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DP/IND/SSR.A/1037  
14 July 1968  
ENGLISH

ESTABLISHMENT OF AN ELECTRONIC SERVICE AND TRAINING CENTRE,  
RAMNAGAR, U.P.

DP/IND/85/062

INDIA

Technical report: Printed circuit board design laboratory\*

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

Based on the work of W. Bosshart  
Expert in PCB Design Technology

Backstopping officer: J. FURKUS, Engineering Industries Branch

United Nations Industrial Development Organization  
Vienna

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## 1. INTRODUCTION

### 1.1 Generally

The setting up of electronics facilities, as planned in the Project Document for ESTC Ramnagar, is indeed a complex and pioneering task. It is therefore not surprising that to progress in the implementation needs a little bit more time than what was stipulated in the mentioned document. Nevertheless, in the long run it is the direction which counts and the actions taken so far are definitely pointing towards the right goals.

The process of creating such servicing and training facilities should go, to the extent possible, in parallel with the growth of the industries to be served. While planning and commissioning of ESTC's facilities can be considered to be a relatively straight forward task, the start and growth of the related industries within the surroundings is without any doubt a more complex process.

Factors like the following play a crucial role:

- Market and marketing of electronic goods
- Availability of trained entrepreneurs and manpower
- Credit terms
- Facilities like land, shed, power and water connection given at special terms to the prospective entrepreneurs
- Specialized advice and know-how available on request
- Availability of testing and servicing facilities

The fully implemented ESTC should thus be able to give support in almost all the points mentioned above. Furthermore, the close proximity of ESTC to the concerned industries and a simple administrative access will help in an optimal use of the services.

## 1.2 Consultant's mission

Job description	DF/IND/85/062/11-62
Post title	Consultant in PCB Design Technology
Duration	Two and a half months in split missions
First mission	12 - 27 May 1988 (2 weeks)

- a) Check with and advise project authorities on work plans regarding the set up and operation of PCB design section within the project for training purposes.
- b) Advise project authorities on facilities required for setting up of PCB design training section within the project.
- c) Assist in selection of candidatures for training abroad, in suggesting their training programmes and advise on possible places for the training of project personnel in the field of printed circuit boards.
- d) Prepare training syllabus in the field of PCB design.
- e) Train project trainers in PCB designs and supervise them in training Complex industrialists.
- f) Provide advisory services to Complex industrialists and advise them on the requirements for starting PCB activities in their units.
- g) Establish liaison with large electronic units to make use of their facilities.
- h) Prepare a detailed report on each split mission reflecting the course and results of the field assignments, especially in view of specific conclusions and recommendations for follow-up actions.

The current state of the project implementation suggested to concentrate during this mission only on a selection of above duties. It was discussed with Dr Pramod Kumar, Director (Technical) on 17 May 1988 and agreed on points a, b, d and h (bold printed); the other points will be considered during subsequent missions.

## 2. MISSION SCHEDULE, ACTIVITIES AND OBSERVATIONS

### 2.1 Schedule and activities

12.5.88 Afternoon: Journey Karachi - New Delhi

13.5.88 Briefing at UNDP New Delhi:

- M Islam, Senior Industrial Development Field Adviser (UNIDO)
- M Ramachandran, Senior Programme Officer & Chief Programme I (Industry), UNDP India
- A K Basak, Industrial Advisor, Small Industries Development Organisation, Ministry of Industry, Govt of India  
Meeting was held at Nirman Bhawan
- L J Jeyaraj, Principal Director, ESTC Ramnagar
- S V Singh, Senior Scientific Officer, ESTC Ramnagar
- Finance Officer (travel allowance)
- Study of Project Document and correspondence regarding ESTC Ramnagar

14.5.88 Saturday: Free day

15.5.88 Journey New Delhi - Ramnagar, along with S V Singh

16.5.88 ESTC Ramnagar:

- Introduction to ESTC and Complex by Dr Pramod Kumar Director (Technical)
- Study of
  - a) Technical Report on PCB manufacturing laboratory by H Hoeger, 16 March 1988
  - b) Minutes of meeting concerning PCB equipment Vienna, 20/21 April 1988
- Various discussions with Dr Pramod Kumar / S V Singh regarding PCB manufacturing equipment selected

17.5.88 ESTC Ramnagar

- Morning: Report writing
- Afternoon: Specifying equipment needed for training in PCB Design

