency of approach
  - improve technical content
  - better presentation
  - reduced response times

  all of which should enable HMC to instill greater confidence amongst their potential clients and thereby win more orders.
- encourage the highest level of managerial involvement in order that the initiatives and enthusiasm required to make effective use of computer methods may be progressively appreciated and disseminated.
- lay the foundation for the second phase of computerisation which will address the volume production work within the design office.

10.3 The supply market

It has been demonstrated that currently the supply market is only able to supply and maintain relatively less sophisticated CAD tools both in terms of software and hardware. This factor influences the potential for satisfying volume/production design work. However, this factor can be turned to advantage in that it enables HMC management to focus on the strengths of the software and hardware available and match that strength to the procedural requirements of the company.

The situation should then be reviewed in six to twelve months time to determine the next investment programme which will be influenced by :

- the development of the supply market and its ability to support more sophisticated CAD tools.
- the rate of assimilation of computer methods within HMC.

10.4 Experience build-up

HMC management must agree, and follow through, a formalised approach to computerisation. This structured programme should encompass a rigorous approach to :

- information generation and data flow
- procedural methods
- staff training using available external and internal resources
- computer utilisation in respect of time and application

11 PROJECT PROPOSAL

The proposal is that HMC invest in a CAD system based on intelligent workstations and network to enable access to a common database.

Stage 1 investment should consist of :

11.1 Hardware and software

Hardware, as specified in the invitation to tender, which will provide an installation configuration of :

1 File server and database
5 CAD workstations
3 Non-CAD workstations
1 A0 plotter for sheets and rolls
1 Hard disk
1 Tape backup
4 Printers

Software :

Multimate	wordprocessing
Lotus 1-2-3 and/or Excel	spread sheet
Dbase III+	database
AutoCAD	2D drafting
SAP86	finite element analysis

All of the above should be subjected to maintenance agreements in order that the equipment may be kept in proper working order and that the software may be updated with a latest enhancements.

Three suppliers of hardware should be shortlisted for close scrutiny, namely

Time and Tune
East West Systems and
Paramount Engineering Services

and two suppliers of software, namely

Yasir Brothers and
Computer Graphics and Systems

11.2 The distribution of equipment should be as follows :

1	File server	Computer section plus all other sections to share
1	CAD workstation	
3	Non-CAD workstations	
1	Plotter	
1	Hard disk	
1	Tape backup	
2	CAD workstations	Electrical dept.
1	CAD workstation	Sugar dept.
1	CAD workstation	Cement dept.

11.3 Suppliers and internal computer staff should be used to ensure adequate initiation and follow-up training

11.4 The situation should be reviewed at six monthly intervals to determine the need for additional investment.

Stage 2 investment should consist of the addition of a significantly powerful workstation of the Apollo type networked to the equipment acquired in stage 1.

12 CONCLUSIONS

The report concludes that there are many significant advantages to be gained by HMC from the extensive use of computers within the design office, and that an investment in hardware/software systems, people and planning should be made immediately.

The external investment in hardware, software and training should be of the order of 2.5 million rupees in the first twelve months.

The internal investment in planning, strategy development, database creation and verification should be in the order of 330 man weeks during the first twelve months.

13 ACKNOWLEDGMENT

The author of this report would like to express his appreciation for all the help and co-operation that he received from HMC staff during the course of this assignment.

In particular he would wish to name the following staff :

N. A. Bhatti, General Manager (Co-ordination), Project co-ordinator for this assignment, for his help and wisdom in carrying out the relevant duties.

Zahoor Ahmed, General Manager (Engineering), for his enthusiasm in co-ordinating the design facilities.

S. M. Haider, Manager (Design Structure), for making the project run so smoothly and arranging so many day-to-day requirements and facilities.

N. A. Salmaan, Assistant Manager (Design Computer), for his very considerable expertise and assistance in arranging the appropriate computer facilities and arranging and attending so many meetings with relevant design personnel.

Saadullah, Junior programmer (Design Computer), for his detailed assistance with the transcription of so much data onto computer files.

and to the many other members of HMC staff who gave so freely of their advice and contributed to the success of the project.

ANNEX-I

PERCENTAGE CONTRIBUTION TO SALES TURNOVER BY PRODUCT TYPE

PRODUCT	1985-86	1986-87
CEMENT PLANT COMPLETE	42.57	17.73
EQUIPMENT		2.68
SUGAR PLANT & EQUIPMENT	7.93	16.61
BOILERS	3.22	4.08
CRANES MOBILE	2.32	0.83
E.O.T.	3.26	1.03
RAILWAY AXLES	2.14	0.47
SCREW JACKS & COUPLINGS	0.14	-
ROAD ROLLERS	10.56	4.92
DEFENCE EQUIPMENT	1.94	0.61
DISTILLERIES	5.31	-
LPG TANKS	-	0.40
STEEL STRUCTURES	5.18	9.01
OIL FIELD EQUIPMENT	4.58	36.39
MISCELLANEOUS EQUIPMENT	10.85	5.24
TOTAL	100.00	100.00
VOLUME IN RS. (000's)	332,354	635,331

HMC

DESIGN & TECHNOLOGY DIVISION

ORGANOGRAM

02 NOV 1987

ZAHOOR AHMED
GENERAL MANAGER

SUGAR PLANTS	SUGAR EQPTS.	M'SC. EQPTS.	CEMENT PLANT	CEMENT EQPTS.	CONSTRUCTION MACHINES	BOILER PR. VESSELS HEAT EXCHANGER	STEEL STRUCTURES	COMPUTER CELL	ELECTRICAL
TARIQ MASOOD MANAGER	KHURSHID AHMED MANAGER	RANA SALEEM MANAGER	SABIR HUSSEIN MANAGER	AHMED SAJJAD MANAGER	ABDUR-RAUF MANAGER	M.A. FIDA' MANAGER	S.M. HAIDER MANAGER		
ON DEPUT. TO DEMAN		ON DEPUT. TO BIN-QASIM							
MUBASHIR AHMED D.M			AHMED DIN D.M.	MUMTAZ D.M	FAIZ D.M.	SHAFIQUE D.M.	MOHD. SHAREEF D.M.	ABDUR-RAZZAQ D.M.	ZAHOOR HUSSEIN D.M.	AMIN-ULLAH D.M.	SHUJA D.M.	MAHMOOD QURESHI D.M.	ARSHAD SALEEM D.M.
MUNAWAR A.M	MOHD RASHEED A.M	FAIZ MOHD. A.M.	NAFEES A.M.	SHAUKAT HUSSEIN A.M.	SHAFIQUE A.M.	ASSAD ULLAH A.M.	QASIM SHAH A.M.	SULTAN A.M	AQEEL A.M	ASHRAF GHAI A.M.	JAWAD KHATTAK A.M.	MOAD HUSSEIN A.M.	MAJEED A.M.	IRSHAD MIR A.M.	NASEER SALMAAN A.M	SHAHID KHALIL A.M.	ATTAULLAH JAN A.M
				ON STUDY LEAVE		ON STUDY LEAVE				ON DEPUT. TO BIN-QASIM				ON DEPUT. TO BIN-QASIM		ON STUDY LEAVE	
M ABBAS D.D.MAN			AMIR-ULLAH D.D.MAN	MOHD. ANWER D.D.MAN	AHMED KHAN D.D.MAN									ZARGHAM D.D.MAN			

ORG/CHART

HARDWARE AVAILABLE IN HMC DESIGN OFFICE

January 1988

1.	IBM XT Computer		1 off
	CPU	8088	
	Coprocessor	8087	
	RAM	640 KB	
	Color graphics screen with adapter		
2.	Dot Matrix printer		1 off
	with draft NLQ and proportional printing		
	Speed	200 cps Draft	
		67 cps NLQ	
	Paper size	7.17 to 16 inches	
3.	X Y Plotter		1 off
	Effective plotting area	350 x 260 mm	
	Plotting speed	180 mm/sec	
	Step size	0.1 mm/step	
	No of pens	8	

Annex - 4
SHT 1 of 3

SOFTWARE AVAILABLE IN HMC DESIGN OFFICE

January 1988

	VERSION	MANUALS	PURCHASED ON
WORD PROCESSING			
Multimate advantage	Ver 3.6	Yes	Early 87
DATA BASE			
Dbase 111		Yes	Late 85
No of fields per file 128			
No Limit to no of file which can be interlinked			
Max 10 files can be open at a time			
RBASE		Yes	Early 87
No of fields per file 40			
40 files can be interlinked			
Use is very easy because of being menu driven. Even custom menus can be created.			
Power Base	Ver 2.2	Yes	Early 87
Very slow in operation. Can not be programmed for custom use. Totally menu driven.			
To be replaced by Dbase.			

