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16755

DP/ID/SER.B/597
11 February 1988
ENGLISH

DEVELOPMENT OF NUMERICALLY CONTROLLED MACHINE-TOOLS

DP/DRK/84/001

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Terminal report

Prepared for the Government
of the Democratic People's Republic of Korea
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Henryk Orlowski, chief technical adviser

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United Nations Industrial Development Organization
Vienna

V.88-21531
5007T

Explanatory notes

The monetary unit in the Democratic People's Republic of Korea is the won (W).

Besides the common abbreviations, symbols and terms, the following have been used in this report:

CAD	computer-aided designing
CAM	computer-aided manufacturing
CNC	computerized numerical control
CTA	chief technical adviser
ICM	Institute of Controlled Machines
KB	kilo bytes = 1024 bits
m/m	man-months
NC	numerical control
NPD	pational project director
PC(board), PCB	printed circuit board
PLC	programmable logic controller
RAM	random access memory
R&D	research and development
ROM	Rrad only memory
TOKTEN	transfer of knowledge through expatriate nationals

Mention of the names of firms and commercial products does not imply the endorsement by the United Nations Development Programme (UNDP) or the United Nations Industrial Development Organization (UNIDO).

At the time of completing this report (January 1988), not all final figures were known. Such figures have been estimated as accurately as possible and marked by an asterisk (*).

The annexes to this report have not been formally edited.

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Annexes

INTRODUCTION

A. Project background

The Government of the Democratic People's Republic of Korea has recognized the development of numerically controlled (NC) machine-tools as the crucial goal for the national economy and not only for the machine building industry alone. The project was preceded by preparatory assistance delivered under the following projects:

DP/DRK/81/010, "NC machine-tools, equipment and methods"; and
DP/DRK/81/016, "Computerized technology for automation in industrial applications".

This assistance consisted of a study tour of six nationals to Austria, Federal Republic of Germany, India and Poland, as well as the provision of consultants' services. The mission of five UNIDO consultants, totalling 17 m/m, took place from February to May 1984 in order to:

(a) Evaluate the availability of local infrastructure to implement the project;

(b) Focus the aims of the future project on the most important and realistic objectives;

(c) Formulate training programmes for fellows to be sent abroad;

(d) Specify the equipment required for laboratories;

(e) Give lectures on chosen topics (microprocessor control, numerically controlled (NC) machine-tools, computer-aided designing (CAD), computer-aided manufacturing (CAM), and cutting processes), in order to prepare the local staff for their training programmes and their future work.

The consultants (Messrs. H. Orlowski, M. Bossak, J. Buc, Z. Wojcik and S. Zientarski) evaluated the situation, delivered lectures and produced a comprehensive report with findings and recommendations, including training programmes for 19 fellows (282 m/m) and purchase specifications and justifications for equipment. These lists had been agreed with the Government. It was also found, that two additional consultants (on servo-drives and printed circuit (PC) board manufacturing) should be placed for the same purposes, but for a shorter time (two months each). Later Messrs. S. Maliszewski and J. Michalski were fielded.

Based on the results of these missions, UNIDO prepared a project document for the large-scale project: "Development of numerically controlled machine-tools" (DP/DRK/84/001) with a budget of $US 2,367,700 and W20,257,500 (in kind), for a duration of 2.5 years. This project was approved on 24 September 1984.

B. Justification of the project

The Democratic People's Republic of Korea had a relatively large machine-tool building industry, including two major factories located at Huichon and Kusong. In the past machine-tools had been an important foreign exchange earner for the country. Approximately 50 per cent of the local production had been exported. However, in 1984, with the worldwide trend to apply numerically controlled machine-tools in the machine-building and metal-working industries, there was a danger that the volume of machine-tool export would decline unless the products would be modernized. In view of that, the Government intended to rehabilitate the existing machine-tool industry and to introduce progressively modern manufacturing techniques that would ensure higher efficiency, better product quality and competitiveness on the world market. The introduction of activities concerning NC machine-tools is not only important for the machine-tool building industry, but the application of such modern equipment is also indispensable in order to improve the quality of final products of many metal-processing industries. Therefore the UNDP/UNIDO assistance was invited in two areas:

(a) Designing and manufacturing of NC machine-tools; and

(b) Application of NC machine-tools.

Looking closely at designing and manufacturing of NC machine-tools one can distinguish two fields of activities: mechanical and electrical/electronic.

Mechanical activities deal with machine-tools themselves, and in particular with problems concerning designing (which in turn requires modern computer-aided methods), manufacturing and testing of machine-tools and their parts.

Electrical/electronic activities deal with control units, servo-drives and eventually the development of some components like measuring transducers (e.g. inductosyn and encoders) and DC servo-motors. To manufacture modern electronic and electric circuits one has to have access to PC board manufacturing facilities.

The application of NC machine-tools, besides the training of the user's staff, requires research in two main fields:

(a) Investigation of cutting parameters (e.g. measurement of cutting forces); and

(b) Development of programming methods for NC machine-tools, referred to as "computer-aided manufacturing" methods.

All afore-mentioned activities must be covered if the development of NC machine-tools is seriously considered. Therefore, these activities have been included in the project document as project objectives or outputs.

C. Implementing organizations

Because of the complexity of the project, the choice of the proper implementor was considered from the very beginning an important but also very difficult task. Designing and manufacturing are directly connected with industry; but even here at least three organizations were involved: Kusong and Huichon factories and the independent Design Office located in Kusong. But due to the lack of any background in electronic control and computer applications in the machine-tool building industry, an outside research and development organization had to be involved. In the Democratic People's Republic of Korea, the Academy of Sciences plays a crucial role in research and development for industry in general. The Academy consists of 42 different institutes and functions on the ministerial level. In 1984 two institutes, namely the Institute of Automation and the Institute of Mechanical Engineering, were commissioned to attain the important national goal of accelerating the introduction of modern methods of manufacturing to the machine-tool and machine-building industries. In the year 1985 the new Institute of Controlled

Machines was established, taking over parts of the premises, staff and equipment of the above-mentioned institutes. The director of the Institute of Controlled Machines, Li Jong Dok, was nominated as the national project director (NPD) and from the Government side, the Academy of Sciences was responsible for the implementation of the project. UNIDO was chosen as executing agency on behalf of the United Nations Development Programme and, in spite of the size and complexity of the project, no subcontractors were involved.

While it was advantageous to have to co-operate with only one organization and one government agency, this solution also had some shortcomings, the main ones being:

(a) The government bodies responsible for the machine-building industries were not enough involved in the project, and the Academy of Sciences had little influence on the machine-tool building factories;

(b) The staff of the new institute had only limited experience in NC machine-tools whereas for instance the staff of the Kim Chaek Technical University, having more than 10 years experience in this field, has not been involved in the project.

D. Monitoring of the project

In order to ensure the smooth implementation of the project, three levels of co-ordination and implementation control were planned:

Level 1: National Steering Committee chaired by the vice-president of the Academy of Sciences. The chairman was supposed to appoint the members of this Committee choosing appropriate directors of co-operating national institutes and ministries. The Committee was supposed to meet at least once every four months.

Level 2: Co-ordinating Group chaired by the national project director. The chairman was supposed to appoint directors of related institutes, factories, design offices and UNIDO chief technical adviser (CTA). The Committee was supposed to meet at least once a month and to invite a UNDP representative to attend each meeting.

Level 3: Working Group chaired by the national project director. The chairman was supposed to appoint national representatives as required and to invite the UNIDO CTA and, if necessary, other UNIDO consultants. The Working Group was supposed to meet once a week.

Meetings at all three levels were held regularly. They helped to monitor progress, and to anticipate and solve problems by taking the necessary measures in advance. However, in order to improve future work, some remarks may be permitted regarding the two upper levels:

(a) The level 1 body happened to have very little influence on organizations outside the Academy of Sciences, in particular on factories;

(b) The main shortcoming of decisions taken at levels 1 and 2 was the lack of setting a time frame for planned events and the lack of a clear indication of available resources (manpower, materials);

(c) Although this was laid down in the project document, the UNDP and UNIDO representatives, including the CTA, were never invited to participate in the level 2 meetings.

The tripartite review meetings, held once or twice each year (December 1985, May and December 1986 and September 1987) played a major role in the monitoring of the project. The CTA prepared five project progress reports, two project evaluation reports, one project performance evaluation report, a number of intermediate reports, and this terminal report.

I. THE PROJECT

The project is presented here as it was finally set up. Differences between the preliminary and the final project document are listed and discussed in chapter III.

A. Immediate objectives

The project had three immediate objectives:

1. To enable the national staff to employ and develop up-to-date technical methods in the design, manufacture and application of numerically controlled machine-tools.

Planned verifiers

A demonstrated capability to design and test NC machine-tools with the utilization of a fully operative cross-table with control system.

Achieved results

The cross-table and the control system were designed, manufactured, integrated and tested. Achieved parameters are presented in annex I.