- 18.5.88 Public holiday (Idl Fitr)  
- Working in hotel on training concept ESTC and general course objectives
- 19.5.88 ESTC Ramnagar  
- Morning: Report writing  
- Afternoon: Planning PCB design facilities
- 20.5.88 ESTC Ramnagar  
- Planning PCB design equipment and discussing it with Dr Pramod Kumar
- 21.5.88 ESTC Ramnagar  
- Morning: Layout PCB Design facilities  
- Afternoon: Discussions with Principal Director about mission progress and report details
- 22.5.88 Sunday: Free day
- 23.5.88 ESTC Ramnagar  
- Morning: Syllabus PCB Design  
- Afternoon: Report preparation
- 24.5.88 - Morning: Visit to Compact Circuits & Systems Ltd. Sultanpurpatti/Kashipur;  
Mr Rao, Production Manager (Chem Eng)  
- Afternoon: Various discussions & report preparation at ESTC Ramnagar
- 25.5.88 ESTC Ramnagar  
Report preparation and discussing contents
- 26.5.88 - Morning: Final discussions on mission with Principal Director and Director (Technical) at ESTC  
- Afternoon: Journey Ramnagar - New Delhi
- 27.5.88 UNDP New Delhi  
Discussion on mission with Mr M Islam, Senior Industrial Development Field Adviser (UNIDO);  
handing over of Mission Report (draft version)  
  
Evening: Return to Karachi

## 2.2 Observations

16.5.88 FCB manufacturing equipment import: List with supplies under discussion could have included few more of the big international companies which may even have their representatives in India.

No order has been placed so far for following essentially required items which are locally available.

- air compressor unit
- air suction facilities for plating line
- reprographic camera

Project authorities have been reminded on this.

Few of the items considered for import might as well be locally available, such as

- Medium- & high-speed drilling machines for PCBs
- Laboratory-type electroplating line
- Resist laminator
- Bench-type vacuum exposure unit
- Photoresist spray-developer, stainless steel

However, quality of such locally made equipment must carefully be checked. Costs if locally made are usually less.

19.5.88 So far, there has no training concept for the training of matriculates been worked out at ESTC. Modular concept, proposed by consultant, is discussed with Director (Technical).

21.5.88 Principal Director now also available at ESTC and introduced to training concept proposal

24.5.88 Visit to Compact Circuits & Systems Ltd., Sultanpurpatti/Kashipur:  
Most of equipment imported from USA; investment approx Rs.2.3 crores. Plating line from Ronus Industries Ltd. Bombay; investment Rs.22 lakhs. Alternate offer for plating line from Grauer & Weil Ltd., Bombay; about same price.  
Small PCB design section using PC with Processor 80386 and EGA; software package REDCAD from Racal-Redac which includes digital circuit design. Pen-plotter from HP (axial-type).  
Company now going for sample production, full-swing after few more month. Only facilities of this sophistication in UP for the near future.  
Staff: Some key staff hired which worked in other PCB setups before. Expertise now to be built up under guidance of Managing Director with corresponding experience acquired in USA.



### 3. TRAINING CONCEPT AT ESTC

According to the project document, training facilities have to be planned for the following intakes:

#### Matriculates

Training subject:	Production and assembly
Training period:	6 months
Yearly intake:	Two times 50 trainees

#### Engineers / Diploma holders

Training subject:	Testing and quality control
Training period:	3 months
Yearly intake:	15 trainees

Training subject:	Repair and maintenance
Training period:	3 months
Yearly intake:	15 trainees

### 3.1 Training of matriculates in production and assembly

#### 3.1.1 Training contents

The type of training given here must be highly practical so that the skills can directly be applied afterwards in electronics industries. Nevertheless, it is a must to give also a minimum exposure to electronics theory, in particular to components and measuring techniques. Therefore, about one third of the time might as well be spent in the classroom.

It is strongly suggested to group the contents of the training into 6 independent modules of one month duration. The advantage of the modular concept is not only a full utilizing of the laboratories and workshops available but also the possibility of individual modules which can be offered to people from industries with very specific training requirements. From the educational point of view, however, it is advisable to complete first the modules on electronic components and measuring techniques before going on to the other modules.