SPREAD SHEET		
Lotus 1-2-3	Ver 2.01	Yes
PROJECT MANAGEMENT		
Pert Muster		No
Microsoft Project		No Late
GRAPHICS		
Autocad	Ver 2.18	No Late 86
(Tutorial book available)		
FINITE ELEMENT ANALYSIS		
SAP 86	Ver 3.5	Yes End 87
LANGUAGES		
Basic		Yes
Fortan 77		No
Pascal		No
Cobol		No
C		No
Logo		No

TRAINING IN COMPUTER BASED APPLICATIONS

Up to January 1988

	STAFF	COURSE	DURATION
1.	N. A. Salmaan	Applications of computer in structure analysis.	5 Days.
2.	Aminullah	Basic language.	8 Weeks.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

1 June 1987

Project in the Islamic Republic of Pakistan

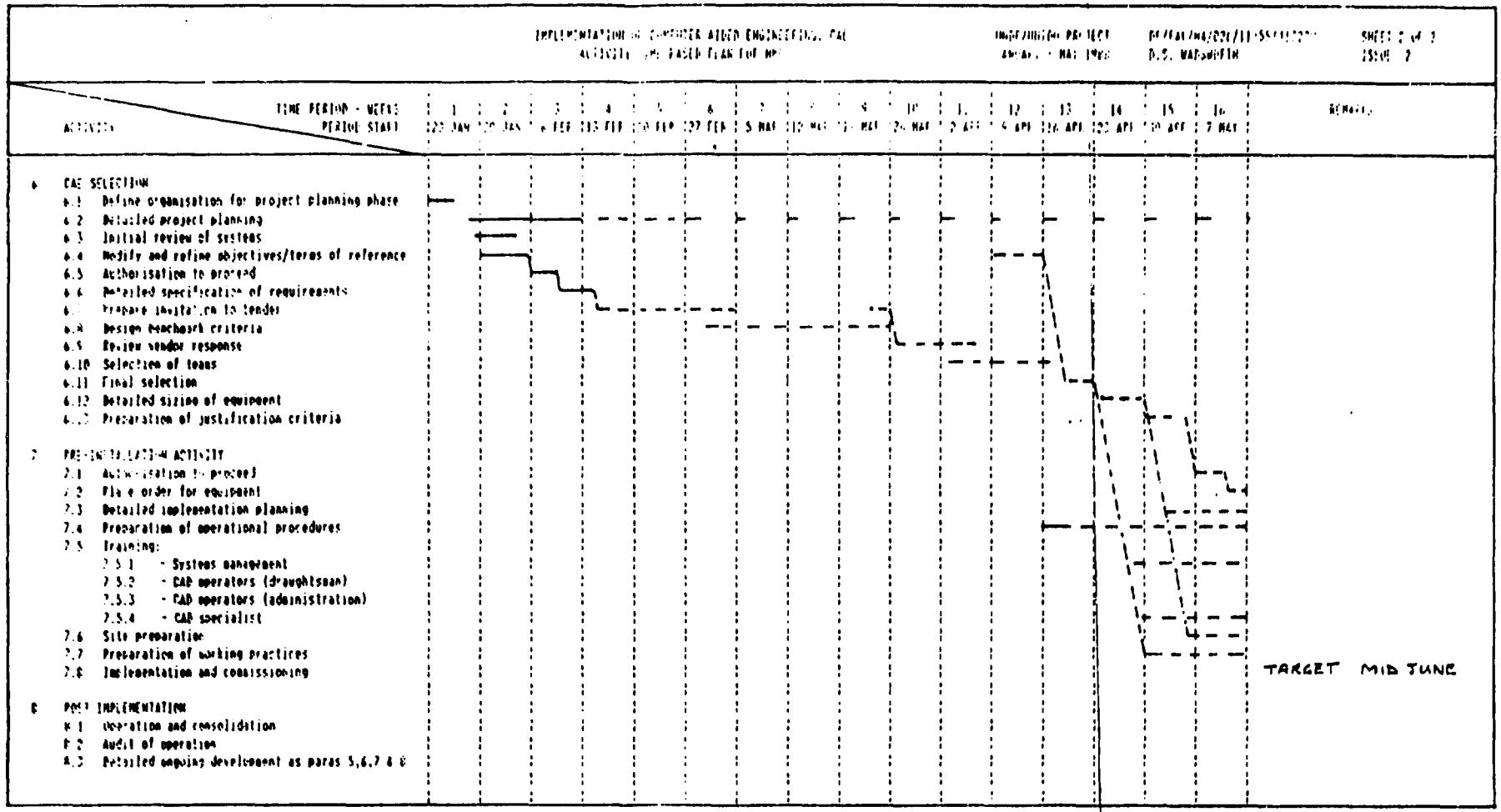
JOB DESCRIPTION

DP/PAK/84/026/11-55/J13208

Post title	Expert in Computer Aided Design (CAD)
Duration	4 months
Date required	As soon as possible
Duty station	Taxila
Purpose of project	The purpose of the project is to introduce a CAD system at the Heavy Metal Complex (HMC) using available software.
Duties	The expert should: (a) Identify hardware and software required for CAD system, keeping in view the present and future requirements of the company; (b) Assist in designing software for specific jobs; (c) Train HMC designers in CAD systems and procedures. (d) Prepare a report.

V.87-85934
3827T

Applications and communications regarding this Job Description should be sent to
Project Personnel Recruitment Branch, Department of Industrial Operations
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. Box 300, Vienna, Austria


ACTIVITY
TIME PERIOD - WEEKS
PERIOD START
1 23 JAN
2
3 6 FEB
4 13 FEB
5 20 FEB
6 27 FEB
7 5 MAR
8
9
10 26 MAR
11 2 APR
12 9 APR
13 16 APR
14 23 APR
15 30 APR
16 7 MAY
REMARKS
6 CAE SELECTION
6.1 Define organisation for project planning phase
6.2 Detailed project planning
6.3 Initial review of systems
6.4 Modify and refine objectives/terms of reference
6.5 Authorisation to proceed
6.6 Detailed specification of requirements
6.7 Prepare invitation to tender
6.8 Design benchmark criteria
6.9 Review vendor response
6.10 Selection of teams
6.11 Final selection
6.12 Detailed sizing of equipment
6.13 Preparation of justification criteria
7 PRE-INSTALLATION ACTIVITY
7.1 Authorisation to proceed
7.2 Place order for equipment
7.3 Detailed implementation planning
7.4 Preparation of operational procedures
7.5 Training:
7.5.1 - Systems management
7.5.2 - CAD operators (draughtsman)
7.5.3 - CAD operators (administration)
7.5.4 - CAD specialist
7.6 Site preparation
7.7 Preparation of working practices
7.8 Implementation and commissioning
8 POST IMPLEMENTATION
8.1 Operation and consolidation
8.2 Audit of operation
8.3 Detailed ongoing development as paras 5,6,7 & 8
TARGET MID JUNE

Design Division Activity Analysis, Comparative Data

Department	Cement		Sugar		Boilers		Cranes		Structures		Electrical		Cont. Gates		C. Machines	
No. of Staff	26		24		13		12		9		8		5		2	
Priority	Activity	%	Activity	%	Activity	%	Activity	%	Activity	%	Activity	%	Activity	%	Activity	%
1	ND	34	ND	24	ND	37	ND	27	ND	48	ND	30	ND	44	PTS LST	22
2	MOD	17	In. RET	20	MOD	13	Trace	13	MOD	12	MOD	14	Other	14	ND	21
3	EST	15	MOD	14	B. DES	11	PTS LST	13	EST	11	EST	8	PTSS LST	14	CALCS	15
4	PTS LST	13	PTS ST	11	CALCS	9	EST	9	MAN Q	6	IN RET	7	CALCS	11	B. DES	15
5	IN.RET	7	RECORDS	8	PTS LST	8	MOD	9	B. DES	6	PTS LST	7	MAN Q	4	IN. RET	7
6	CALCS	5	EST	7	SCHED	7	CALCS	8	calcs	5	OTHER	7	IN. RET	4	EST	5
7	B. DES	4	MAN Q	4	IN. RET	6	MAN Q	6	PTS LST	4	SCHED	7	EST	4	MOD	5
DRGS PER ANNUM	4500		4220		3400		520		700		450		100		140	
HOURS PER DRG	3.7		2.6		2.7		12.1		11.4		10.5		43.5		6.1	
MODS PER ANNUM	665		2500		1350		65		160		200		40		50	
HOURS PER MOD	12.4		2.5		2.3		30.7		12.4		11.5		1.4		4.4	

KEY

ND: New drawing
MOD: Modification to drawings
B. DES: Basic design
EST: Estimating
PTS LST: Parts lists
IN. RET: Information retrieval
CALCS: Calculations
RECORDS: Record keeping
MAN Q: Manufacturing queries
SCHED: Equipment schedules
TRACE: Tracing

RESPONSIBILITIES AND PROCEDURES FOR CEMENT DESIGN

ACTIVITY	REGULATORY (Contractual)	COMPANY POLICY	STDS. & PROCEDURES EXTERNAL/INTERNAL	RESPONSIBILITY	WORKING INSTRUCTIONS/ACTION	WORKING DOCUMENTS OR PROFORMA'S USED	OUTPUT/DESTINATION
Commercial	Customer's requirement			Sales	Write IDN	IDN	IDN to Design Division with customer req!
Proposal	Customer's requirement or plant requirement		ASTM BS DIN	M	Pass proposal to DM		to DM
				DM	Prepare proposal	Content of proposal 1. Plant Specification (Descriptive) 2. Cost estimate by equipment type 3. Flow Sheets 4. Layout	Send workings of proposal to M Files copy of Items 1, 2, 3 & 4 for record
				M	Check proposal, consolidate and write IDN	IDN	Item 1, 3 & 4 with summary of item 2 to Sales
Design	Order	Start work after down-payment.	ASTM BS DIN	M	Compare order, prepare layout together with drafting staff. Expand equipment specification	5. Layout drawings 6. List of imported parts 7. List of local purchase parts 8. Equipment specification sheets	Items 1 & 5 to DM Item 5 to Electrical Dept. for initial working Item 5 to Structure Dept. for initial working Send item 8 to Purchase for floating enquiry
				Purchase	Obtain quotations from suppliers		Send quotations to M
				M	Check and select equipment	9. Comparative Statements	Return recommendations with Item 9 to Purchase
				DM	Undertake detailed design and calculation	10. Calculation sheets 11. Sketches 12. List of instruments 13. Critical Part List	Files items 10 for record Item 11 to AM Item 12 to Electrical Item 13 to Production Planning & Control (PPC)
				AM	Undertake equipment design together with drafting staff	14. Manufacturing drawings 15. Parts list 16. Erection & Installation drawings 17. Foundation bolts list 18. List of motors 19. Civil Design Data 20. Electrical Design Data	Files items 14 to 20 for record Items 14, 15, 16, 17 & 19 to DM Items 5 and Assy. of 14 to Structure Items 5, 18 & 20 to Electrical
				Structures Electrical	Do detailed structure design & detailing Do detailed electrical design		To P.P.C. for manufacturing To P.P.C. for manufacturing
				DM	Check and approve drawings Issue relevant information		Items 14 & 15 to P.P.C. for manufacturing Items 5, 16 & 17 to Installation Item 19 to Customer