2. To strengthen and broaden the Institute's facilities in order to enable the national staff to carry out research and development in the design and application of NC machine-tools.

Planned verifiers

The following adequately equipped laboratories:

- Laboratories for testing and evaluation of NC machine-tools including mechanical structures, control units, servo-drives and measuring devices;

- Design analysis and programming laboratories;

- NC system laboratories;

- Mechanical subassemblies, elements and cutting processes laboratories;

- Printed circuit laboratory;

- Servo-drive and transmission laboratory;

- Demonstration and training in the application of NC programming in machining laboratory.

Achieved results:

The following laboratories have been established through the project:

Abbreviation		Total staff	Researchers Total	Researchers Trained abroad
NC Machine-tool Laboratory	MTL	19	15	7
Control Unit Laboratory	CUL	16	12	2
Servo-drive Laboratory	SDL	18	14	4
Computer Laboratory	CL	18	14	3
Measuring Laboratory	ML	3	3	2
Sensor Laboratory	SL	19	12	1
PC Board Workshop	PCW	18	6	3
Total		106	76	22

The tasks listed in the project document are carried out by the following laboratories:

- Testing and evaluation of NC machine-tools: MTL and ML; mechanical structures: MTL and ML; control units: CUL; servo-drives: SDL; measuring devices: ML and SL;

- Design analysis and programming: MTL and CL;

- NC systems: CUL;

- Mechanical subassemblies, elements and cutting processes: MTL and ML;

- Printed circuits: PCW;

- Servo-drives and transmissions: SDL;

- Demonstration and training in the application of NC programming: MTL and CUL.

3. To elaborate a comprehensive and integrated long-range research and development programme in the areas mentioned under points 1 and 2 above, in accordance with the Government's Seven-Year National Industrial Development Plan.

Planned verifiers

Appropriateness and timeliness of planned outputs with regard to national development goals.

Achieved results

The programme has been elaborated and is attached as annex II.

B. Expected outputs

1. Design and manufacture of one cross-table with 2 axes, controlled by a fully operative CNC system, equipped with DC drives supplied by UNIDO, encoders in 2 axes and an inductosyn in the X-axis.

2. Operating laboratories with at least 30 qualified national staff undertaking the following major programmes:

- Development of the modular system of electronic boards for microprocessor control units;

- Development of programs and problem-oriented software;

- Development of measuring devices and methods;

- Development of control units for NC machine-tools and training of NC machine-tool users;

- Development of servo-drives.

3. Future research and development programme covering the above areas.

C. Achieved outputs and their utilization

1. Design and manufacture of a cross-table

The cross-table was designed, manufactured and integrated firstly with the CNC system type Sinumerik, bought by UNDP/UNIDO as a sample, and with the measuring system for inductosyns. Next, the Sinumerik control system was replaced by the locally developed control unit. These activities produced the following results:

(a) The capability has been gained to design, machine and assemble main subassemblies of any NC machine-tool, to manufacture friction-free plastic slides and to apply ball-screws. These skills are required for the design and manufacture of any NC machine-tool;

(b) The local personnel has learned how to integrate a CNC system with a drive system and a controlled machine. This knowledge is indispensable for both, the development of local NC machine-tools and the utilization of imported NC machine-tools or their components;

(c) The Institute of Controlled Machines is now equipped with the precision, laser-based instrumentation for the measurement of inductosyns. This is the basis for future research work to develop inductosyns, which serve as measuring devices for NC machine-tools.

2. Laboratories

Through the project seven laboratories have been established (see the list above) and, in the relatively short time of 1.5 years of their work, almost all of them achieved appreciable results which now serve for national economy and demonstrate laboratories' full capability for future work.

(a) Development of the modular system of electronic boards for microprocessor control units

With extensive assistance of UNIDO consultants, the modular system of electronic boards for microprocessor control systems has been developed in the Institute. The system consists of 18 different PC boards (modules) and is fully expandable. The modules were designed, manufactured and tested locally. They were used for a control unit for NC machine-tools (see below) to demonstrate their performance. However, they are not only suitable for different kinds of NC machine-tools, but also for industrial robots and other applications, where digital automation is required. The system includes two kinds of microprocessors (8 and 16 bit, respectively models Z-80 and 8086) and also enables the assembling of programmable logic controllers (PCL).

Thanks to the delivery of tools and components and a proper training of the personnel, nationals have also gained the ability to perform in two important fields:

(i) Manual designing of artwork for PC boards;

(ii) Assembly of electronic components on the PC boards.

For the development of a modern system of electronic boards, a facility for the manufacture (starting from artwork) of both single- and double-sided PC boards is indispensable. The PC Board Workshop had been recognized from the very beginning as a crucial element of this project, because no such facilities existed earlier in the Democratic People's Republic of Korea. Now, the PC Board Workshop is established and could serve both, the Institute of Controlled Machines and other research and development organizations. In fact, at present it is engaged in research work for the Kim Chaek Technical University.

(b) Development of programmes and problem-oriented software

On the basis of extensive training abroad of 16 fellows and the delivery by UNDP/UNIDO of software packages worth $US 135,683, the Institute has gained the capability to use and develop software in the following fields:

(i) Software for computer-aided designing (CAD) of machine-tools and their subassemblies;

(ii) Creation of control programs for NC machine-tools by application of computer-aided manufacturing (CAM) methods;

(iii) Software for CAD of PC boards.

This software is described in more detail in chapter II, section E, point 5.

(c) Development of measuring devices and methods

The development, manufacture and control of NC machine-tools calls for devices and methods of extremely high precision.

To measure and test NC machine-tools, the Measuring Laboratory has been established and equipped by UNDP/UNIDO with a comprehensive set of instruments of the most respected brands. A particularly valuable one is the laser interferometer with a software package for processing measured data. It enables quick measurement of linear dimensions with high accuracy. The staff was trained in its application both abroad and on the spot by UNIDO consultants. This laboratory is now operating and could be used not only for measuring and testing of NC machine-tools but also for all kinds of machine-tools. To increase accuracy and to extend the range of measuring, new methods must be developed and tested.

Each NC machine-tool incorporates devices for the measuring of positions in each of controlled axes, for which inductosyns and encoders are most commonly used. To deal with this task, the Sensor Laboratory has been established and the development of inductosyns is its major task. Due to limited resources, only a small input has been delivered here: no training, no consultants, no know-how, but only, as mentioned above, a measurement system for inductosyns. Therefore, for the manufacture of inductosyns the Laboratory utilizes only the technology delivered for the manufacturing of PC boards, and its output is smaller than that of other laboratories.

(d) Development of control units for NC machine-tools and training of NC machine-tool users

The Control Unit Laboratory now has the capability to develop control units for NC machine-tools, using the modular microprocessor control system described above. The capability is proved by having designed and manufactured the control unit for a cross-table.

The Laboratory is able to build prototypes of control units for various NC machine-tools according to the demand of the national industry.

(e) Development of servo-drives

The Servo-drive Laboratory has been established, its personnel trained, instruments bought and a consultant's assistance was provided. Research and development work was undertaken in the field of designing servo-drives for industrial robots.

3. Future research and development programme

The programme for future research and development activities covering NC machine-tools and related subjects has been elaborated (see annex II) and is now being fulfilled by the Institute of Controlled Machines and other organizations involved in this field.

D. Inputs

The following UNDP/UNIDO inputs were provided through the project:

1. Expertise

Expertise, totalling 76.9 m/m* was provided in the following fields: control systems based on microprocessor technique, interpolation in control systems, control systems, computer-aided designing (CAD), computer-aided manufacturing (CAM), NC lathe and cross-table design, NC machine-tool testing, machine-tool servo-drives, feed-back in control systems and their integration with machine-tools, interpolation and interfacing programming, software for NC control systems, PC board manufacturing, CAD for PC boards, mechanical structures for electronic circuits, measurement of mechanical parameters and assembling of electronic circuits. The above-mentioned man-months include the placement of the chief technical adviser (CTA) for 22.9 m/m who also served as consultant on microprocessor techniques.

2. Fellowships

The fellowships of a total of 250 m/m were provided for 28 fellows. This input is discussed in the chapter II, section C.

3. Equipment

UNDP/UNIDO delivered equipment worth $US 1,517,157* according to the specification elaborated during the preparatory mission (see annex III).

The Government's contribution for equipment was W8,020,000 (approximately $US 3,730,000), including the main-frame computer.

4. Total inputs

In total, the UNDP/UNIDO input was $US 2,503,498*.

The total Government's input was W.2,383,616 (approximately $US 10,000,000) which covered also buildings for laboratories and the PC board manufacturing workshop, personnel, local training and services for consultants (transportation, interpretation etc.).

II. IMPLEMENTATION OF THE PROJECT

A. Management of the project

The co-ordination of the project on the Government's side was assigned to the national project director (NPD). At the inception of the project this was Li Son Bong, Director of the Institute of Automation, and from 1985 on Li Jong Dok, Director of the Institute of Controlled Machines.