Here the list of the 6 modules:

- Electronic Components  
General objectives later in this report
- Measuring Techniques  
General objectives later in this report
- Soldering and Assembly
- PCB Manufacturing
- PCB Design  
General objectives later in this report
- Wire-wound Components

Preparation schedule:

(Needs to be further specified by concerned authorities)

	:Electronic: :Components:	:Measuring :Techniques:	:Soldering :& Assembly:	:PCB Manu- :facturing:	:PCB :Design	:Wire-wound: :Components:	:
:General	:UNDP/	:UNDP/	:UNGP/	:UNDP/	:UNDP/	:UNDP/	:
:Objectives	:Bosshart	:Bosshart	:?	:	:Bosshart	:?	:
:	:	:	:	:	:	:	:
:Deadline	:ready	:ready	:?	:May 68	:ready	:?	:
:Syllabus	:?	:?	:UNDP/	:UNDP/	:UNDP/	:UNDP/	:
:prepared	:	:	:?	:	:Bosshart	:?	:
:	:	:	:	:	:	:	:
:Deadline	:?	:?	:?	:?	:ready	:?	:
:List of training	:n.a.	:?	:UNDP/	:UNDP/	:UNDP/	:UNDP/	:
:equipment	:	:	:?	:Hoeger	:Bosshart	:?	:
:	:	:	:	:	:	:	:
:Deadline	:	:?	:?	:ready	:ready	:?	:
:Course details	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:
:incl. exercises	:?	:?	:?	:?	:?	:?	:
:	:	:	:	:	:	:	:
:Deadline	:?	:?	:?	:?	:?	:?	:
:Equipment and	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:
:exercise materials:	:?	:?	:?	:?	:?	:?	:
:	:	:	:	:	:	:	:
:Deadline	:?	:?	:?	:?	:?	:?	:
:Course notes	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:ESTC/	:
:prepared	:?	:?	:?	:?	:?	:?	:
:	:	:	:	:	:	:	:
:Deadline	:?	:?	:?	:?	:?	:?	:

### 3.1.2 Batch-organisation for practical training

Because of the workplace limitations when giving practical training, it is suggested to split the group of 50 trainees into four batches with approximately 12 trainees. Each one of these batches will go through the whole program in a different sequence. The first two modules, however, will always be Electronic Components and Measuring Techniques in either order.

	Electronic Components	Measuring Techniques	Soldering & Assembly	PCB Manufacturing	Hand-Design	PCB Design	Wire-wound Components
1st Month	Batch 1+2	Batch 3+4					
2nd Month			Batch 3+4	Batch 1+2			
3rd Month				Batch 3	Batch 1	Batch 4	Batch 2
4th Month				Batch 4	Batch 2	Batch 1	Batch 3
5th Month				Batch 1	Batch 3	Batch 2	Batch 4
6th Month				Batch 2	Batch 4	Batch 3	Batch 1

### 3.1.3 Electronic Components: General objectives

After going through the 1-month training module, the trainee is able to

- identify components on a PCB, i.e. whether it is a resistor, capacitor, electrolytic capacitor, diode, fuse, LED, IC (SSI, MSI, LSI), Transistor, DIP switch, transformer, inductor, a zener diode, thyristor, relay etc.
- explain necessary handling/soldering/assembly precautions for listed components
- read component value colour code
- name at least one electrical parameter characterising each of the listed component (-family)
- explain in simple words the difference in analog and digital signal processing
- describe at least one condition which may destroy listed components
- indicate rough price of most typically used representatives (values) of such components
- name at least one company in India (if not applicable then foreign) manufacturing listed components
- draw symbol of 10 different discrete components

### 3.1.4 Measuring Techniques: General objectives

After going through the 1-month training module, the trainee is able to

- explain difference between AC and DC
- apply Ohm's law calculations in practical situations and verify
- measure current, voltage, resistance and diode polarity by using a multimeter
- measure capacitance and inductivity by using a LC-bridge
- properly connect a simple oscilloscope to a working circuit and read AC- and DC signal voltages
- measure and calculate time constant of R-C components in highpass- and lowpass configuration
- measure clock frequencies using oscilloscope and frequency meter
- measure temperature using electronic temperature meter
- read simple circuit diagram and identify the relating components of actual circuit

### 3.2 Training of engineers/diploma holders

Although specialising in testing and quality control, respectively in repair and maintenance, their practical working is as much related to production and assembly. It is therefore suggested to let them go through one-week modules in the following specialities:

- Soldering & Assembly	1 week
- PCB Manufacturing	1 week
- PCB Design	1 week
- Wire-wound Components	<u>1 week</u>
totally	<u>4 weeks</u>

This will take one month of their 3-month training period; it can be justified because they probably will not have much previous experience in electronics production.