KEY:

M - DESIGN MANAGER

DM - DEPUTY MANAGER

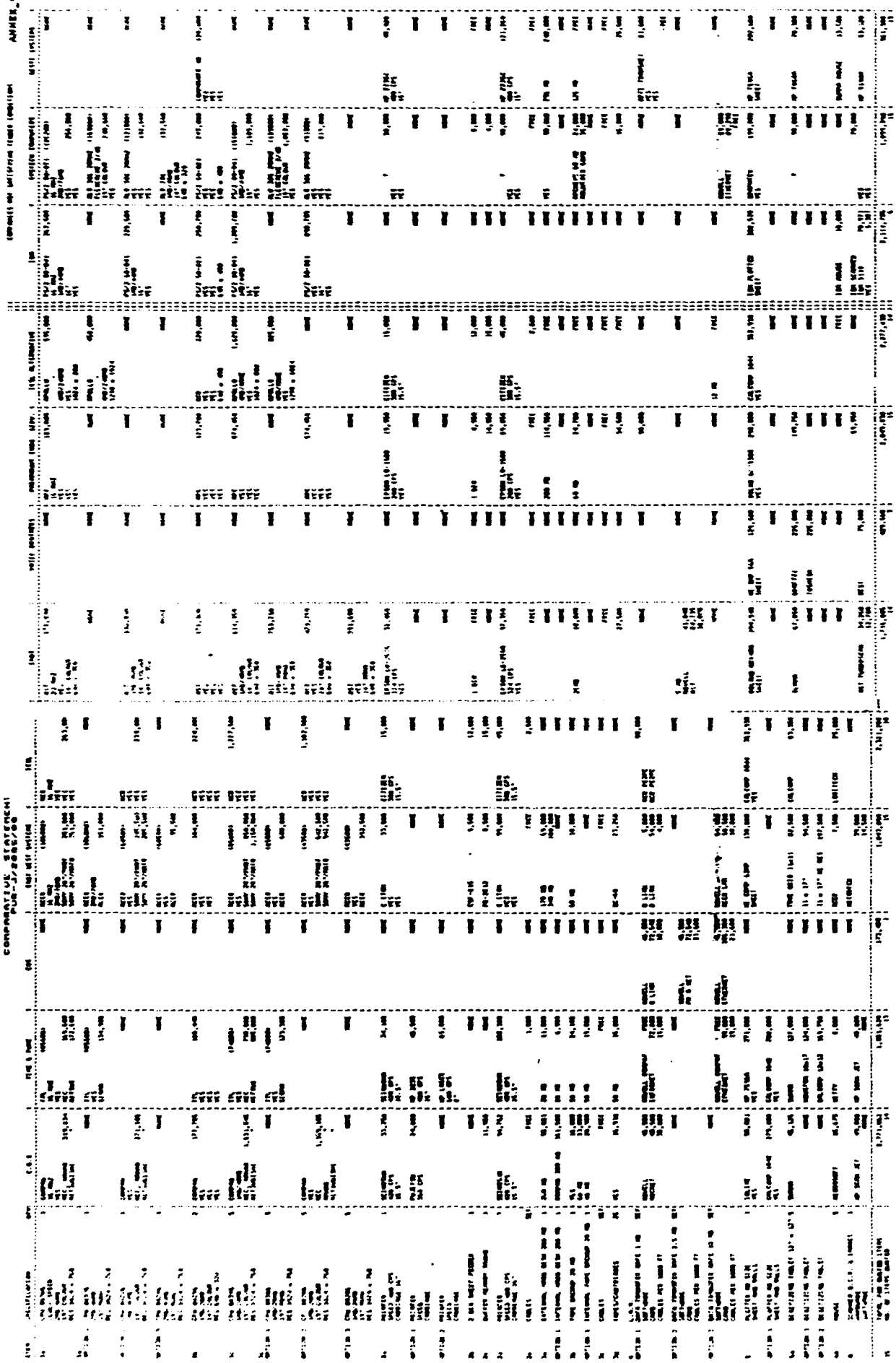
AM - ASSISTANT MANAGER

DD - DESIGN DRAFTSMAN

NO PROFORMA

PROFORMA

COMPUTERISED PROFORMA



COMPARATIVE STATEMENT
PUR-J/2883/88

ITEM	SPECIFICATION	DADI	CSSL	YASIR BROTHERS	CGS	CSSL ALTERNATIVE	COMPANIES NOT SATISFYING TENDER TERMS	
							EAST WEST SYSTEMS	SEESI SYSTEMS
1	AUTOCAD VER. 2.6	RELEASE 9 51,775	NONE	YES 90,000	RELEASE 9 59,400	D06S-2D 405,000	RELEASE 9 57,000	YES 50,000
	WITH:-							
	AUTOLISP LANGUAGE	NONE	NONE	YES	NONE	YES		NONE
	REL MECHANICAL	NONE	NONE	YES	YES 5,500	YES	YES 10,000	NONE
	SEMEAL LIBRARIES		ACAD PARTNER 118,430				NONE	
	PIPING	NONE	YES	YES	YES 21,890	YES		NONE
	OPTION 1				PROPIPE/ISO 56,250			
	ELECTRICAL	NONE	YES	YES	YES 5,390	YES	NONE	NONE
	OPTION 1				PRO-ELEC 25,300			
	WELDING	NONE	YES	YES	YES 2,500	YES	NONE	NONE
2	HEAT EXCHANGER DESIGN		AAA T & S CO 325,000		AAA T & S CO	NONE	NONE	
	THERMAL	NONE	TRI-THERM	NONE	TRI-THERM 137,500			NONE
	MECHANICAL	NONE	TRI-MECH	NONE	TRI-MECH 129,500			NONE
3	PROCESS FLOW ANALYSIS		ENGINEERED SOFT 32,474	90,000	AAA T & S CO 120,028	PROVUE 3D 731,232	NONE	
	STRESS ANALYSIS	NONE	YES	YES	TRI-FLEX	PLANT DESIGN		NONE
	ISOMETRIC VIEWS	NONE	YES	YES	TRI-FLEX			NONE
	DETAIL DESIGN	NONE	YES	YES	TRI-FLEX			
4	PRESSURE VESSEL DESIGN	NONE	NONE	NONE	TRI-VESSEL 109,750	NONE	NONE	NONE
5	STRUCTURAL ANALYSIS	NONE	NONE	SAP 90 50,000	NONE	NONE	SAP 86 V3.4 33,000	NONE
	OPTION 1						MSC/CAL 21,000	
	OPTION 2						MSC/PAL 2 40,000	
	OPTION 3						SUPER SAP 13,500	
6	DRAWING ADMINISTRATION	NONE	CADMAN 20,270	NONE	CUSTOMISED 30,000	NONE	NONE	NONE
					MS PROJECT			
	OPTION 1				CUSTOMISED 60,000			
					DBASE III+			
	OPTION 2				PRIMAVERA PP 89,000			
7	PARTS LIST E.T.M.	NONE	NONE	NONE	SUNFLEX 14,500	NONE	NONE	NONE
					PME PIPING 95,000			
					PIPECON 247,500			

POINTS TO WATCH FOR IN BENCHMARKING SYSTEMS

I Separate from actual Benchmark Visit:

a) Visit other user sites
- (i) to find real evidence of the systems capability to handle complex jobs and see sample drawings. Don't just believe the vendor - 'honesty is inversely proportional to investment'.
- (ii) to find out what the system can't do, or can't do well.
- (iii) to find out what the system can do on day 1 and define learning curve times.

b) Attend a user group meeting for general background and see what users are complaining about.

c) Choose sub-sections for the benchmark test prior to the visit bearing in mind the system selection criteria.

II During the Benchmark Visit

a) General background points:
- (i) Take the opportunity of acquiring supporting information. Get user lists and find out how many users there are of the system you are being offered and what their disciplines are. Don't be fobbed off with totals of all systems supplied or numbers of workstations.
  Inspect the training and reference manuals to check they exist and that they are understandable.
- (ii) To what an extent can the system be used as a development base? Can bespoke developments be done on the system, for example.
- (iii) Beware of manana software. Software development always takes twice or three times longer than planned. Therefore software promised to be available next month may only be available in 6 months time.

b) Choice of Benchmark Content:
- (i) Don't waste time benchmarking the more simple aspects. All the top-selling turnkey systems have adequate 2D drafting facilities.
- (ii) Don't allow standard demonstration material to be used. Insist on a live demonstration based on your drawings, even if time only permits a subset of your problems to be shown.
- (iii) On 3D ask for:
  - line drawings with hidden line

removal, not shaded pictures.
- mass properties
- doubly curved surfaces such as bends or castings
- sheet metal is usually more difficult than machined components
- sections through an object
- sheet flattening

(iv) On schematics as for:
- connectivity list (variously known as net lists, points of equi-potential)
- parts lists with added attributes such as component costs
- edits on the schematic which changes the connectivity and parts list

(v) On wiring harnesses ask for:
- automatic scaling from an unscaled schematic
- query the wires passing through a point on the harness.

c) Subsections of the Bench mark

(i) - Choose lengths of time for each sub-section and stick to them. If things get bogged down, nove onto the next sub-section. Time can pass quickly.