UNDP/UNIDO assigned, with the approval of the Government, S. Orlowski, UNIDO expert on microprocessor control systems, as chief technical adviser (CTA).

The project was monitored by a three-level co-ordination and implementation system (described in the Introduction, section D), tripartite review meetings held regularly each year (in 1986 twice), the every-day work of the backstopping officer and a special technical adviser, both in Vienna, the UNDP resident representative in Pyongyang and their staff.

For the management and monitoring of the project, 11 activities had been formulated and time-schedules (bar-charts) had been prepared for each of them. The list of the activities was as follows:

1. Training abroad;
2. NC lathe prototype;
3. NC milling-machine prototype;
4. Microprocessor modular control system;
5. Establishing of laboratory facilities in the Institute of Controlled Machines;
   - 5.1. Design and manufacture of a cross-table with a control system (activity amended later);
6. Main-frame computer installation;
7. Establishing of CAD/CAM activity and training facilities;
8. Application of one industrial robot;
9. PC board manufacturing;
10. Training in NC applications;
11. Placement of consultants.

These activities were aimed at the achievement of the planned outputs and, specifically, of demonstrable verifiers. The progress of the project was continuously monitored and managed according to detailed time schedules (each activity was described by 5 to 18 tasks, and a time frame indicated). During each tripartite review meeting the time-schedules of activities were reviewed and changed if necessary.

B. Institutional framework

Almost all activities at the site were concentrated in the Institute of Controlled Machines of the Academy of Sciences of the Democratic People's Republic of Korea in Pyongsong, where the following laboratories were established and involved in the project:

1. NC Machine-tool Laboratory

Outputs: Designing of the cross-table;
Measuring and testing of machine-tools.

Activities: 1, 5 and 5.1.

2. Control Unit Laboratory

Outputs: Development of the modular system of electronic boards for microprocessor control units;
Development and manufacture of control units for NC machine-tools.

Activities: 1, 4 and 5.

3. Servo-drive Laboratory

Outputs: Designing and manufacturing of one cross-table with two axes controlled (electrical part);
Development of servo-drives.

Activities: 1, 5 and 5.1.

4. Computer Laboratory

Outputs: Development of programs and problem-oriented software.

Activities: 5, 6 and 7.

5. Measuring Laboratory

Outputs: Measuring and testing of machine-tools and their subassemblies.

Activities: 5, 5.1.

6. Sensor Laboratory

Outputs: Development of measuring devices (inductosyns).

Activity: 5.

7. PC Board Manufacturing Workshop

Outputs: Participation in the development of the modular system of electronic boards for microprocessor control systems;
Participation in the development of control units for NC machine-tools.

Activity: 9.

The personnel of these laboratories is listed in annex IV.

The mechanical part of the cross-table was manufactured in the Comprehensive Machinery Factory of the Academy of Sciences in Pyongsong (castings, machining of small parts), the Kusong Factory (machining of large parts) and in the NC Machine-tool Laboratory (assembling and testing).

The preliminary design of the NC lathe prototype was done by a joint design team of the Institute and designers of the Industrial Design Office working in Kusong.

The metal cabinet for the control-unit prototype was manufactured in the Experiment Workshop for Computers of the Academy of Sciences in Pyongyang.

The type Riad R-55 main-frame computer in the Hydrometeorological Institute in Pyongyang was used to run programs prepared for the main-frame computer.

UNIDO consultants were involved in all the above-mentioned activities. No other organizations, in particular the Institute of NC machine-tools of the Kim Chaek Technical University, were involved.

The day-by-day management of the project was carried out by the NPD and the CTA.

C. Training

A detailed training programme had been established during the preparatory mission in 1984. Fifty different training courses were proposed of total duration of 282 months. Because the Government released only 28 staff to attend the courses, they were combined in such a way that some of the fellows attended two or three courses in sequence, an approach which reduces the practical utilization of the gained knowledge.

UNIDO had reserved places for trainees in Poland through the ZORPOT Training and Consulting Organization, according to the views expressed by the participants of the study tour and the availability of facilities. The training was accomplished between February 1985 and January 1986, i.e. with a delay of five months. This was due to the late requirement of the Government to run half of the training courses in the German Democratic Republic, which caused UNIDO great difficulties in providing the training according to the previously settled programme and time table. Consequently, some training courses had to be changed or the programme reduced and some were cancelled (development of 16-bit microprocessor control units, inductosyns, DC motors, ball-screws and application of industrial robots). During the 1985 tripartite review meeting, it was decided to reduce the total training component and to provide extended expertise for the uncovered fields. The reduction of training was followed by a reduction of the number of goals, in order to stress the major objectives of the project.

Training in Poland covered four fields: computer-aided designing (4 programmes, 10 fellows), computer-aided manufacturing (4 programmes, 8 fellows), manufacturing of PC boards (3 programmes, 3 fellows) and preparation of PCB art-work (2 programmes, 1 fellow). Training in the German Democratic Republic covered three fields: design and manufacturing of the CNC-600 numeric control unit (1 programme, 8 fellows), design and manufacturing of NC milling-machine (1 programme, 4 fellows) and cutting and welding methods (1 programme, 1 fellow). Fellows sent to the German Democratic Republic and Poland had also short visits to factories and research institutes other than their main places of training. The list of the training provided is presented in annex V.

In general, the training courses were considered useful, a fact which is reflected in the minutes of the May 1986 tripartite review meeting. Particularly good was the training in PC board manufacturing in Poland and in designing and manufacturing of NC milling-machines in the German Democratic Republic. Nevertheless, some measures should be taken in the future to increase the benefits derived from training. For details see chapters V, X, conclusions and recommendations.

D. Provision of premises, equipment, software and know-how

1. Premises (government input)

The laboratories of the Institute of Controlled Machines were established in an earlier erected building in Pyongsong (about 30 km north of Pyongyang, the capital), in an area where numerous institutes and facilities of the Academy of Sciences are situated. The space assigned for laboratories is comfortable and during reconstruction all requirements were fulfilled, with the exception of the internal electric power installation which must be improved to fulfill safety and earthing requirements. The adaptation of the rooms, especially of those for the PC board Workshop where chemical processes are carried out, was seriously delayed, i.e. by more than six months.

Serious problems were caused by the instable electric power supply for the whole Pyongsong scientific area, characterized by frequent breakdowns. Until July 1986, i.e. during the first two years of the project, the voltage fluctuated between 145 and 190 V instead of the stable 220 V. Since by February 1986 the training of fellows was completed and the majority of the equipment delivered, work was jeopardized only by the lack of a proper power supply. As of August 1986, the voltage level was effectively improved to about 200 V, but until April 1987 frequent breakdowns were registered (e.g. in March 1987 electric power was continuously supplied only during 11 calendar days). Although further improvements were made, the electric power supply remained inadequate for the requirements of an area where modern research and development work is supposed to be carried out. Failures of the electric power supply cause stoppage of water supply, which is very disturbing for PC board manufacturing and badly effects the lifetime of precision instruments and computer systems.

Winters in Pyongsong are severe, with usual outdoor temperatures below -5 °C, sometimes below -20 °C and the central heating system (steam system) is not reliable, not sufficient and during long periods not operating at all. This situation is harmful to the sensitive instruments delivered through the project and jeopardizes the execution of precision measurements, let alone the effects it has on the staff.

For 10 laboratory rooms (two for the minicomputer, two plotters, cross-table, NC drilling-machine, NC milling-machine, mechanical measurement, sensor laboratory and developing room in the PC board workshop) UNDP/UNIDO provided 16 air-conditioners. However, they are designed only for the stabilization of temperature, but not for the heating of rooms during severe winters.

Delays in the preparation of laboratory rooms and the lack of a stable electric power supply were among the main reasons why the project was extended by one year.

2. Non-expendable equipment (UNDP/UNIDO input)

A list of equipment had been prepared in 1984 during the preparatory missions of six consultants. This list was later amended. After international bidding, UNIDO purchased and delivered machines, instruments, software and know-how according to the specifications.

Due to restrictions imposed on the trade with the Democratic People's Republic of Korea by some developed market economy countries, some choices were made according to availability, but not necessarily based on performance/price advantages. Accepting this factor, all required equipment was well chosen.

For the majority of the equipment, UNIDO arranged for it to be gathered in one place in Europe and transported by a chartered cargo plane directly to the airport situated 30 km away from the project site. The total cost for storing (some items for a couple of months), handling and transporting was only $US 40,511, i.e. 5 per cent of the transported value. Nothing was lost or broken. On the contrary, at least half of the few items which were transported by standard carriers (by air or the Trans-Siberian railway) caused problems such as loss, delay or damage. Although almost everything was finally settled (for exceptions see chapter IV), it involved costs and delays.