A good time to run this program will be the first or second month of the matriculate's training when the corresponding workshops or laboratories are not utilised. For the engineers/diploma holders, the program is best conducted at the beginning of the training period.

#### 4. TRAINING FACILITIES FOR PCB DESIGN

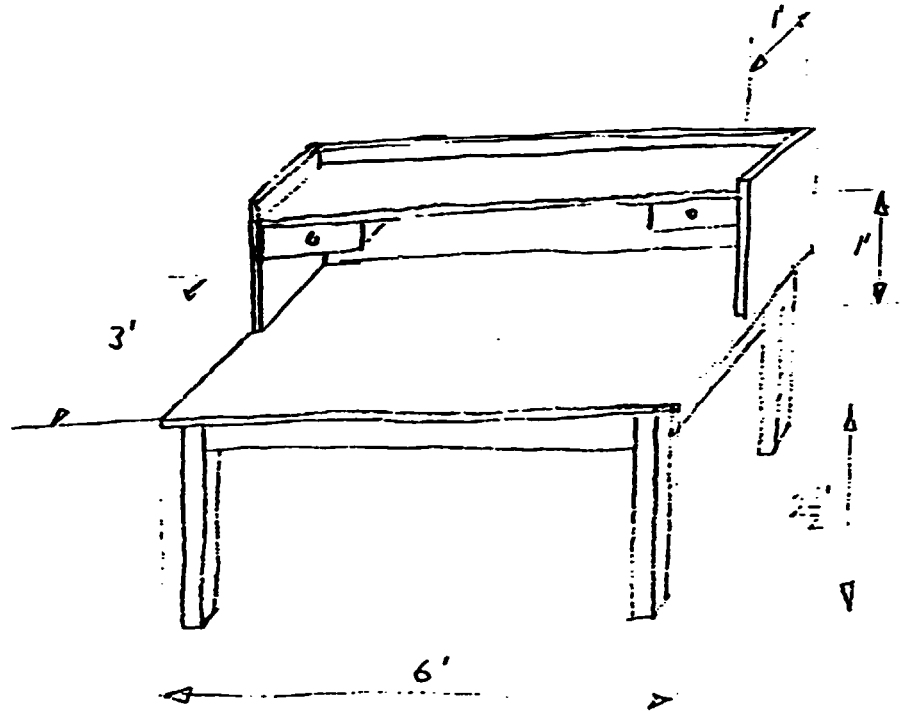
##### 4.1 Equipment and software

The requirements specified here care of a batch size of typical 12 trainees which results of the modular concept suggested under heading 3.1.

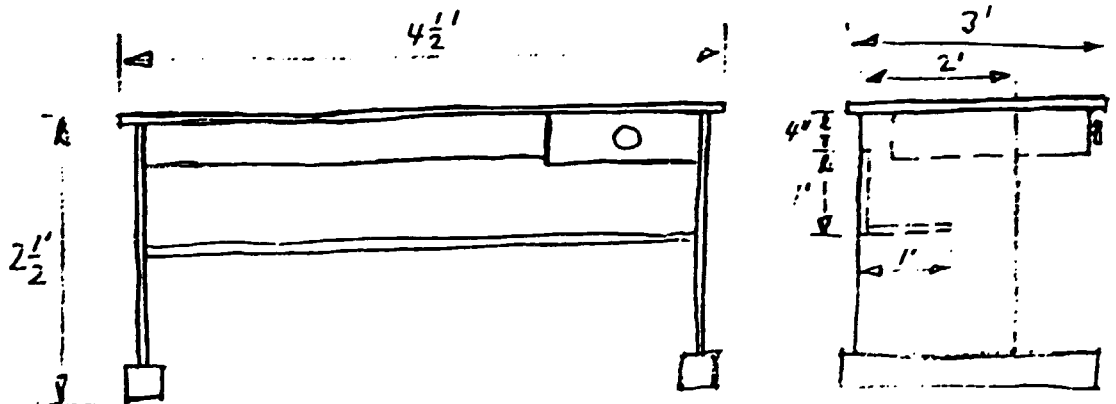
##### Furniture:

Nos.	Item	Approx costs	
		India [Rs]	Import [US\$]
6	Designer's table (Sketch on page 13) wood, Formica top, 6' x 3' x 2.5' with top shelf and 2 drawers	10'000	
12	Stool to designer's table, wood	1'800	
3	Computer table (Sketch on page 13) wood, Formica top, 4.5' x 3' x 2.5' with shelf below and 1 drawer	6'000	
3	Chair with armrest to computer table	1'200	
1	Almirah cupboard standard steel-type, 6.5' x 3' x 1.5'	2'500	
1	Table general-type, 5' x 3' x 2.5', 1 drawer	1'500	
1	Drawer cabinet for artwork storage standard steel-type min drawer size 2' x 4', min 6 drawers e.g. Godrej 6-drawer plan cabinet	3'000	
1	Blackboard wall mounted, 8' x 4', with chalk board	500	
1	Artwork inspection table transilluminated e.g. Monotype India, Model 441	6'000	
2	Drafting machine, pantograph-type	10'000	
		-----	
Total furniture		42'500	-
		-----	

DESIGNER'S TABLE:



COMPUTER TABLE:



Computer:

Nos.	Item	Approx costs	
		India [Rs]	Impo [US\$]
1	AT-Compatible 1 MB RAM, min 4.77/8 MHz, 20 MB harddisk EGA standard, 14" EGA monitor Floppy drive 1.2 MB, coprocessor 80287 serial- and parallel port incl digitizer pad	75'000	
2	XT-Compatible 640 KB RAM, min 4.77/8 MHz, 20 MB harddisk CGA standard, 14" CGA monitor Floppy drive 360 KB, coprocessor 8087 serial- and parallel port incl digitizer pad	100'000	
1	Uninterruptible power supply 2'500 VA for 30 min, incl line conditioner, voltage stabilizer, battery etc.	150'000 ) <sup>1</sup>	
1	Dot-matrix printer 132 column, min 150 cps, NLD capability	16'000	
1	Pen plotter A1-size, multi-pen & axial type		10'00
Total computer		341'000	10'00

)<sup>1</sup> Price was indicated by Dr Pramod Kumar. To the consultant it seems rather high, about one half of it would be international market price. Line conditioner for training purposes not essential, normal provisions in PCs should be sufficient.

Software:

1	PCB CAD package  <u>PCB TURBO:</u> single- & double-sided PCBs max size 600x600mm, 9 different conductor widths, 9 types of solder pads, 3 text sizes, 13 cursor step sizes, 6 scaling factors, auto- routing, 0.1" grid, English/German, mouse support Supplier: Oswald Boll AG, P.O.Box, CH-8702 Zollikon, Switzerland		2'50
Total software		-	2'50