(ii) - Get a hard copy of the drawing at the end of each session at the workstation At the start of the next session compare your copy with what comes up on the screen. Any differences indicate that they've been modifying previous work. THis should not be allowed you should insist on seeing everything live - demonstrations of pre-prepared material proves nothing.

d) During the Benchmark test itself

(i) make comprehensive notes of everything which happens and the time of significant events.

(ii) Watch the prompts being issued by the system. This gives a good indication of what goes on. Check for sytem crashes. For example, on PRIME/Medusa systems messages such as ****5Q is an error message by the PRIME operating system and would indicate a failure of MEDUSA.

(iii) Timed tests are more a test of the operator than the system. The objective of benchmarking a shortlist of systems is to make a final choice of systems; it is not to prove, or dispose, productivity ratio assumptions.

(iv) Don't let the salesman waste time by talking about it. You're there

to see it done on your benchmark. Salesman will usually jump at any opportunity to talk at a conceptual level so they can generalise away from specific details and hence cover up a missing parts or weaknesses.

(v) A good demonstrator will explain everything he is doing in clear and understandable terms. If he uses jargon, ask for an explanation. If he can't give one he either lacks experience or he's trying to cover up something.

e) Above all else, keeping asking yourself: - could I learn how to use this system and apply it to my work effectively?

CONTENTS

NOTES ON FORMULATING BENCHMARK TESTS

1. Purpose of a Benchmark Test

The purpose of a benchmark test is to evaluate a systems suitability for a proposed application. Putting a number of systems through the same test should provide an objective basis for system selection. Such tests may involve identifying the limits of a systems capabilities but the primary objective is not to cause a system to fail - it is to test its ability on a real and relevant application.

1.1 Keeping Control

It is important to keep tight control on what is done and how it is done if meaningful comparisons are to be made. If a vendor has a particular facility applicable to some facit of the benchmark it is reasonable to see this demonstrated, but ensure that the original purpose of that part of the benchmark is properly dealt with.

2. Preparation of Benchmark

2.1 Performance Criteria

It is essential to consider what perform..ce criteria are relevant to a particular user. Speed of response is not the only one nor is it necessarily as measurable at it appears. Quality of prompts, the use of default values and the level of detail on error messages are all likely to be important. Many performance criteria are subjective and difficult to rate objectively but still important from the system choice viewpoint. Such criteria include the ergonomics of the workstation and general friendliness of the software interface.

It is important to consider performance criteria in detail when benchmarking.

2.2 Preparatory Work

The sample of work used in the benchmark must be carefully chosen to ensure that it will both represent the expected workload and provide a basis for grading the system vis-a-vis the performance criteria. The potential user must therefore choose an example from the main stream of his work and provide instructions that guide the operator through the benchmark in a manner that would permit evaluation against the performance criteria.

Scripts should be prepared that include the instructions for the demonstrator in order that the systems are tested on a like for like basis. A script also ensures that every point on the benchmark is covered.

2.3 Analysis Documentation

Prepare forms for the analysis of a benchmark in advance so that they can be used during and/or immediately after the event. These forms should have room for comments to be made and are likely to include a list of desired features generated from the performance criteria. They should be constructed as objectively as possible to concentrate on the systems ability and so minimise the risk of comparing operators rather than systems.

3. Test Procedures

3.1 Duration

In order to properly evaluate a system a user should allow two days for a benchmark. It may become clear that the system is unsatisfactory in a much shorter time, but barring drastic failure, two days is realistic.

3.2 Documentation and System Operation

The quality of documentation that is supplied with a system is very relevant. A user must be able to understand the documentation and use it as a first level of support. Confusing, inaccurate or outdated documentation represents a serious weakness in a systems support.

The basic knowledge of how to start up and run a system is obviously essential. Some systems are more complex than others. It will be necessary to take back ups of magnetic media and to do so reliably. The documentation should be studied to ensure that instructions for this are included and to guage how complicated the work is. Include a "cold start" in the benchmark and compare actual with documented procedures.

3.3 The Benchmark Team

Physical contraints of access to one workstation limits the number of staff who could usefully attend a benchmark test to about three. Generally the whole team should attend all sessions of a benchmark so that they all have as full a picture as possible. Where a large range of uses is envisaged the team could be expanded, but this will mean some degradation in detail viewing of the work.

The background and experience of the team should cover all the planned areas of application if possible.

The team should be technically qualified in their own fields and, if necessary, be given the opportunity to study the other potential applications. They must be experienced and pragmatic so that they are not so impressed by the technology that they forget the realities of the application. Exposure to one or more systems before taking part in a benchmark would be useful.

4. Test Content

4.1 Introduction

The content of a benchmark test for a particular user will depend on the planned application. However CAD can, to some extent, be reduced to a number of basic disciplines, each of which requires the inclusion of certain features in a benchmark. The three main disciplines are:

a) 2D Draughting
b) Parametric Design
c) 3D Modelling

4.2 2D Draughting

Convential draughting consists of straight lines, arcs, circles, splined curves and text. Given facilities to geometrically manipulate these any drawing can be produced. However facilities should be available that will further assist the creation of drawings. These facilities include the ability to manipulate groups of geometry to incorporate libraried drawings and previously created drawings into the current drawing, to modify the graphical representation of geometry and to use the created data for other purposes.

Benchmark drawing material should have the following features to veryify a system geometric ability when applied to separate items:

Points - absolute position
- relative position from lines and points
- defined by intersections of lines

Lines - straight, point to point, tangent to tangent, vertical, horizontal, angle, perpendicular, normal
- arcs, 3 points, tangent to tangent, 2 points/radius
- circles, centre/radius, concentric
- ellipses, angular rotation
- fitting a smooth curve through a set of points with and constraints.

If the draughting system can do these satisfactorily, then the majority of mandatory geometric contructions are provided.

Incorporate examples of the following operations on geometric groups into the benchmark by choice of an appropriate drawing(s).

i) copy and rotate (leaving hatching at same angle)
ii) copy and create new shape, with subsequent editing
iii) mirroring

Choose some standard features to be stored in a library and recalled for inclusion on a drawing. These might include the company logo, standard manufacturing notes or the geometry of a frequently used bought out item.

The following features are also worth including in any benchmark

i) cross hatching in different directions and pitches and around islands within an area
ii) line style changing of part of an existing line (this is often needed on assembly drawings)
iii) editing text
iv) dimensioning and re-dimensioning after a modification
v) filleting and line trimming
vi) area calculation
vii) paper size selection

If all the features outlined are included in a benchmark a good comparison of 2D facilities could be made.

4.3 Parametric Variation

Create the specification of a simple parametric examples, such as a flange, that a vendor could use to demonstrate a systems parametric facility. Be prepared to note details of the use of parametrics and to obtain a hardcopy of the resulting program. Try to include a conditional statement (e.g. IF DIAM IS LESS THAN THICKNESS THEN STOP) to demonstrate a reasonably full parametric language.

4.4 3D Modelling

Where 3D work is applicable it is essential to select a realistic example that is not too demanding of computing time. The user must insist that each step in the modelling process is fully explained. The type of model being created must be made clear (e.g. wire frame, surface or solid). The model type must be considered against the desired performance criteria and, where an option is possible, born in mind when comparing systems.

Users must be prepared to note the length of delays caused by the modelling process and, in a time sharing environment, consider the impact of the extra computing load on other users.

5. A Recent Example

A recent benchmark test is described as a typical example.

5.1 Electrical Schematic

Part of an electrical schematic drawing was chosen to be reproduced. The area was marked out on the drawing and the operator instuctions included the following:

a) create ten graphic symbols (marked 1 to 10 on the drawing)

b) demonstrate how these symbols are held in a symbol library, how that library is interrogated, how origins of symbols and connection points are defined

c) recall symbols to construct drawing using a GRID facility

d) establish connections between symbols

e) add annotations and text on a separate layer and display switching on and off

f) generate list of components by symbol title

Each vendor was asked to comment on associating further data with each symbol.

The following features were also considered during this part of the benchmark:

a) cross hatching of symbols

b) establishing origins and connection points

c) text size, justification and choice of typeface

d) text handling in component listing

5.2 Mechanical Engineering Drawing

Part of an mechanical engineering drawing was marked out to be reproduced and the operator told to proceed as follows;

a) create one view including an enlarged detail

b) carry construction lines for other views

c) carry construction lines for a section detail

d) dimension one view

e) create a text symbol library to include 3 standard manufacturing notes

f) recall notes from library and position on the drawing

g) add other text and edit existing text

h) incorporate a change that effects all views

i) mirror a view

j) copy and rotate a view

k) calculate the area of one view.

During this part of the benchmark the ease of use and error recovery of the system were considered.

5.3 3D Modelling

Using the views created in 5.2 the following actions were taken:

a) create a 3D model of one component

b) display views of model equivalent to the original drawing

c) generate the section detail that was created in 5.2 c)

d) create an isometric view of model, create a second view rotated by 60° around one axis

e) Interrogate model for volume

During this work consideration was given to

a) ease of model generation

b) ease of model amendment

c) was the modeller solid or wire framed? Were hidden line removal, automatic cross sections generation and volumetric calculations available?

d) creation of a model will usually require the use of Boolean operations in a solid modelling system. How easy to specify were these?

5.4 Windowing and Panning

Windowing and panning facilities were benchmarked by displaying 4 copies of the (A4) mechanical drawing used in 5.2 on one A0 sheet. Diagonal construction lines were then created across the entire sheet. This resulted in the equivalent of a complex A0 drawing that was used to test the speed, ease and limits of windowing and panning facilities.

Report into the need for a CADCAM Development Scheme in Pakistan

1 Introduction

This report has been compiled as a result of a UNDP initiative to determine the scope for promoting "CADCAM development and training programmes" in Pakistan, with the specific objective of accelerating the acceptance and effective utilisation of CADCAM technology.