The received equipment was registered, checked and distributed to the specific laboratories. An inventory system was established in the Institute by which all instruments with their accessories are registered and documented, separately from expendable materials and components. Each item is assigned to one person, who is responsible for it. All operating manuals and technical instructions have been translated into Korean by the end of 1987 and the translation of other items, such as maintenance manuals, is in progress. By the end of the project all instruments, with the exception of one (see chapter IV) were working and in good condition. Nothing was lost. The list of equipment is attached as annex III.

It should be pointed out that many pieces of the delivered equipment, besides serving their main purposes, are also master pieces for numeric control. In particular, UNDP/UNIDO delivered:

- Two NC machine-tools (item 12 milling-machine and item 40.1 drilling-machine);

- Two numerically controlled plotters (items 20 and 22.1);

- Sinumerik control unit for milling-machines (item 10, used for a cross-table;

- Thyristor and transistor servo-drives (item 5).

3. Non-expendable equipment (government input)

The Government delivered the cross-table, the industrial robot and ordered the main-frame computer. In the meantime the Government established the access to another main-frame computer in the Hydrometeorological Institute.

4. Expendable equipment (UNDP/UNIDO input)

This equipment was delivered to cover the following needs:

- Materials, particularly chemicals, and small tools to manufacture PC boards;

- Electronic components and small tools to build the modular microprocessor control system and the numeric control unit;

- Electronic and electric components for research work on servo-drives;

- Consumables for computers;

- Consumables for measuring instruments (especially registration paper and batteries);

- Spare parts for instruments (especially lamps and bulbs); and
- Consumables for office machines.

5. Expendable equipment (government input)

This equipment was delivered to cover the following needs:

- Materials to build the cross-table;
- Materials for the metal cabinet of the control unit;
- Display for the control unit;
- Some chemicals to manufacture PC boards;
- Tools and materials to run the NC milling-machine; and
- Some electronic components for research work in the Control Unit and Servo-drive Laboratories.

6. Software

UNDP/UNIDO have delivered the following software:

(a) Software for computer-aided design (CAD) of machine-tools

This software, worth $US 44,616, is intended to be used for solving problems submitted by design offices of the machine-building industry. It is indispensable in the designing of NC macnine-tools, but is also useful for the design of other machine-tools. It consists of:

Item 16.1: PAMES finite element software package;
Item 19.3: Pre- and post-processors for the PAMES software package;
Item 19.4: UNISYS modelling software package;
Item 19.5: SPIDIS and SPIEIG spindle analysis software package;
Item 19.6: ADAPT power transmission (gear box) analysis software package.

(b) Software for the creation of control programs for NC machine-tools by application of CAM methods

The application of NC machine-tools requires control tapes, specific for each different detail (machining part) supposed to be manufactured by a NC machine-tool. It is very time-consuming and sometimes even impossible to prepare these control tapes manually. Through this project, a modern method of creating these tapes using computers was introduced for the first time in the Democratic People's Republic of Korea. UNDP/UNIDO bought the APT-like software package and trained the personnel of the Institute in how to use it.

It is worth $US 73,400 and consists of:

Item 16.4: APT-like programming package;
Item 16.5: Post-processor for WMW type FKRSRS250/CNC-H646 milling machine;
Item 19.7: Machinability data and optimization of cutting processes software package.

The software package is adapted through an appropriate post-processor for the creation of control tapes for the WMW NC milling-machine bought through the project.

(c) Software for CAD of PC boards

This software (item 21: PROGRAF software package), worth $US 17,667, was supplied and installed through the project, local personnel was trained and now the software is being used. It is an important tool to prepare artwork for PC boards to be manufactured in the PC Board Workshop.

Together with instruments, the following programs have been delivered:

Item 3 (Laser interferometer): Programs for processing measured data by the IMB PC/XT microcomputer;

Item 17 (minicomputer): An operating system, compilers, tests and a large program library;

Item 17.3 (Graphoscop): A graphic package to be used with the minicomputer;

Item 20 (Benson flat-bed plotter): Tests and a graphic library to be used with a minicomputer and a main-frame computer;

Item 25.2 (EPROM-programmer): Programs for running the programmer by the IBM PC microcomputer;

Item 44 (Siemens system controller): Tests and a graphic package.

7. Know-how

For the PC Board Workshop, the know-how for electroless copper plating and copper and tin-lead electroplating of PC boards was bought. It has enabled the manufacturing of double-sided PC boards.

E. Activities in the field

1. Manufacturing of the cross-table

The cross-table was designed in the NC Machine-tool Laboratory during May to December 1985 (designer: Ko-Sang-Ho), with the assistance of UNIDO consultant A. Mankowski. The castings for the cross-table were made in a short time in January 1986 in the Comprehensive Machinery Factory of the Academy of Sciences in Pyongsong, where also small parts were manufactured. Then a very long time elapsed until the machine-tool building factory in Kusong machined these castings and assembled the cross-table. When the cross-table was finally ready in June 1987, UNIDO consultant J. Gaciag tested it and, at the same time trained the local staff in the use of modern testing instruments and methods (e.g. laser interferometer). J. Gaciag also made some recommendations concerning the improvement of the cross-table and future work. After the introduction of the suggested improvements, the cross-table had sufficient performance characteristics.

The experience gained by the local staff during the designing, manufacturing and testing of the cross-table covers the following aspects which are important for developing any NC machine-tool: manufacturing of friction-free precision slideways and application of ball-screws, inductosyns and encoders.

2. Integration of the cross-table with the servo-drives and the CNC unit

When the cross-table was completed in the ICM, the servicemen from Koprotech, Poland, were invited to integrate this cross-table with the Siemens type Sinumerik CNC unit and the two Siemens servo-drive units (thyristor and transistor). All three units had been bought separately from Siemens and assembled into two cabinets by Koprotech. This Siemens equipment is very good, but it is not foreseen for direct application by end-users. Its construction and documentation requires experienced labour for customization according to final needs. This task was accomplished in November 1987.

The cross-table and the customized control and drive systems permit to run a number of experiments on numerical control systems and thyristor and transistor servo-drives.

3. Integration of the cross-table with the measuring system for inductosyns

After the integration of the cross-table with the servo-drive and NC units, Koprotech's servicemen integrated it with the measuring system for inductosyns, bought from that company. This was done in November 1987.

This measuring system can be used both for R & D of inductosyns and for their testing during batch production.

4. Development of the modular system of electronic boards for microprocessor control units

(a) Designing of the modular system

The modular system of electronic boards for microprocessor control units was designed in the Control Unit Laboratory with extensive assistance of three UNIDO consultants (A. Kaczynski, J. Franczak and T. Pawelec) during April-December 1986. It is an up-to-date system consisting of an 8-bit Z-80 and a 16-bit 8086 microprocessor and two standard buses, both enabling multiprocessor work.

This system was then used and checked for development of a CNC control unit. The system consists of 18 different boards on modules (see annex I), but is fully expandable due to its modular nature.

(b) Designing of PC boards

Based on the logic schemes of the modular system, the local staff (after training) designed themselves the PC board layouts and later created the PC board artworks using the manual method. This was done in January-April 1987.

In the meantime the automatic PROGRAF software package for computer-aided design of PC boards was put into operation by the engineers of the supplier (Metronex, Poland) and the staff was trained by UNIDO consultant P. Perkowski in the use and development of this package. Bak Chan Un had earlier been on a three-month fellowship at the manufacturer's site in Poland and had received training in this subject. The PROGRAF package was implemented in June 1987 and was tested by designing one PC board for the modular system.

(c) Manufacturing of PC boards

During his preparatory mission UNIDO consultant J. Michalski recommended the machines, materials and know-how to be bought, the necessary construction work to prepare the premises for the execution of chemical processes, and he formulated the training programme. Prior to this project neither the Institute nor this country had had experience in manufacturing double-sided PC boards.

The Academy of Sciences provided generous space in an existing building and all construction work was completed according to requirements, although with a serious delay of about six months. These works have included: electric installation, water installation (including tanks for reserve water), waste water drain (including neutralization of chemical sewage), ventilation, special lighting in some rooms, chemically-proved floors and doors, as well as temperature and humidity stabilization. The installations were well done and are working, with one exception (see chapter V).

Three Korean engineers were trained in Poland (total 8 m/m) in the experimental plant of the supplier of the know-how, the Institute of Tele-Radio, Warsaw.

While the purchase of machines and instruments was relatively easy, the purchase of materials was difficult due to three main factors:

- The large variety of different materials and small tools (hundreds of items), required usually in small, not commercial quantities;

- The highly corrosive property of some materials (acids) which were required in comparatively large quantities (hundreds of liters), but transportation of which is governed by special rules;

- The lack of these materials in the Democratic People's Republic of Korea or the inability of the Academy of Sciences to provide them.

Fortunately UNIDO had involved only one supplier (Metronex, Poland) in three other activities directly connected with PC board manufacturing: training, delivery of some equipment and delivery of know-how for manufacturing of double-sided PC boards. Therefore it was relatively easy to order from them a set of all materials and tools for one year of work in the PC Board Workshop. Only acids required in large quantities had to be bought from China due to the high transportation cost from Europe. This single purchase caused serious problems and was solved only thanks to the deep involvement of the UNDP office and UNIDO SIDFA at Beijing.