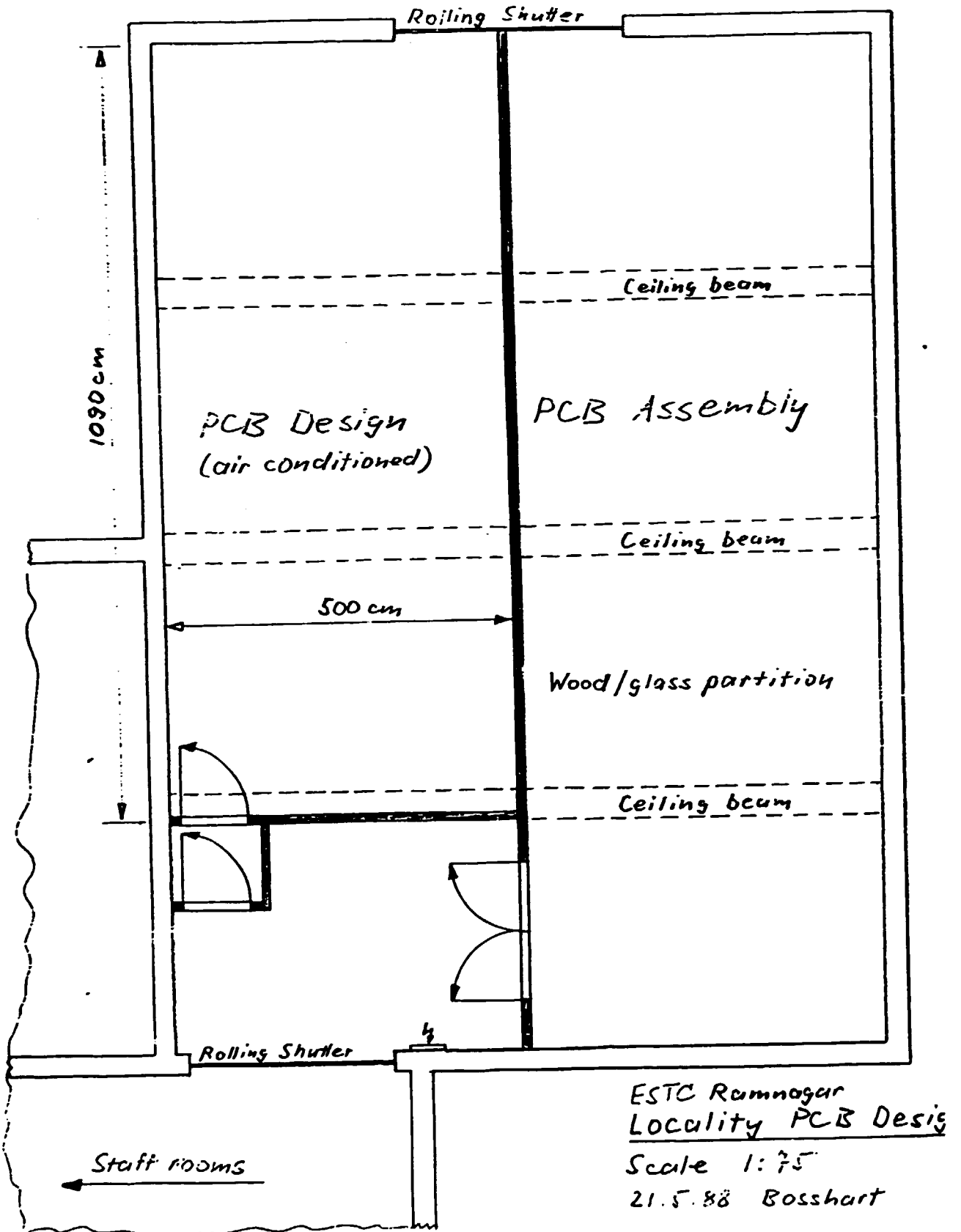
Various:

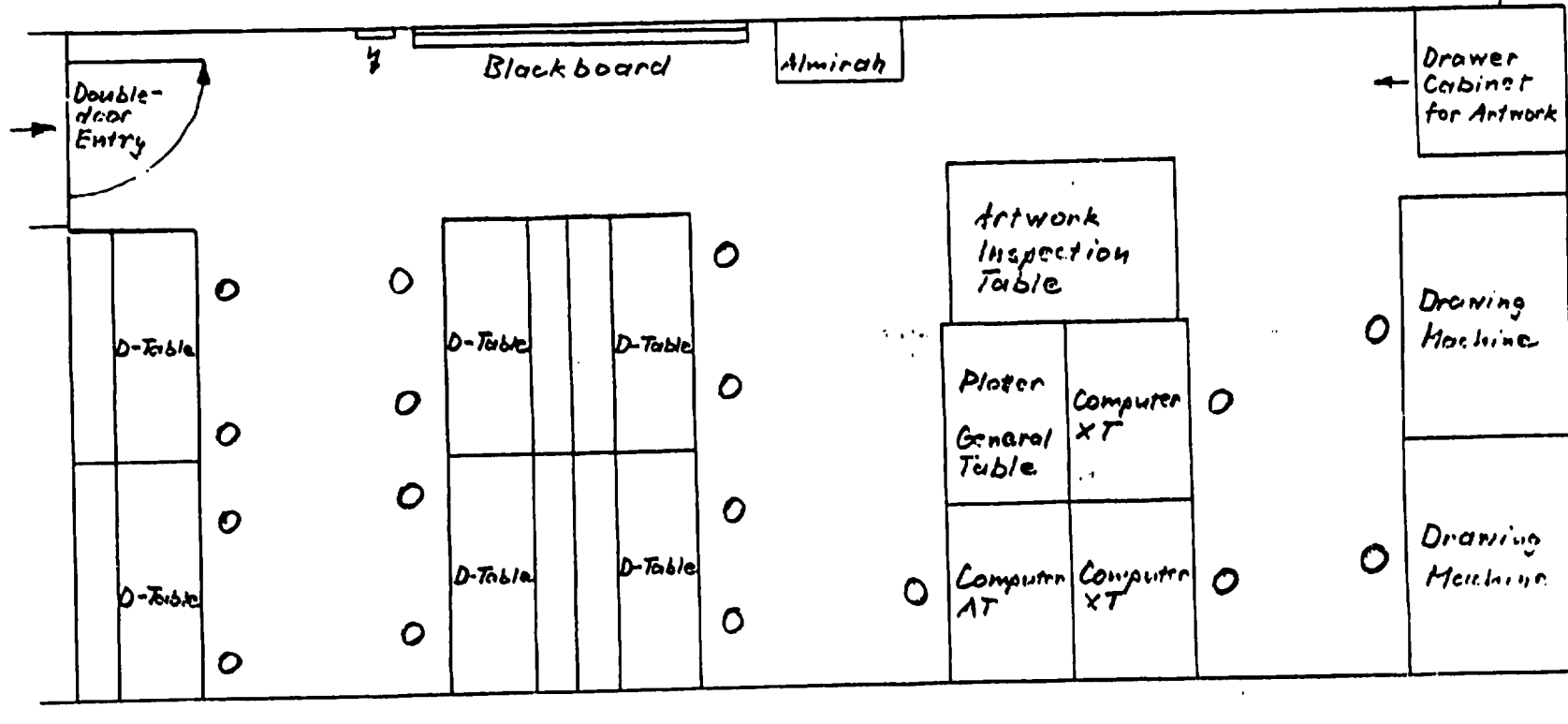
Nos.	Item	Approx costs	
		India [Rs]	Import [US\$]
	Various artwork materials tapes, pads, connectors etc.	8'000	
8	Ink drawing set different pens, stencils etc.	15'000	
3	Air conditioning unit 1.5 ton	60'000	
Total various		83'000	-