The initiative was formulated under the guidance of Mr Bernardo Vunibobo, resident representative of UNDP in Pakistan and Mr Aftab Akhtar, Senior Consultant. The programme of work was undertaken by David S Wadsworth, CADCAM expert, currently released from his assignment at HMC Taxila.

The purpose of the project was:-

1.1 to determine, within a time frame of one month, to what extent CADCAM technology had been adopted by both public and private organisations within Pakistan, to determine the effectiveness of its current use and to identify the more significant restraints witholding the widespread adoption of this technology.

1.2 to make recommendations regarding the most effective strategy which should be adopted in order to accelerate the process of computerisation in engineering and design installations.

2 Acknowledgement

Mr Wadsworth would like to take this opportunity to thank the Management of HMC, and in particular Mr N A Bhatti, for placing so many facilities at his disposal during the information gathering and report preparation phases of this project.

3 Methodology

The method used to gather the essential information was by means of a questionnaire, shown in Appendix 1, and to use this questionnaire as a basis for face-to-face interviews with Managing Directors and/or other senior managers in as many companies as time permitted. The locations chosen for detailed examination were Lahore and Karachi, and five days were spent in each area using local UNDP transport facilities. The effectiveness of these facilities is acknowledged which contributed significantly towards 58 organisations being canvassed during the survey.

A summary of the breakdown of the companies canvassed is as follows:

Users and Potential Users	Public	11
	Private	28
Unable to provide information		3
Suppliers and/or Training Organisations		15
Finance Houses		1
Total		58

The size of users, or potential users, varied from Rs 0.25 million per annum to Rs 850 million per annum turnover, and the distribution was as follows:

Rs million per annum	< 10	12
	10 - 100	12
	> 100	15

The response to the questionnaire was very positive* and allowed free expression of beliefs and prejudices. In this respect, the questionnaire did not limit respondents to the number of observations regarding restraints or benefits, perceived or otherwise. Neither were the responses ranked in priority. The results should therefore be interpreted as significant to the extent that the observations were worthy of mention.

* Only three companies were visited who, due to commercial pressures at the time, were unable to attend to the questionnaire - unfortunately their promise to send the relevant information by post did not materialise either.

4 Results

The results of the survey are shown in Tables 1, 2 and 3.

4.1 Software Utilisation

Of the thirtynine user or potential user companies canvassed, fourteen (36%) had no computers at all, six (15%) had just one Personal computer, sixteen (41%) had more than one Personal computer and three (8%) companies had Mini-computers.

Eighteen (46%) companies were using software for word processing and spreadsheet applications and fifteen (38%) companies were using software for specialist applications such as structural analysis, machine control, flowcharting or artificial intelligence.

Fifteen (38%) companies had computer aided design software (all Autocad). Nine (23%) of these companies had plotters but only five (13%) of the companies were using CAD as a productive tool. One of the companies who had CAD software did not consider that it was appropriate to their needs and another company stated that it would be two years before they started to use the software.

Fifteen (38%) companies stated that they intended to use CAD as a productive tool within the next twelve months and a further five (13%) companies that they would start to use CAD within the next two years. Only two companies in the survey considered that CAD was inappropriate to their needs, and a further three companies stated that CAD was not a high priority, although it should be noted that some of these opinions might be reversed if well informed independent advice were to be available. Twelve companies (31%) indicated that it would be more than two years before they began to use CAD.

4.2 Restraints

The respondents were asked what factors were considered to be significant in restraining progress towards computerisation.

Of the eighteen respondents who listed "Management Awareness" as a significant restraint, eleven already had computers; and of the eleven respondents who listed "Organisational Attitudes" as a significant restraint, nine already had computers.

Of the fourteen respondents who listed "Lack of Finance" as a significant restraint, eleven already had computers and a further twelve respondents listed "Financial Justification" as a significant restraint.

Of the sixteen respondents who listed "Lack of Suitable Software" as a significant restraint, ten already had computers and two used bureau facilities.

Sixteen respondents considered that the "Lack of Training Facilities" was a significant restraint and as many respondents considered that either the "Lack of Professional or Technical Skills" posed problems to the advancement of computerisation.

Twentyfive (64%) of the thirtynine companies believed that computerisation was inevitable and therefore they had taken, or would take, the initiative to be involved in its use. Fourteen (36%) of the thirtynine companies felt that the need to computerise arose directly from competitive pressures.

In summary, the five most frequently quoted restraints were seen to be:

4.2.1 Management awareness
4.2.2. Lack of suitable software
4.2.3. Lack of training facilities
4.2.4. Lack of finance and/or financial justification
4.2.5. Lack of computer literacy and technical skills

4.3 Benefits Achieved

Many advantages have been achieved through the use of computerisation.

In particular the survey indicated that twentytwo (17 who used computers, 5 who did not), respondents reported that the speed of completing tasks was vastly improved, fifteen (9, 6) respondents reported that economy of effort was significant and fourteen (10, 4) respondents reported that the accuracy and confidence with which results were obtained was considerably improved.

Nine (7, 2) of the respondents felt that the benefits of computerisation were to be achieved by undertaking tasks which would not have been possible by manual methods.

Many examples were quoted to support this positive response. For example, one engineering company is using CAD to design carton packaging profiles. Each profile is now created in ten minutes whereas previously it took a draughtsman one day to complete. Not only is the profile produced more rapidly but the use of the material is also optimised, thus generating further savings to the company as a whole.

One consulting company regularly produces as many as fifteen hundred sectional elevations to assist in the specification of highway design projects. This is many more than would be generated by manual methods and thus provides more accurate estimate for the ensuing earthworks.

Another company was using spreadsheets to integrate the contents of seventy files for analysis purposes, a procedure that could not have been contemplated using manual methods.

One manager noted that the depth of analysis that could be achieved using computer methods contributed directly to the retention and improvement in the quality of the company's personnel.

Many managers spoke of time savings of between two and ten, and that the accuracy and indepth analysis enabled the production of more optimal designs. This had far reaching effects, not only in the initial winning of contracts, but also impacted significantly on the costs and implementation schedules associated with executing the contracts.

5 General Observations

During the course of the survey, sixteen supplier companies were canvassed. The companies, and the nature of the support that they provide are listed in Table 3. As a result of the discussion with these companies and the observations of the user market it is possible to draw some generalised conclusions, which are set out below.

5.1 Market Support Characteristics

Various aspects of the market support will be discussed under the following headings:

5.1.1 Hardware

In general, PC hardware is easy enough to obtain - most of it is IBM compatible. manufactured in the Far East and "dumped" without properly structured outlets or support. Several small companies are being created who are prepared to maintain hardware, although their preference is to support only what they sell.

Processors larger than PC's are difficult to acquire and even more difficult to obtain appropriate maintenance support. American companies do not export directly, therefore equipment arrives in Pakistan via third party agents who basically just operate as shipping agents.

The larger computer manufacturers such as IBM, ICL and Wang direct their activities towards the commercial market.

Therefore, any computer aided engineering activity has to be carried out on PC's apart from a few exceptions where the demand for sophisticated engineering analysis has been established. Access to these facilities tends to be highly priced.

5.1.2 Software

During the course of the survey it was noted that the selection of demonstrable software for engineering design was minimal. Less than ten named packages were available for sale or being used. The list included four named computer aided drafting, CAD, systems and no computer aided manufacturing, CAM, systems. This compares with directories of several hundred packages to be found in European countries and America.

There are no Pakistan based computer magazines which promote the sales of software and describe successful applications. Magazines are used in other countries to identify sales outlets and to publish articles describing user achievements or the advantages and disadvantages of various systems.

Software that is sold in Pakistan is acquired after reading sales literature. It is not normally possible to see software demonstrated prior to purchase. In one exceptional example noted during the survey, the company concerned had sent two of their staff to England to see software demonstrated prior to placing an order. In Europe and America it would be considered standard practice to attend a demonstration of software prior to its purchase.

With the exception of two CADCAM vendors, namely PAFEC and NORSK DATA, the majority of engineering software in Pakistan has been pirated. As a consequence, the effective use of software is heavily dependent on personal motivation since there are few training schools and few software manuals available. However it should be noted that even where software manuals are available, their use is not always effective since many staff do not possess the requisite understanding of the English language.

Most of the software that has been pirated, has come from abroad, brought by people who may or may not have received adequate training.

The fact that the import of software has been so spasmodic has led to many companies developing their own. There is thus a wide range of small undocumented programs of doubtful quality which may or may not be providing an adequate service to the user population.

5.1.3 Training

Since most of the software has been pirated, the majority of personnel have to teach themselves how to use the software.

Some commercial organisations have sprung up to try to fill the vacuum of knowledge, but their knowledge is scant and not directed to any particular technical sector of the market. Neither is their knowledge directed towards any particular application or professional group.

Doubt was expressed as to the ability of universities or colleges to fill this gap - there seemed to be too few of them with too few facilities.

The most significant training was therefore acquired from abroad. However, there seemed to be a general concensus of opinion that of the many who went abroad for training, too few came back to use and disseminate the knowledge so gained.

5.1.4 Financial

Although there are many institutions willing to invest money in high technology, the majority of finance is directed towards creating plants to manufacture products not previously manufactured in Pakistan. Little demand is made for money to invest in "enabling technologies" and what demand there is, faces stiff competition from other investment programmes.

5.2 Market Motivation

In order to have a strong vibrant technological thrust, certain factors need to be at work within the market to stimulate the process. These stimulating factors would include the following:

5.2.1 Customer Demands

From the information collected there was little evidence to suggest that either the private customer or the Government procurement authorities were placing any demands on consultants, designers or manufacturers to demonstrate their use of advanced enabling technologies in an effective manner.