All instruments, machines and technological processes were put into operation and are working.

(d) Assembly and putting into operation of electronic boards for the modular system

The personnel of the Control Unit Laboratory (three technicians) were trained in the assembly of electronic circuits using modern technologies and tools by UNIDO consultant K. Budny in July 1987. It now possesses all the necessary skills for piece production, suitable for research and development work.

This personnel assembled 25 of 18 different PC boards and manufactured 64 cables of 39 different kinds in the period July to mid-September 1987. These PC boards and the model of the control unit as a whole were put into operation from mid-September to November 1987, with the assistance of three UNIDO consultants, Messrs. Kaczynski, Franczak and Pawelec. Only very few mistakes were found on the PC boards, much less than one could expect.

Future development work will be carried on for the substitution (wherever possible or reasonable) of materials and components bought with hard currencies by locally made ones or such that are available through bilateral exchange.

5. Application and development of programs and problem-oriented software

The application of purchased software and the development of a new one is closely connected with the availability of computers. The software packages bought together with instruments were put into operation together with instruments and caused no problems. This software is intended for direct use but not for being improved in the Institute. Other application software packages are intended to be used with a main-frame computer or a minicomputer system and to be extended.

(a) Software to be run on the main-frame computer

During the preliminary mission it had been decided that the main-frame computer would constitute the Government's input and that it should be the Riad type, made in centrally planned economy countries, and compatible to IBM 360/370. Unfortunately, the selection and contracting by the government agencies took a long time and the computer (the Polish-made type R-34 main-frame computer) was delivered only on 30 November 1987. Because the installation of such a computer necessarily takes a couple of months, and since by the end of 1987 some imported construction elements for the computer rooms were still not available, the purchase of this computer had no influence on the progress of the project.

As a temporary solution, the Government promised to give access to a similar computer in the Hydrometeorological Institute, a type R-55 main-frame computer made in the German Democratic Republic. But the access to this computer, formally established since April 1987, was affected by two shortcomings:

- Frequent breakdowns, and

- The lack of experience among local personnel in the linkage of user's software to the operating system of the main-frame computer.

Only in December 1987 all problems were solved and the purchased software was put into operation. This, however, was too late for its useful application for the national economy and its further development during the life of the project. These activities are now foreseen for the future (see annex II).

(b) Software to be run on the minicomputer system

To run this software, UNIDO bought the Polish-made type SM-4 minicomputer system, compatible with the DEC PDP-11/34 computers. This computer was put into operation as soon as suitable conditions existed at the Institute, i.e. in the second half of 1986. Subsequently, a part of the purchased software, namely spindle, gear box and power transmission analysis software packages, and in particular the PROGRAF system for computer-aided design of PC boards, were put into operation, used and extended. To use the software package of the PROGRAF kind, one must have a data bank, containing information on the characteristics of the components to be placed and connected automatically on PC boards, and of technology parameters of the applied manufacturing processes. So far the local staff fed this bank with data of 200 locally used electronic components, 5 standards and 5 production data, rendering it capable to be used for practical work. The extension of the data bank and the development of the system to cover future needs is included in the work plan.

Only the UNISYS software package was not put into operation during the project life. This package, as delivered, requires a skillful personnel to integrate it with the particular computer system. It was too difficult for the local staff and a consultant in this field, supposed to be invited by the Government, has not yet been placed. UNIDO asked the supplier to deliver a simpler version, but it did not arrive until December 1987. For proposed solutions see chapter IV.

6. Development of measuring devices and methods

(a) Development of measuring devices

As reported before, the UNDP/UNIDO input for this task was very small. Nevertheless, the researchers of the Sensor Laboratory, by using the technological processes received for manufacturing of the PC boards, succeeded in developing 10 micrometer inductosyns. These inductosyns are planned to be manufactured in the near future and applied by the national industry in locally made NC machine-tools (see annex II, item 5).

(b) Development of measuring methods for measuring and testing of machine-tools (NC machine-tools in particular)

The development and manufacture of NC machine-tools require measuring of mechanical and electrical parameters with very high precision. It concerns both, machine-tools as whole units, and separately their subassemblies such as guide-ways and measuring sensors (e.g. inductosyns). Also, the parameters of machining (e.g. cutting forces) must be measured to establish the data required for control programs for numerically controlled machining.

Prior to this project, no such measuring facilities existed in the Democratic People's Republic of Korea. Thanks to the project, a full set of instruments (including a laser interferometer) was provided and the Measuring Laboratory has been established.

The fellows were trained in machine-building factories in the German Democratic Republic, in how to measure machine-tools during their production. Later, in the first half of 1987, two UNIDO consultants, J. Gaciag and J. Szymkowski, provided training in high-precision measurement required for testing of models and prototypes of NC machine-tools during their development.

At this stage, the Measuring Laboratory, the NC Machine-tool Laboratory and the Servo-drive Laboratory together are fully capable of measuring NC machine-tools, their subassemblies, servo-drives and inductosyns.

In addition to the application of learned methods, these laboratories also work on the improvement and development of both applied methods and programs for processing measured data using computers.

7. Development of control units for NC machine-tools and training of machine-tool users

(a) Development of the control unit

Based on the microprocessor modular control system developed through this project, control units for different machine-tools could be built. In 1987 a prototype control unit, designed for a cross-table, was made. It will be extended in 1988 to control lathes.

Korean fellows were trained in this field in the NUMERIK factory at Karl-Marx-Stadt, German Democratic Republic. During designing and putting into operation of the control unit extensive assistance of UNIDO consultants was provided:

- Electronic part: J. Kaczynski, T. Pawelec and J. Franczak;
- Software: J. Bienkowski and D. Krzywoblocki;
- Mechanical structure and cabling: J. Rudzki.

The developed control unit incorporates two 16-bit and two 8-bit microprocessors, a display and sophisticated circuits. Its parameters are presented in annex I. After completion of the control unit, it was integrated with the cross-table, replacing the Sinumerik control unit, and was checked. Later some necessary improvements were introduced. UNIDO consultants Pawelec and Bienkowski assisted in that work. The final testing of the developed control unit with the cross-table completed the main output of the project and demonstrated the Institute's capability to perform R & D of NC machine-tools. Integration and testing took place in December 1987. Development work will be carried on in the future in order to modify this control unit for application to specific machine-tools and to establish its lot production.

(b) Training of NC machine-tool users

This training, executed by the personnel trained abroad and making use of the equipment delivered by the project, began in 1987. Six training sessions of a total of 415 hours were held. The 226 participants who attended the training courses came from the Institute of Controlled Machines, other research organizations, and from the Huichon and Kusong factories. For details see annex VI.

8. Development of servo-drives

After the staff had completed the training in the German Democratic Republic, and with consultant Maliszewski in the field, work in the Servo-drive Laboratory concentrated on the following topics:

(a) Full understanding and practicing the application of the sophisticated instruments bought through the project, in particular the frequency response analyser, loading device and thyristor and transistor servo-drive systems for the cross-table. Now personnel know how to use these instruments;

(b) When the servo-drive unit in the received WMW NC milling-machine broke down, the local personnel looked for reasons and eliminated a number of faults, learning at the same time how to deal with servo-drives for NC machine-tools;

(c) The servo-drive for industrial robots was designed in the laboratory;

(d) The personnel participated in designing the cross-table and its integration with servo-drives.

Other practical work in this laboratory was limited due to the lack of components. The ordering of components recommended by Mr. Maliszewski was postponed until other purchases, being more crucial for the project, would be completed, i.e. until October/November 1987. Activities making use of these components will be possible from 1988 onwards.

F. Expertise

It was clear from the outset that the provision of extensive expertise by UNIDO consultants was crucial for the success of this project. Later the number of experts was increased because not all fields had been covered by fellowships and many sophisticated instruments were delivered. In total 76.9 m/m of expertise were provided (see annex VII) by 17 consultants during 26 missions. They all arrived on time, with the exception of one delay and one too early placement, and performed their tasks very well.

At the beginning of the project some persons suggested to recruit consultants from different countries, according to the principles of "best available" and "equal distribution". However, it seemed advisable to limit the spectrum of consultants' nationalities for the following reasons:

(a) The project deals with one single subject, although broad and complicated. Therefore, experts dealing with different aspects must share the very same ideas of solutions. This means, that in many instances they should not only be from one country but even from one and the same research group;

(b) The work of a particular consultant was frequently closely linked to the work of another one. Consequently the timing of their placement had to be strictly adhered to; delays of more than one week were unacceptable in many cases and, in fact, did not happen. This, again, was possible only if consultants came from one source;

(c) Consultants, and even their visiting families, coming from the same country could help each other by shipping books, software, tools and electronic components in a fast and reliable way;

(d) A lot of work could and was prepared in the home country, prior to placement and in co-operation with other consultants.