\*\*\*\*\*

<u>Total cost figure for equipment and software:</u>	[Rs]	[US\$]
Furniture	42'500	
Computers	341'000	10'000
Software		2'500
Various	83'000	
Total	466'500	12'500

### 4.2 Locality and layout





○ = Stool/Chair  
 D-Table = Designer's Table

ESTC Ramnagar  
 Layout, PCB Design

Scale 1:50

21.5.88 Bosshart

### 4.3 Course contents

#### 4.3.1 General objectives

After going through the 1-month training module in PCB Design, the trainee is able to

- prepare manually and independently the layout of a simple, double-sided PCB according to component list/dimensions and circuit diagram.
- manufacture film masters for single- and double-sided PCBs
- design and fabricate artwork which confirms established practice rules (e.g. with respect to conductor spacing, border spacing, conductor width, solder pad diameter, electromagnetic stability, component density, etc.)
- name at least 6 measures in PCB layout which make later PCB servicing/calibration/repair easier
- produce artwork for simple circuit by inking method
- produce artwork for single-sided PCB by taping method
- produce medium-complexity layout with interactive CAD software on a personal computer
- plot artwork of CAD layout on pen-plotter
- draw mechanical- and assembly drawing of a PCB

#### 4.3.2 Syllabus

##### Layout planning:

Scale, grid system, board types

Practical layout procedure

Documentation of PCB: Circuit diagram, component list, layout sketch, mechanical drawing, assembly drawing

##### Layout, rules and parameters:

Resistance of conductor

Capacitance between adjacent conductors and between conductors on opposite sides of PCB

Realising supply- and ground conductors

Special considerations for supply- and ground lines of digital circuits

Component placing procedure

Component mounting

Checking the layout with respect to general-, mechanical- and electrical considerations

##### Manual artwork preparation:

Ink drawing

Taping method

General rules regarding conductor routing, spacing

Hole diameter and solder pad diameter

Component polarity identification

Artwork check- and inspection procedures

##### Computer aided layout/artwork preparation:

Handling of the personal computer and loading of software

Performance and limits of using the software package

Initial settings before starting with the layout

Practical procedures

Draft printing of artwork on dot-matrix printer

Final plotting of artwork on pen-plotter

##### Film master fabrication:

Characteristics of reprographic film

Processing steps

Setting for optimum exposure

Precautions for accuracy, registration, handling, etc.