5.2.2 Indigenous Design

It is a matter of fact that the amount of indigenous design is very low. Most of the products manufactured in Pakistan are either of a repetitive nature with little new associative design technology or are manufactured under some licencing agreement whereby the original design is imported and only minor changes are made to products for either the home market or for re-export.

Any stimulus for advanced technology stems from major capital expenditure programmes as evidenced by highway, civil construction and energy resource development.

5.2.3 Foreign Aid Programmes

Although Pakistan has been the beneficiary of many foreign aid programmes, too little of the associated technology has been assimilated within the fabric of Pakistan's skills profile. This has been due to a lack of simultaneous indigenous development.
The only positive motivation arises when foreign consultants, working in conjunction with indigenous expertise, insist on the use of technologically based skills or, when local consultants are used in their entirety.

5.2.4 Standardisation Authorities

There appeared to be scant evidence that authorities were being established in Pakistan to provide appropriate Quality Assurance Standards either within the consumer market or in the supply industries which would impact upon the need to implement enabling technologies such as CADCAM.

6. The Need for a Structured Programme to Increase the Use of Enabling Technologies

In spite of the difficulties related in the previous paragraphs, companies are making moves towards the use of CADCAM technology.
However, the process is fragmented, fitful and in many instances lacks commitment. The majority of installations lack a balanced understanding of the technology and its management which, unless corrected will lead to a significant under achievement and sense of disillusionment.

There is an overwhelming need for a co-ordinating programme which would focus on the potential and achievable benefits to be gained by using CADCAM technology and to provide demonstration and leadership stature to one of the most powerful and wide-ranging enabling technologies yet devised.

It became apparent during discussions that the "Management of Technology" was one of the biggest stumbling blocks towards an effective computerisation programme.

Computer systems cost money, they are difficult to justify, therefore software is pirated and the cheapest computers are bought, namely PC's.
However, even when the equipment is installed no investment in the form of training is made and the provision of formal training is neglected. Certainly the vendor cannot help - because the software has been pirated, and there are insufficient training schools with insufficient application experience to help. So training becomes another, but critical, 'Cinderella'.

Self-training and self-motivation can only go so far towards effecting the sound use of enabling technologies such as CADCAM.

The one essential ingredient that could begin to mould the process together is the 'management of understanding' together with the 'management of time'.

In far too few instances during the survey were examples of CAD being used as an effective productive tool discovered. Most companies had failed to reach this stage because management had not allocated either time for training or arranged a work load suitable for this technology.

Many more installations will fail in this process because of a lack of understanding of the technology and its effective application unless positive steps are taken now.

There is therefore an overwhelming need for a structured programme in order to focus and harness the energies being expended at the moment, to ensure that those limited resources that are available are used to their best advantage and in the shortest possible timescale.

To be effective, such a programme would address as many of the following factors as possible.

- It would promote market stability.
  ie. by promoting a better informed and educated forum for decision makers the worthiness of hardware and software products would become more apparent and would provide a framework of stability within which the potential customer could have confidence in his commitment to purchase.

- It would identify CADCAM as an effective enabling technology in Pakistan's development towards indigenisation.
  ie. it would identify CADCAM applications, identify or develop appropriate software and spread an understanding of its potential.

- It would focus on the need to manage technology.
  ie. it would recognise the lessons learned by more advanced countries, when they first introduced similar advanced technologies, but would temper these lessons with specific indigenous criteria.

- It would provide a forum for the exchange of technological expertise and understanding.
  ie. by promoting lectures, workshops, seminars and conferences it would disseminate an educated understanding of the technology and its management.

- It would provide bureau services.
  ie. for new users or for more specialised (and therefore more expensive) applications which require more resources than could be economically justified by one user.

- It would act as a stimulus towards financial institutions.
  ie. it would focus the benefits of CADCAM, as an effective enabling technology in an overall indigenisation programme, within financial institutions; thus releasing positive financial stimuli to the potential user market.

- It would stimulate the need for consortia.
  ie. it would bring together like minded requirements and provide the stimulus necessary for joint development programmes or joint service agreements.

- It would provide training facilities.
  ie. it would identify the need for, and the location of, training facilities covering all aspects of CADCAM technology from management awareness and management of technology, through to the inculcation of technical skills and their effective application.

- It would act as a demonstration centre.
  ie. it would focus on the best available software and demonstrate its potential in a non-sales, non-pressurised environment.

- It would promote the development of user groups.
  ie. one of the best ways to ensure an informed forum of user opinion is through the medium of active user or application oriented groups.

- It would act as a pressure group on vendors.
  ie. currently there are too few vendors, therefore the price of software is too high and pirating of software takes place. Action should be taken to reverse this self-defeating process. Action should also be taken to attract major software development companies to open branches within Pakistan and promote indigenous software development.

7. Conclusions

The purpose of this paper has been to demonstrate the need for, and the value of, establishing an Institute or "Centre of Excellence' to develop and promote the effective use of CADCAM technology. The fact that less than ten examples of engineering software were found during the survey compares unfavourably with over five hundred examples of different types of marketable engineering software to be found in European countries or America and highlights the current poor state of the market in Pakistan.

The value of the current survey is twofold:

1 It has enabled the expression of many of the prejudices, perceived or real, which management consider to be obstacles to the widespread adoption of CADCAM as an enabling technology.

2 It has highlighted, to a large degree, the extent and type of industry which would benefit from a more positive approach to the use of CADCAM technology.

Note: It was not the intention of the survey to quantify the total need within the country. However it is reasonable to suggest that the survey canvassed the cream of private and public sector organisations of significant size or potential usage. These companies can be assumed to represent the forefront of current thinking on the subject.

It is interesting to note that those companies who had made a commitment to computerise their design office methods, individually and on average:

had invested Rs 500,000 todate,
would invest Rs 500,000 within the next twelve months and

expected to invest nearly Rs 4,000,000 in the next five years.
This report concludes that the establishment of a "CADCAM Centre of Excellence" would materially assist these companies in their goal to maximise their individual investments.

To establish such an Institute requires the co-operation of, and contribution from, a number of organisations. For example, an organisation such as UNDP could provide assistance in the form of financial aid with which to purchase hardware and software from overseas and to provide the very necessary consultancy support that such a project would require.

The Ministry of Production might supply assistance in the form of buildings and staff salaries, and Private industry could be expected to provide essential inputs based on their needs and their commercial strengths at the appropriate time. The first requirement is to establish a management structure which will ensure the maximum progress and optimum utilisation of the resources placed at the disposal of the project.

Such a project should be seen as enhancing parallel programmes to develop a sound indigenous industrial policy. To be effective it requires a funding and organisational commitment for a minimum period of at least five years, with a review after three years to determine the degree of success achieved todate and to determine the extent to which the project requires additional acceleration funding.

In the first instance the institute would require headquarter facilities appropriately located adjacent to a centre of utilisation. It would also require to be sited where good communications with the rest of the country could be established.

After a period of time, consideration should be given to providing a local immediacy to the services provided.

This might be achieved in two ways :-
First, by the provision of local branch offices with excellent data communication links to the central establishment,
Second, by the provision of mobile consultants. These consultants would be deployed on an "as required" basis. Their effective utilisation could be encouraged by a Government funded scheme whereby individual companies are entitled to a predetermined number of days (say 10) in order to have a feasibility study undertaken at nominal cost, and additionally have substantially more subsidised consultancy to assist with the planning and implementation of appropriate systems. In the first instance this consultancy service could be co-ordinated by UNDP, but the ultimate aim would be to encourage an indigenous supply of consultants. The purpose of this consultancy programme would be to encourage the best use of the technology available.

This paper has not assigned detailed costs to this project - some projected budgetary costs were mooted in the working paper that preceded this study. REF APPENDIX 2: WORKING PAPER ON A UNDP AIDED PROJECT TO PROMOTE CADCAM DEVELOPMENT AND TRAINING PROGRAMMES IN PAKISTAN, D S WADSWORTH & N A BHATTI, FEB 1988.

In the light of the additional work carried out during this survey, it is reasonable to suggest that the figures mooted on page 7 of Appendix 2 were, perhaps, in excess of the requirements which could usefully be exploited during the formative stages of this project.

However, it should be noted that a project designed to satisfy a five year programme, which would meet the requirements described earlier in this report, is likely to require an initial funding of the order of $ 4,000,000 in terms of foreign aid and Rs 20,000,000 internal funding.

8. Recommendation

The recommendation is for UNDP to gather together a forum of interested parties and proceed as quickly as possible in identifying the availability of resources such that this project may be implemented within the shortest possible time frame.

D. S. Wadsworth
UNDP Consultant
March 1988

ANNEX I

CADCAM DEVELOPMENT IN PAKISTAN

UNDP QUESTIONNAIRE FOR SELECTED COMPANIES

Company Name: Private/Public

Company Address:

Contact Name: Telephone No.

No of staff: Turnover:

Type of Industry: Main Products or services:

No of Engineers, Designers, Architects, Draughtsmen

No and type of drawings produced per year:

Existing degree of Computerisation:

System Hardware:

Software applications:

What benefits achieved so far, if any:

What aspirations towards CADCAM:

What Pressures from market or main contractors:

Difficulties foreseen:

1. Staff - Computer Literacy
   - Professional skills
   - Technical skills
2. Availability of appropriate hardware:
3. Availability of appropriate software:
4. Availability of vendor support:
5. Availability of training organisations:
6. Availability of investment:

Rate of progress foreseen in computerisation programme, Investment in 12 months; Investment in 5 years

What factors does the respondent believe to be the most significant in restraining progress ?