Because of these reasons, consultants were invited from two countries only: the German Democratic Republic and Poland.

During the December 1985 tripartite review meeting, considerably different views on the extent of required expertise were expressed. UNIDO representatives insisted that at least 91 m/m should be provided, while the government representatives argued that 68 m/m would be sufficient. Finally it was decided that 71 m/m will be provided by UNDP/UNIDO and 4 m/m by the Government through bilateral co-operation or TOKTEN. All consultants planned for by UNIDO were recruited and placed, although those from the German Democratic Republic were replaced by Polish consultants, because the Government of the German Democratic Republic could not provide the project with the required consultants for the periods indicated.

Unfortunately, the Government, in particular the Academy of Sciences, did not succeed in placing any expert through bilateral or TOKTEN agreements. This caused a delay in the application of the bought software and, in consequence, jeopardized the development of new software. With that exception, the total duration of the provided expertise was sufficient, however, only because the designing of the NC milling-machine prototype and the manufacture of both, NC lathe and NC milling-machine prototypes, were cancelled.

III. FINAL PROJECT PERFORMANCE VERSUS PLANNED PERFORMANCE

The final substantive revision of the project document took place during the December 1986 tripartite review meeting. The targetted time and project objectives, as settled then, were reached. Compared with the original project document signed in September 1984, the following changes were introduced:

A. Inputs

1. UNDP/UNIDO inputs

(a) Training

Fellowships were reduced from 282 m/m to 250 m/m, i.e. by 11 per cent. The following training courses were waived: application of industrial robots and development of DC motors. Training on measuring devices did not cover the manufacture of inductosyns. Training on transmission did not cover ball-screws. Training courses on control units did not include training in 16-bit microprocessor technique. These reductions were caused by the fact that in the last moment the Government of the Democratic People's Republic of Korea withdrew from these training courses prepared in Poland and asked to have them in the German Democratic Republic; however, the Government of the German Democratic Republic was unable to provide such training and there was no time to arrange it elsewhere.

(b) Expertise

Expertise was increased from 67 m/m to 76.9 m/m, i.e. by 15 per cent. This was decided in order to cover some topics not covered by fellowships but still essential for the achievement of the project objectives.

(c) Equipment

The equipment foreseen in the project document has been delivered, with the following changes:

(i) Reductions:

- Three-dimensional measuring machine (item 2) - cancelled due to its high price (about $US 100,000) and not being essential for project completion;

- Microprocessor development system (item 25) - not available from the developed market economy countries due to trade restrictions and very expensive in centrally planned economy countries (about $US 40,000). It has been replaced by the microcomputer with suitable accessories and a PROM programmer is planned to be built by ICM's staff using components delivered by UNDP/UNIDO;

- Shaking test machine (item 37) - because a similar shaking machine could be used in the Institute of Automation;

- Corrosion test chamber (item 38) - because it was not necessary for this project;

- Digital AC power meter (item 6.3) - replaced by the simple analogue Watt meter (item 57.63) being much cheaper ($US 175 versus $US 5,409);

- Components for the lathe and milling-machine prototypes - because manufacturing of these prototypes was waived.

(ii) Additional purchases:

- Control unit and components for the cross-table - following the decision to build the cross-table;

- Standard chemicals required for the manufacture of PC boards - because the quality of locally available chemicals was found to be below requirements;

- Additional components for the microprocessor modular control system - because the quality of locally available components was below requirements;

- Air-conditioning equipment - because the Government was unable to provide it on time and had no convertible currency to buy it on the free market. The Government compensated this expenditure by partial payment of consultants' hotel bills;

- Accessories, consumables and services for the bought instruments. In fact, during the planning of the project, the costs for keeping the instruments in good working condition during project life had been underestimated. In some other cases, only after the instruments were put to practical use, could it be determined what additional accessories were indispensable.

UNDP/UNIDO were originally expected to spend $US 1,117,500 for equipment, but in fact have spent $US 1,517,157*, i.e. an increase of 35 per cent has occurred.

There were three reasons for that increase:

(a) The significant drop in the value of the US dollar between the date when the purchase recommendations were made and the time when payment for purchases was effected;

(b) The underestimation of the cost for transport, services and accessories;

(c) The overestimation of the Government's capability to deliver components and materials for manufacturing processes from the local market; eventually almost everything had to be delivered by UNDP/UNIDO.

The increase of the equipment cost was made up in the following way:

(a) $US 4,824 (7%) - through an increase of the project budget during the December 1986 tripartite review meeting;

(b) $US 59,000 (5%) - through savings on experts' cost because the Government paid some experts' hotel bills;

It should be noted that while the cost of training was reduced by 37 per cent, the quantity of training was reduced by only 11 per cent. This was possible because the cost of training was lower than had been estimated.

The final increase of the project budget was 5.7 per cent ($US 2,503,498* versus planned $US 2,367,700), but two costly goals had to be sacrificed, namely the development of NC lathe and milling-machine prototypes which were replaced by the less expensive manufacturing of one cross-table.

2. Government inputs

Beside the changes described above, there was one major change in the government inputs: instead of materials and labour to design and manufacture the NC lathe and NC milling-machine prototypes, the Government provided inputs for designing and manufacturing a cross-table.

The total government input, in kind, was:

Originally planned: won 20,257,500

After extension of the project by one year, planned: won 26,336,500

Finally won 22,383,616.

Again, the savings are due to waiving the construction of the NC lathe and milling-machine prototypes.

B. Immediate objectives

One project objective, namely "To enable national staff to use industrial robots in production processes" was deleted. Although the development of industrial robots has not been envisaged for this project, the application of industrial robots in connection with NC machine-tools was recognized as one of the objectives in the original project document. In order to focus the project on a limited number of goals and taking into account that no UNDP/UNIDO input was provided for it, this objective was dropped during the May 1986 tripartite review meeting. However, it should be noted that this project will have an impact on the progress in robotics in the Democratic People's Republic of Korea through at least two of its objectives:

(a) The established Servo-drive Laboratory develops servo drives for robots;

(b) The microprocessor modular control system developed through the project is also useful for the control of industrial robots.

Originally activities were to be carried out in equal shares in three places: institutes, design offices and factories. Eventually they were limited to one institute only. For an explanation see "Introduction", section C.

Topics dealing with the manufacturing of NC machine-tools were partly covered by developing the cross-table and the manufacturing of control units was fully covered.

C. Outputs

1. Designing of an NC milling-machine and manufacturing of NC lathe and NC milling-machine prototypes

These outputs were dropped and partially replaced by designing and manufacturing of the cross-table. This deletion was due to the following reasons.

By the middle of 1986, the technical designing of both machine-tool prototypes should have been almost finalized and substantial progress in manufacturing had been assumed. In fact, with the assistance of UNIDO consultants, only rough technical specifications were completed.

UNIDO consultants working with designers of the Kusong and Huichon factories found that both factories involved in the project were interested in the development of NC machining centres but neither in lathes nor milling-machines. Later, UNDP officials were informed that a decision to build machining centres instead of a lathe and a milling-machine had been taken by the Committee of Metal and Machine-Building Industries, a high-level government body and therefore out of the control of the Academy of Sciences. Until October 1986, no final decision about the types of machine-tools for development as prototypes had been taken. This uncertainty had the following effects: some design work had been undertaken for a lathe, but only by the staff of ICM without involvement of the industry, and nothing had been done for designing a milling-machine. Of course, nothing had been manufactured for machine-tool prototypes. Finally, UNIDO suspended the placement of further consultants on machine-tool designing and manufacturing, because it was not possible to prepare their job descriptions in agreement with both; the project document and the requirements of industry.

Consequently it was not realistic to assume that all project objectives could be reached within the planned time and cost frames. To build a machining-centre prototype, some additional $US 200,000 were required. Moreover, UNIDO consultant J. Gaciag found that the Kusong factory was not fully equipped with the machine-tools required for the manufacturing of NC machine-tool prototypes. At least four expensive machines (a jig boring machine or a machining-centre to machine spindle head bodies; a grinding machine, to machine slideways and bodies; a gear grinding machine; and a spindle grinding machine) would have been required, as well as a number of instruments (including a balancing machine). In the Huichon factory facilities were no better. Knowing from previous experience with this and other projects how difficult co-operation among different organizations in this country is, one could expect that the manufacture of NC machine-tool prototypes would take very long.

For these reasons, the December 1986 tripartite review meeting decided to drop the development of lathe and milling-machine prototypes. Instead, the Institute built, in co-operation with the Kusong factory, a cross-table which has been cheaper and better suitable for research work.

2. Application of industrial robots

An industrial robot was bought by the Government, but its application in industrial processes was deleted from the project due to reasons explained above.

IV. TASKS NOT FULLY COMPLETED UPON TERMINATION OF THE PROJECT

A. Government

1. The main-frame computer, although bought and received, has not yet been put into operation. The plan for its installation is presented in annex II, item 7.