Retouching

4.4 Schedule of implementation

	: 1988							: Responsible :
	: Jun :	: Jul :	: Aug :	: Sep :	: Oct :	: Nov :	: Dec :	
: Approve concept	XXXXX	XXXXX						: PNC / ESTC :
: Approve funds	XXXXX	XXXXX	XXXXX					: ESTC / UNDP :
: Get quotations	XXXXX	XXXXX	XXXXX					: ESTC / UNDP :
: Evaluate quotations					XXX			: ESTC / UNDP :
: Place orders					XXX			: ESTC / UNDP :
: Delivery of equipment						XXXXX	XXXXX	: ESTC :
: Install equipment						XXXXX	XXXXX	: ESTC :
: Start training trainers							XXX	: UNDP / ESTC :

## 5. SUMMARY AND RECOMMENDATIONS

### 5.1 Training in PCB Design

The facilities suggested make it possible to train a group of approximately 12 trainees in the different methods currently used to produce PCB layouts and artwork. The manual layout method is included since it is still very popular and cost-effective in India for laying out of simpler circuits. Furthermore, a designer able to produce a manual layout, will definitely better understand CAD with its different routines and thus also produce better CAD results. Similar applies to artwork production where also inking/taping techniques are exercised before using CAD assistance.

This 1-month training program should fit into the 6-month training period planned for matriculates. It is strongly suggested to divide this 6 month period into 6 modules of 1 month duration which together care fully of the envisaged training in production and assembly. The subject of these training modules:

- Electronics and Components
- Measuring Techniques
- Soldering & Assembly
- Wire-wound Components
- PCB Manufacturing
- PCB Design

Further details and recommendations to the organisation of this modular-structure training are contained in this report.

To implement the facilities for PCB Design, an approximate amount of Rs. 466'500.- and foreign exchange of US\$ 12'500.- will be needed.

For the staff-in-charge of the PCB Design section, the consultant suggests B.E. qualificiation in Electronics, eventually diploma holder with considerable experience. It is of high importance to have one person fully responsible (full-time) for the PCB Design section!

An implementation schedule has been proposed with installation starting in November 1988. This would fit with another 2-weeks mission of the consultant in December 1988 to supervise final installations and to give first training to the project staff concerned.

## 5.2 ESTC

The organisation of the Centre is still in its infancy stage with people at the helmet just joined few months back.

Since a sizeable number of technical as well as administrative staff will be recruited soon, the time would be ideal now to work on a staff structure/organigram. This could clearly reflect the direction in which the Centre will move. Such a staff organigram should be supplemented by individual job descriptions giving objectives in sufficient details. The advantage of such organising will be a much clearer concept for future actions and realistic visions.

Simultaneously, an implementation bar chart of the overall project activities could be developed. This would reflect, for each month and year, where energy and funds are going and which goals, even if minor ones, have already been achieved.

It should hardly be mentioned that such a Service & Training Centre relies on a good and effectively working administration. Administrative objectives, brought down to paper, could help in clarifying structure and type of staff to be recruited. This is to avoid technically specialized staff to spend substantial time on administrative procedures which normally discourages dedication and interest.

The availability of electrical power is another concern on which presently a proposal is worked out at ESTC. During the consultant's stay at ESTC, the availability from public supply was at about 60% of the time.

Probably the most crucial success parameter for ESTC is the attraction exercised on potential entrepreneurs to settle down the now available but still empty sheds of the complex. With the information available from the Department of Electronics and the active participation of UPTRON and related organisations, a concept could be worked out to indicate direction of further actions. This would also stimulate qualitative growth in ESTC's activities. Just to bring some life into the sheds, why not induce some TV assembly using ET&TDC's kits?



### 5.3 Mission and personal remarks

During the current mission of half month duration, the following tasks could by-and-large be completed:

- Check with and advise project authorities on work plans regarding the set up and operation of PCB design section within the project for training purposes.
- Advise project authorities on facilities required for setting up of PCB design training section within the project.
- Prepare training syllabus in the field of PCB design.

The primary contents of this report were discussed with the Principal Director and the Director (Technical) on consultant's last day at ESTC.

For the evaluation of quotations for the equipment suggested, a one-day meeting at UNDP New Delhi is proposed (around first half of September) in which the participation of the consultant is also desirable.

During this whole mission, the Director (Training) was unfortunately not available because of leave followed by sickness. His presence would definitely have had a positive impact on the results of the mission. In his absence, most of the discussions were held with Dr. Pramod Kumar, Director (Technical), since the Principal Director was out of station as well during the first half of the consultant's stay in Ramnagar.

Cooperation with the staff of ESTC was good and special thanks are expressed to Mr. L.J. Jeyaraj, Principal Director, and to Dr. Pramod Kumar, Director (Technical) for all their support and help.