WORKING PAPER ON APPENDIX 2

A UNDP AIDED PROJECT

TO PROMOTE CADCAM DEVELOPMENT AND TRAINING PROGRAMMES IN PAKISTAN

INTRODUCTION

Pakistan is a young developing country sandwiched between the highly automated and sophisticated industrial power bases of Japan on the one side and the western countries of Europe and America on the other. Market forces were never more competitive, and the need to develop & maintain a sound industrial base never more evident. Fortunately some tools are available in the world which can assist in the process of improving design and manufacturing techniques which play a central role in determining competitiveness.
The technology is known as CADCAM i.e. computer aided design and computer aided manufacture.

Todate, knowledge of these tools, their development and application to the needs of industry within Pakistan, has been scant. There are few outlets for technical literature on the subject, even fewer vendors of the equipment (since vendors have not as yet realised the potential market within Pakistan) and finally there are only a handful of organisations who have begun to address the need to implement this technolgy. Those companies who have introduced this technology have in no way begun to tap the full potential of the tools available, in that, they have embarked on a tentative and experimental period of use before engaging the technology fully in productive processes.

There is an overwhelming need to fund a progressively structured CADCAM programme which will accelerate this process and provide the essential momentum to industrial development in Pakistan.
The objective of such a programme would be not only to ensure that the availability of effective CADCAM tools is demonstrable within Pakistan but also, by means of a carefully structured process, provide positive managerial and technical training to ensure the successful injection of this technology into industry at large.

This would be achieved by the provision of:

1. Comprehensive demonstration facilities for a wide range of equipment and applications.

2. Management appreciation courses in the selection and managerial aspects of advanced engineering technology.

3. Courses which promote design methods and creative design, such as that required for engineering applications eg. boilers, structures, process plant, civil and architectural projects, and electrical/electronic applications; and to include design for economic manufacture and computer aided information systems.

4. Introductory and advanced training facilities for specific equipment and methods in CAD and CAM.

5. An information liaison and dissemination service.

6. Conferences, seminars and workshops on a wide variety of related topics in conjunction with educational institutions and industry.

7. Consultancy on a wide range of computer-based engineering applications.

8. Bureau facilities for users prior to the acquisition of their own equipment.

9. Facilities for the design and development of specialist software for applications that will be required by companies including HMC, PECO, PMTF, SHIPYARD, PAEC, WAPDA, NESPAK and the private sector organisations.

POSSIBLE SOLUTIONS

1. Management

It is proposed that the management of this development programme is set up jointly between HMC and UNDP in the form of a Centre of Excellence, to serve the growing needs of industrial and scientific organisations in Pakistan.

After an appropriate period of time, estimated to be five to eight years, this centre will be wholly managed by HMC and become a subsidiary to HMC.

2. Location

It is proposed to set up such a centre at Islamabad, which would be conveniently accessible to various clients and where there will be ample scope for the residential requirements of delegates.

3. Staffing.

The project would be managed by a Chief Executive with wide international and industrial experience and assisted by a resident UNDP representative/advisor.

The supporting staff would consist of:

3.1 Pakistani Staff

- 5 Application specialists
- 20 Operator/software/application specialists
- 10 Senior software/application specialists
- 3 Equipment specialists
- 2 Senior management course leaders
- 10 Support administration officers
- 1 Librarian/technical editor

3.2 UNDP Staff

4/5 UNDP specialists on short term assignment

3.3 Total staff complement.

The total staff complement would be 53 permanent staff together with visiting specialist staff as required.

4. Facilities.

The facilities should consist of:

4.1 Office accommodation for 30 officers

4.2 1 conference and 3 meeting rooms

4.3 3 training rooms

4.4 1 library room

4.5 3 equipment rooms

4.6 Reception area

4.7 Secretarial support room

4.8 Open plan office for 10 staff

4.9 Telephone, telex and telefax services

4.10 Wide variety of services for computer hardware and software

4.11 Furniture - desks, chairs, storage media, etc.

These facilities would be housed in double storey accommodation with a covered area of 900 sq. metres, in land of area 3,600 sq. metres.

5. Equipment

Computer hardware and software would be provided or developed to assist with the design and analysis of:

Process plant.

Energy network distribution.

Buildings and construction industry.

Fluid dynamics.

Boilers/heat exchangers

Architecture.

Civil engineering.

Heating and ventilation.

Structures.

Mechanical design and manufacturing.

Electrical/Electronic design and manufacture.

Facilities management.

Plastic moulding.

5.1 Hardware.

The hardware would consist of:

One large mini-based computer, such as Convergent Technologies, serving up to 32 workstations.

Four powerful workstations of the Apollo type.

Forty medium to high powered PC based workstations.

Demonstration machining and photoplotting facilities.

Plotters and printers to support the workstations.

Stable and uninterruptable power source.

5.2 Software.

The following is a list of software required to assist with both general and specfic applications:

CAD

CAM

NC part programming:

- Milling
- Turning
- Punching/nibbling
- Wire spark errosion
- Profile turning

DNC

Robotic animation

Mechanisms

Mechanical designs

General drafting

Parameterics

3D solid modelling

3D surface modelling

Visualisation, perspective generators

Mapping and land survey

Process design

Pipework

Fluid flow and thermodynamics

Pressure vessel design

FEA for static, dynamic and fatigue performance
Gear design
Coding and classification
Bills of material
Computer aided process planning
Computer aided production management
Project management
Drawing administration and engineering records
Word processing
Desktop publishing and technical documentation
Database
Spread sheet
Compilers:
- Fortran
- Basic
- C
- Pascal

Interfaces:
- IGES
- DXF
- VDA

PCB design

5.3 Educational and Publicity Aids

The training programme would require the support of a variety of educational equipment including:

Video recorder and player
Video camera
Overhead projectors
Flip charts
Photocopiers
Training videos for a variety of general and specific educational requirements.

6 BUDGET

Budget costs are estimated as follows:

6.1 Set-up (first year) costs	Rs	$
Project management	50,000	75,000
Building & fittings	4,000,000	
Furniture	500,000	
Computer hardware		800,000
Computer software		800,000
Equipment		45,000
Staff salaries (six months)	2,300,000	
UNDP specialists		150,000
Publicity material	150,000	
Total	7,000,000	1,870,000

6.2 Running cost per annum	Rs	$
Building services and maintenance	50,000	
Hardware/software maintenance		200,000
Equipment update		650,000
Staff salaries	4,500,000	
Consumables	1,000,000	
UNDP support specialists		150,000
Publicity material	100,000	
Total	5,650,000	1,000,000

6.3 Estimated five year project cost	Rs	$
Total	29,600,000	5,870,000

Prepared by David S Wadsworth UNDP Consultant
Naseem Ahmed Bhatti HMC

Date: Feb 1988

TABLE 1 CAD USERS, OR POTENTIAL USERS, WHO PROVIDED INFORMATION FOR UNDP SURVEY

NO	NAME	STATUS	BUSINESS
1	ALLIED ENGINEERING CONSULTANTS (PVT) LTD	PRIVATE	ARCHITECTS ENGINEERS AND PLANNERS
2	ALLWIN ENGINEERING INDUSTRIES LTD.	PRIVATE	MANUFACTURERS
3	ALSONS INDUSTRIES (PVT) LTD.	PRIVATE	MANUFACTURERS
4	ASSOCIATED CONSULTING ENGINEERS ACE (PVT) LTD	PRIVATE	CONSULTING ENGINEERS
5	AUTO MACHINE TOOLS & PARTS INDUSTRIES (PVT) LTD	PRIVATE	MANUFACTURERS
6	BESCON ENGINEERING (PVT) LTD	PRIVATE	ENGINEERING DESIGN AND CONSULTANCY
7	ELECTRICAL MECHANICAL CONSULTANTS	PRIVATE	ELECTRICAL AND MECHANICAL DESIGN CONSULTANTS
8	EMMAY ASSOCIATES (PVT) LTD	PRIVATE	ENGINEERING CONSULTANTS
9	ENGINEERING AND TECHNICAL CONSULTANTS (PVT) LTD	PRIVATE	ENGINEERING CONSULTANTS
10	ENGINEERING ASSOCIATES	PRIVATE	CONSULTING ENGINEERS AND ARCHITECTS
11	FCCL, PAK KOREA ENGINEERING CO. LTD.	PUBLIC	CHEMICAL PLANTS
12	HASHIM KHAN ASSOCIATES	PRIVATE	ARCHITECTS AND ENGINEERS
13	HASHIMI CAN COMPANY LTD.	PRIVATE	MANUFACTURERS
14	HEAVY MECHANICAL COMPLEX (PVT) LTD.	PUBLIC	MANUFACTURERS
15	INCEM LTD	PUBLIC	STRUCTURAL DESIGNERS
16	INDUS ASSOCIATED CONSULTANTS LTD.	PRIVATE	HIGHWAY DESIGNERS AND CONSULTANTS
17	ITTEFAQ FOUNDRIES (PVT) LTD.	PRIVATE	MANUFACTURERS
18	JOHNSON AND PHILLIPS (PAKISTAN) LTD.	PRIVATE	MANUFACTURERS
19	KARACHI SHIPYARD AND ENGINEERING WORKS LTD.	PUBLIC	MANUFACTURERS
20	KSB PUMPS CO LTD	PRIVATE	MANUFACTURERS
21	NATIONAL ENGINEERING SERVICES PAKISTAN LTD.	PUBLIC	ENGINEERING CONSULTANTS
22	NAYYAR ALI DADA AND ASSOCIATES	PRIVATE	ENGINEERING CONSULTANTS
23	PACKAGES LTD	PRIVATE	MANUFACTURERS
24	PAKISTAN CABLES LTD.	PRIVATE	MANUFACTURERS
25	PAKISTAN CYCLE INDUSTRIAL CO-OPERATIVE SOCIETY LTD	PUBLIC	MANUFACTURERS
26	PAKISTAN ENGINEERING SERVICES (PVT) LTD.	PRIVATE	CONSULTING ENGINEERS PLANNERS AND ARCHITECTS
27	PAKISTAN MACHINE TOOL FACTORY	PUBLIC	MANUFACTURERS
28	PAKISTAN STEEL	PUBLIC	MANUFACTURERS
29	PECO PAKISTAN ENGINEERING COMPANY LTD	PUBLIC	MANUFACTURERS
30	PEPAC	PUBLIC	ENVIRONMENTAL PLANNING AND ARCHITECTURAL CONSULTANTS
31	PROGRESSIVE CONSULTANTS	PRIVATE	CONSULTING ENGINEERS PLANNERS AND ARCHITECTS
32	REPUBLIC ENGINEERING CORPORATION (PVT) LTD	PRIVATE	CONSULTING ENGINEERS PLANNERS AND ARCHITECTS
33	RIST CONSULTANTS LTD	PRIVATE	ARCHITECTS, TOWN PLANNERS AND STRUCTURAL ENGINEERS
34	SIEMENS PAKISTAN ENGINEERING CO LTD.	PRIVATE	MANUFACTURERS
35	TECHNO - CONSULT LTD.	PRIVATE	CONSULTING ENGINEERS
36	UNICON INTERNATIONAL	PRIVATE	ARCHITECTS, ENGINEERS, PLANNERS AND MANAGEMENT CONSULTANTS
37	VENDOR DEVELOPMENT CORPORATION TRAINING CELL	PUBLIC	VENDOR DEVELOPMENT AND TRAINING CELL (PACO)
38	ZAFAR AND ASSOCIATES	PRIVATE	CONSULTING ENGINEERS PLANNERS AND ARCHITECTS
39	ZEAL (PRIVATE) LTD.	PRIVATE	ENGINEERING CONSULTANTS AND MANUFACTURERS