2. The cross-table has not been fitted with the hydraulic loading device for investigation of servo-drives. ICM expects to do it in March 1988.

3. An expert in linking the user's software with the operating system of the SM-4 minicomputer should be placed through a bilateral agreement. The expert would help to solve problems with putting the UNISYS software package into operation.

B. UNIDO

1. The UNISYS software package has not been put into operation due to lack of experience of the local personnel in how to integrate user's software with the operating system of the SM-4 minicomputer. Ways to solve this problem, being alternative to the one described above under A.3, are to supply another version of the UNISYS package which is easier to apply, or to request the supplier to send a serviceman to the Democratic People's Republic of Korea to put the UNISYS package into operation. UNIDO should try to arrange it through the UNISYS supplier in Poland.

2. Some small pieces of equipment recently ordered by UNIDO for this project have not yet been received. They are listed in annex VIII. Probably they will be delivered shortly.

V. CONCLUSIONS AND RECOMMENDATIONS

A. To all parties

1. The original project document assumed a broad co-operation of organizations, belonging to different high-level government agencies, as an indispensable factor to achieve the project objectives and outputs. It was found that in the Democratic People's Republic of Korea to get such co-operation for UNDP/UNIDO projects is very difficult if not impossible. Therefore, projects in the Democratic People's Republic of Korea should be framed for only one ministry (or an equivalent agency such as the Academy of Sciences), and preferably for only one organization.

2. When the project budget was established, broad use of locally manufactured components and materials was assumed; practically, they could not be provided at the requested time or had insufficient performance parameters. Therefore, particular care should be taken when the use of local resources is assumed.

3. For large projects with interlinked tasks, consultants should be recruited, if possible, from one organization or institute or at least from one country only. This was done with the present project and proved to be successful.

4. To get some additional money for equipment in this project, it was decided in 1986 to pay the consultants only 50 per cent of their DSA and the Academy of Sciences agreed to pay the cost of their accommodation. Many problems arose on the subject of which costs should or should not be borne by the Academy of Sciences. These problems were spoiling a previously smooth atmosphere of consultants' work. Because good mutual relations between consultants and the receiving country are crucial for the success of projects, the CTA strongly recommends to avoid, in the Democratic People's Republic of Korea, arrangements whereby the Government covers directly costs of consultants' accommodation.

5. In the Democratic People's Republic of Korea the standard of hotels, and especially that of meals served in hotels, is rather modest. Therefore, a stay in a hotel for more than one month is difficult if not unacceptable for many experts, and the renting of flats and services can be arranged only through government organizations, which may be easy once, while sometimes impossible, and always needs time. In order to provide consultants with good living conditions, especially if they are staying for a longer time, the exact type of accommodation should be discussed and settled with the Government prior to their placement, and the local UNDP office should take an active part in it.

6. Once the training plan has been settled (programmes and places), it should not be changed. If changes are introduced, a delay for the whole project and additional costs must be assumed; or otherwise the quality of provided training will be limited.

7. For the managerial personnel, study tours should be arranged (to many places but of short duration). They should not attend long training courses on narrow and sophisticated subjects which they do not need in their work, as it happened with this project.

8. One fellow should be sent to learn one subject only. If he or she covers more than one topic, the later usefulness and application of the learned skills would be limited.

B. To the Government

1. On many occasions nothing, or almost nothing, was prepared prior to the placement of consultants, to render their work efficient immediately after their arrival, even if it was a consultant's second mission, and in his report on the first mission he had put down what was required in order for him to proceed with his assignment. Also, the interest demonstrated by nationals in the work of consultants, e.g. attendance at lectures, was relatively modest. To make full use of consultants' time, the government organizations should prepare all conditions to enhance their work and assign a sufficient number of counterparts, well before the consultants' arrival.

2. Much more attention should be paid to the working conditions of employees. For instance, the lighting must be sufficient and adequate furniture must be provided for laboratories.

3. Considering that the local personnel has a lot to learn, these endeavours should be strengthened and enough time should be devoted to separate, longer lasting tasks. A frequent change of goals is ineffective and even counter-productive in scientific work. This recommendation is perhaps the most important one to ensure a continued benefit from this project.

4. With time and the continuous use of the instruments, their maintenance, calibration and repair are required. At present, this work is entrusted to each individual laboratory in ICM and the technicians working there. It is recommended to establish one common maintenance workshop, suitably equipped to handle all repair and service work for measuring instruments for the Institute and, even better, for the whole Academy's of Sciences area in Pyongsong.

5. The Academy of Sciences should provide, through bilateral co-operation, training in the maintenance of the minicomputer system and in the linking of the computer operating systems with the user's software. This training is needed and has so far not been provided.

6. In addition to the above, the Academy of Sciences should arrange for regular visits of service engineers from the minicomputer manufacturer (twice a year) in order to maintain the minicomputer system in good working condition.

7. ICM must ensure a stable, continuous electrical power supply with suitable parameters (220 V, 60 Hz).

8. Electric installations in ICM should be rebuilt and properly grounded according to the internationally recognized safety standards. The laboratory stands should have a fixed, built-in electric installation according to these standards and must not be connected to wall outlets by movable cables.

9. The building of ICM should be effectively heated (above +18 °C indoor temperature) when the outdoor temperature is low.

10. The water supply in ICM is often affected by breaks. For PC board manufacturing this causes not only a loss of time and labour, but also losses of expensive materials. An emergency water tank with a capacity of about 8 m^3 should therefore be put up and also connected to the developing machine.

11. The minicomputer system and the NC microprocessor control unit being the most complex project inputs/outputs, a sufficient number of researchers, much larger than in 1987, should be assigned to take care of and to develop the hardware and the software.

12. The developed devices, especially the cross-table and the control unit, as well as the bought machines, especially the NC milling-machine, should be run continuously and be extensively tested to find out all their shortcomings and to learn testing methods.

13. The responsibility for one technological process should not be split among different organizational units. At present the designing of PC board artworks is carried on in the Computer Laboratory and their manufacturing in the PCB Workshop. It is recommended to produce production masters (films), to manufacture PC boards and to carry out related R & D work in the three divisions of the PCB Workshop.

14. Many instruments delivered to the Institute are for the testing and measuring of machine-tools according to a request from the industry. Such machine-tools should be brought to the ICM for testing rather than instruments being moved out from the Institute to various factories. This would greatly minimize the danger of damaging the instruments and reduce the time required for their calibration. To this end, a large room should be constructed at the Institute permitting trucks to enter it easily, and an overhead crane should be installed to place the machine-tools on the testing stands.

15. The developed microprocessor modular control system could and should be used for different applications in automatic control, but not only for NC machine-tools and industrial robots.

16. Through the project sophisticated instruments have been supplied and it had been assumed that the basic instruments and tools available at the Institute of Mechanical Engineering and the Institute of Automation would be used. The new Institute of Controlled Machines has got very few of these instruments and tools. For instance, it still is not equipped with a manual electric drilling machine and an optic lever. It is therefore recommended to equip ICM with the basic mechanical and electrical instruments such as level gauges, squares, cylindrical squares, straightedges, rules, block gauges, precision barometer, hydrometer and basic hand-tools in a sufficient number.

17. The Institute of Controlled Machines should be equipped with a workshop with basic machine-tools and other facilities for the manufacturing and modification of accessories required for testing of machine-tools and any research work.

18. In the PCB Workshop, complicated chemical processes are being carried out with a concentration of many different kinds of chemicals. However, their usage over a period of time has resulted in some leakages and overflowing. The key to solving this problem is maintenance. Since ICM has neither the capability nor the necessary tools to maintain chemical installations, it is recommended to try to obtain assistance from other chemical institutes, where the necessary equipment and skillful labour may be found, to ensure that the installations of the PCB Workshop will continue to function effectively.

19. The capacity of the PCB Workshop is much larger than the needs of ICM or even of all organizations developing NC machine-tools. It should, therefore, serve other governmental R & D organizations. However, to enable this, the Government should provide the Workshop with sufficient quantities of materials and consumables required for the manufacturing processes.

20. The principles of designing and local standards for PC boards should be established. They should be elaborated on the basis of recommendations made by the consultants and locally gained experience.

21. When the local staff will have experience in the application of the PROGRAF package for computer-aided designing of PC boards, they should be trained on an advanced level by foreign consultants or through fellowships. Bilateral co-operation could be used for this.

22. The creation of programs for NC machine-tools using CAM methods being a complex task, eight staff of ICM should be assigned exclusively to perform this task.

23. Some industrial branches are interested in specialized subsystems for the design and manufacture of products with double-curved (sculptured) surfaces, e.g. TV tubes, car bodies, ships, turbine blades, dies and moulds. After having gained the necessary experience with the available APT-like system and other software, ICM should, therefore, organize training courses for the personnel from factories, and after completion of these training courses, the joint institute-industry CAD development programmes should be considered.

24. After all improvements and changes of the project's outputs have been completed, in particular those of the control unit, final documentation should be produced for all devices and software packages developed through the project.