TABLE 2 CASE USERS, BY INDUSTRIAL SECTOR, RESPONSE TO QUESTIONNAIRE

COMPANY CLASSIFICATION PROVIDED IN TABLE 1		TOTAL	PERCENT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NUMBER QUESTIONNAIRES RECEIVED																		
NO. OF STAFF																		
NO. OF BUSINESSES																		
NO. OF BUSINESSES PCS ISSUED																		
NO. OF PCS IN USE AND COMPUTER AVAILABLE																		
NO. OF PLANTOPS																		
SOFTWARE FOR KNOWLEDGE BASED SYSTEMS USE	KBSS PROCESSING	16	46				1	1		1							1	
	SPREAD SHEET	16	46				1	1		1							1	
	DATA BASE	14	36					1		1							1	
	STRUCTURED OR OTHER ANALYSIS	16	46				1	1	1	1	1				1		1	1
	CASE	15	38			1	1	1	1								1	
NO. OF BUSINESSES PURCHASED KB CASE		4	11															
COMPUTER INVESTMENT DECISIONS BID	TO DATE			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NEXT FUTURE MONTHS			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NEXT FIVE YEARS			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RESTRAINTS	UNDERSTAFF AWARENESS	18	46		1	1			1			1					1	
	ORGANISATIONAL ATTITUDES	11	28		1						1	1						
	LACK OF COMPUTER LITERACY	13	33	1		1					1							
	LACK OF PROFESSIONAL SKILLS	6	15	1				1		1	1							
	LACK OF TECHNICAL SKILLS	13	33	1	1	1					1							
	LACK OF TRAINING FACILITIES	16	46	1	1	1		1				1			1		1	
	LACK OF FINANCE	14	36	1	1		1	1		1		1					1	1
	RESPONSE BY COMPANY GROUPS	8	21						1						1		1	
	FINANCIAL JUSTIFICATION	14	36			1			1						1		1	
	KBS NOT APPROPRIATE FOR WORK PERFORMED	2	5		1			1		1							1	
	LACK OF SUITABLE HARDWARE	7	18				1	1				1						
	LACK OF SUITABLE SOFTWARE	16	46	1			1	1			1	1					1	
	POOR VENDOR SUPPORT	12	31			1			1		1	1					1	
KBS HAVE BEEN USED FOR THE NO. OF YEARS				1	-	-	1	-	88	88	-	88	88	-	88	-	88	88
KBS HAVE BEEN PRODUCTIVE FOR THE NO. OF YEARS				1	1	1	1	-	1	-	1	1	88	1	-	-	1	-
EXPERTISE	COMPETITIVE	14	36										1				1	1
	POOR RESULTS	25	64	1	1	1	1	1	1	1	1	1		1	1	1		
	SPEED	12	31	00		1				1		1	1	1			1	1
	ECONOMY	15	38	00								1	1	00			1	
SPECIFIED QUALITY	DESIGN ARBITRARY, FACILITY	1	25			1							1				1	
	ACCURACY/CONSISTENCY	14	36	00		1						1	1		1		1	1
	TO BETTER STAFF	2	5				1											
	FUNCTION NOT POSSIBLE OTHERWISE	9	25							1			1	00			1	

COMPANY CLASSIFICATION PROVIDED IN TABLE 1		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
NUMBER QUESTIONNAIRES RECEIVED																									
NO. OF STAFF																									
NO. OF BUSINESSES																									
NO. OF BUSINESSES PCS ISSUED																									
NO. OF PCS IN USE AND COMPUTER AVAILABLE																									
NO. OF PLANTOPS																									
SOFTWARE FOR KNOWLEDGE BASED SYSTEMS USE	KBSS PROCESSING						1																		
	SPREAD SHEET						1																		
	DATA BASE						1																		
	STRUCTURED OR OTHER ANALYSIS						1																		
	CASE						1																		
NO. OF BUSINESSES PURCHASED KB CASE							100																		
COMPUTER INVESTMENT DECISIONS BID	TO DATE	0.0					0.0																		
	NEXT FUTURE MONTHS	0.0					0.0																		
	NEXT FIVE YEARS	0.0					0.0																		
RESTRAINTS	UNDERSTAFF AWARENESS						1																		
	ORGANISATIONAL ATTITUDES						1																		
	LACK OF COMPUTER LITERACY						1																		
	LACK OF PROFESSIONAL SKILLS						1																		
	LACK OF TECHNICAL SKILLS						1																		
	LACK OF TRAINING FACILITIES						1																		
	LACK OF FINANCE						1																		
	RESPONSE BY COMPANY GROUPS						1																		
	FINANCIAL JUSTIFICATION						1																		
	KBS NOT APPROPRIATE FOR WORK PERFORMED						1																		
	LACK OF SUITABLE HARDWARE						1																		
	LACK OF SUITABLE SOFTWARE						1																		
	POOR VENDOR SUPPORT						1																		
KBS HAVE BEEN USED FOR THE NO. OF YEARS		1	1.5	-	-	-	88	-	-	-	-	-	88	-	-	-	88	-	-	88	-	-	-	-	-
KBS HAVE BEEN PRODUCTIVE FOR THE NO. OF YEARS		1	1	1	1	1.5	88	1	88	2	-	1	1	-	-	1	1	-	-	1	1	88	1	-	88
EXPERTISE	COMPETITIVE																								
	POOR RESULTS		1																						
	SPEED			1	00		1		1				00	00	1		1			1	1	1	1	1	1
	ECONOMY			1			1		1	00		1	00	00			1			1	1				
SPECIFIED QUALITY	DESIGN ARBITRARY, FACILITY		00		00	00	1		1						1										1
	ACCURACY/CONSISTENCY		00		00		1		1				00												1
	TO BETTER STAFF																								1
	FUNCTION NOT POSSIBLE OTHERWISE				00		1		1																1

KEY:

AI ARTIFICIAL INTELLIGENCE
FL FUZZY LOGIC
IC INTERFACE CONTROL
PCS POINTED CLOSEST BOARD DESIGN

TABLE 3 SYSTEM SUPPLIERS, TRAINING ORGANISATIONS AND FINANCE HOUSES CANVASSED DURING THE SURVEY

COMPANY		TYPE OF SUPPORT							
		SOFTWARE		TRAINING			MAINTAINANCE		SOFTWARE DEVELOPMENT
	FINANCIAL	HARDWARE	ENGINEERING	COMMERCIAL	OPERATING	LANGUAGE	APPLICATION	HARDWARE	SOFTWARE	
ABN DATA SYSTEMS (PVT)		DATA GENERAL TELEVIDEO				X		X	X	
APOLLO COMPUTERS		APOLLO						X		
CGS COMPUTER GRAPHICS AND SYSTEMS		COMPAQ CONVERGENT TECHNOLOGY	AUTOCAD				X			
DIGITAL CORPORATION (PVT)		SPERRY, FORTUNE, ICL AT ELECTRONICS	X	X	X	X		X	X	X
FAST MUST SYSTEMS (PVT) LTD.		ACER	AUTOCAD		X			X		
EGS ELECTRONICS AND GENERAL SERVICES (PVT) LTD.		IBM, TELEVIDEO, ZENITH COMPAQ, VAX		X			X	X	X	X
IBM INTERNATIONAL BUSINESS MACHINES		IBM		X	X			X		
IBS INTERNATIONAL BUSINESS SYSTEMS		WEARNES TECHNOLOGY		X						X
ICSL INTERNATIONAL COMPUTER SERVICES LTD.		VARIOUS	PAFEC	X	X	X	X	X	X	X
INNOVATIVE COMPUTERS		VIP	AUTOCAD	X	X	X	X	X	X	X
INSTITUTE OF ELECTRICAL ENGINEERS						X	X			
JAFFER BROTHERS (PVT) LTD.		VAX			X	X		X		
NDFC NATIONAL DEVELOPMENT FINANCE CORPORATION	X									
NORSK DATA PAKISTAN (PVT)		NORSK DATA	NORSK DATA	X	X	X	X	X	X	X
OFFICE SYSTEMS INTERNATIONAL		2nd HAND		X				X		X
PAKISTAN COMPUTER BUREAU						X	X			