25. The user's maintenance and programming manuals for the control unit should be prepared soon.

26. All unfinished tasks (see chapter IV) should be completed as soon as possible.

27. The R & D programme for NC machine-tools for 1988-1990, presented in annex II should be followed as closely as possible.

28. It is recommended to develop a power-supply unit for control units to replace the imported ones. It can be done by using present knowledge, instruments and patterns, but this needs time. The unit should work on the switching principle.

C. To UNDP/UNIDO

1. In the Democratic People's Republic of Korea, the recruitment of consultants through bilateral agreements or by TOKTEN takes so much time that it should not be considered as an element of projects, but rather for the post-project phase.

2. It was assumed that all fellows may use English easily, and if they were not fluent during the preparatory mission, that they would improve their language skills before going on fellowships. This not having been the case, it is recommended that fellows, before going abroad, pass an examination in the UNDP office in the language of training; otherwise interpreters should accompany them.

3. Instruments should not be delivered before rooms and installations are ready. Otherwise the manufacturers' guarantees expire too soon.

4. Since in the Democratic People's Republic of Korea there are no manufacturers' maintenance facilities, at least not from developed market economy countries, the delivery of maintenance documentation and tools should be made obligatory and included in purchase orders.

5. One lesson learned from this project was that, when instruments are put into operation and used, considerable additional costs would arise. Additional accessories and service tools were required, as well as consumables and spare parts, especially after the expiration of guarantees. These costs had been underestimated during the preparatory mission. In the future 25-30 per cent of the value of purchased instruments should be obligated for their installation and exploitation.

6. For large projects, instruments and equipment should be gathered in one place in a developed country, near the major sources of supply, and later transported in bulk by charter. A lot of problems were avoided for this project due to the implementation of that idea.

7. With regard to the transportation of goods from Europe and Japan to the Democratic People's Republic of Korea the following was experienced:

(a) Consignments in small boxes (maximum size about 54 x 54 x 100 cm) when sent through Beijing, arrive quickly;

(b) Large boxes do not fit into the small aircrafts operating between Beijing and Pyongyang and remain at Beijing airport until somebody from the local UNDP office would find them and ship them by railway;

(c) Consignments sent via the Union of Soviet Socialist Republics are usually shipped (independently of what the original air-bill promises) via Moscow - Khabarovsk (a distant town in Eastern Siberia) to Pyongyang, and they are passing custom inspections twice (at Moscow and Khabarovsk). This takes two to three weeks. The Soviet carrier is much cheaper for suppliers registered in COMECON countries than carriers operating through Beijing (even their national carriers). Therefore the Soviet carrier should be chosen only for large boxes and for shipments that are not urgent, coming from COMECON countries.

8. For this project, hundreds of different electronic components and a good number of chemicals were required. Such materials are usually sold in large quantities only, larger than one project needs. The most outstanding example was a condensor, of which one piece was required, but which was available only in packs of 1,000 pieces. To avoid unnecessary expenses, the expert recommends two alternative solutions:

(a) If UNIDO is involved in several similar projects, it would probably be worth establishing a co-ordination/packing service which would buy components in cheap, large bulks and redistribute them to the individual projects by single consignments or by pouch;

(b) Instead of ordering from commercial enterprises, contracts could be concluded with research or manufacturing organizations which deal in the project's fields of activity and have their own stocks of the required goods. The purchase orders for instruments, machines or know-how should be placed with such organizations, and include the necessary quantities of all materials. This solution was applied, with a good result, for buying materials and small tools for PC board manufacturing.

10. The procedure for buying books by UNIDO through Munksgaard A/S (Denmark) for this project was not satisfactory. When the recommended books were ordered, about 50 per cent were delivered relatively quickly, and an additional 5 per cent arrived during the following three years. UNIDO remained passive and the CTA was advised to wait for Munksgaard's reactions. For the outstanding books, no substitutes were proposed nor was information received on

the expected date of issue of new editions. The UNIDO book purchasing service should be more active in tracing book supplies and providing substitutions. To do so, the unit should employ technically competent people or make regular use of consultants coming for briefings and debriefings to Headquarters, as well as co-operate directly with leading publishers of technical literature.

11. Correspondence from Vienna to Pyongyang and vice versa takes too long. Cables are being sent through Bangkok and delivered sometimes after five days, and letters sent by pouch arrive at Vienna two to three weeks after departure from Pyongyang. UNIDO should try to improve that situation. Cables between Pyongyang and Vienna should be sent directly and pouches should travel much more quickly.

12. The UNIDO inputs listed in chapter IV should be completed as soon as possible.

Annex I

TECHNICAL/PERFORMANCE PARAMETERS ACHIEVED THROUGH THE PROJECT

A. Cross-table

1. Table size:		800 x 800 mm
2. Travel length in x - axis		1000 mm
y - axis		500 mm
3. Rapid traverse in both axes		10 m/min
4. Maximum acceptable load on the table		1000 kgs
5. Parallelism of slideways:	x - axis	0.02 mm
	y - axis	0.02 mm
6. Roughness:	x - axis	1.25 micro m
	y - axis	2.5 micro m
7. Hardness:	x - axis	46 HRC
	y - axis	30 HRC
8. Torque of friction:	table	1.52 Nm
	SADDLE	6.3 Nm
9. Straightness of X movement:	pitch	6 s
	yaw	8 s
Y movement:	pitch	5 s
	yaw	6 s

B. Microprocessor modular control system

This system consists of following PC boards (modules):

1. SBC80 Single board 8-bit computer	RAM 4KB, EPROM 32 KB, Clock 4 MHz
2. SBC86 Single board 16-bit computer	RAM 16 KB, EPROM 64 KB, Clock max. 5 MHz
3. RAM48 RAM memory of central bus	48 KB
4. ERM16 EPROM/RAM memory	16 KB
5. DCM01 Display control module	RAM 4 KB, EPROM 2 KB
6. KCM32 Keyboard interface module	
7. CPM01 Control panel module with operating circuits	
8. CPM02 " " " " alphanumeric key matrix	
9. CPM03 " " " " NC key matrix	
10. CPM04 " " " " machine key matrix	
11. PIM03 I/O module for positioning measurement using inductosyns	3 axes
12. POM03 " " " " " " encoders	3 axes
13. SCM04 Servo-control analog output module	4 axes
14. DIM32 Digital input module	32 inputs
15. DOM32 Digital output module	32 outputs
16. PCM01 Peripheral and clock module	
17. MCM01 Monitor control module # 01	
18. MCM02 " " " # 02	
19. Power supply board for a monitor	DC 12 to 30V
20. IAM01 Inductosyn pre-amplifiers	
21. IIM01 Inductosyn interface	

C. Numeric control unit

1. Control of 2 axes for lathes and 3 axes for milling-machines

2. Linear and circular interpolation for 2 out of 3 axes.
3. Traversing and interpolation range: +- 99 m.
4. Input/output resolution: 0.001 mm.
5. Position measuring by encoders and inductosyns.
6. Compensations
   - 199 blocks of memory for tool length, range +- 9999.999 mm;
     cutter radius, range +- 999.999 mm;
   - backlash compensation, range +- 0.65 mm.
7. Technology:
   - feedrate: 1 mm/min to 5000 mm/min;
   - rapid traverse up to 5000 mm/min.
8. Data input:
   - paper tape input via a paper tape reader;
   - MDI via the keyboard.
9. Program:
   - input code: ISO;
   - incremental or absolute values;
   - programming of the actual contour;
   - program memory up to 32 KB;
   - up to 9999 programs in the program memory;
   - 99 subroutines;
   - 9999 blocks in each program or each subroutine;
   - decimal point notation;
   - full circle programming;
   - program editing (deletion, insertation, replacement).
10. Manual overrides
   - feedrate: 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 20 and 10 %;
   - rapid traverse: 50 and 10 %.

D. Parameters measured after integration of the cross-table with the developed control unit

1. Drift of servo-drives in both axes:
   x - axis   0 to + 2 microm (delta = app. 1 microm)
   y - axis   -5 to +13 " (delta = app. 6.1 microm).

2. Positioning accuracy:
   x - axis at speed 5 m/min: delta = 1 microm;
   y - axis at speed 10 m/min: delta = 1.9 microm.

3. Accuracy of the reference point:
   x - axis   delta = 0.22 microm;
   y - axis   delta = 1.4 microm.

4. Stability of movement velocity along lines:
   delta = 0.1 m/min.

E. PC board manufacturing

1. Maximal size of one PC board: 300 x 450 mm;
2. Minimal width of a path or distance between paths   0.3 mm;
3. Accuracy of drilling (repetation):   0.015 mm;
4. Maximal storage time of SnPb covered boards: 0.5 year.

Annex II

PROGRAMME OF NC MACHINE-TOOL RESEARCH AND DEVELOPMENT FOR THE YEARS 1988 TO 1990

Specification	1988	1989	1990
1.NC Machine-tool Laboratory Head: Prof. Hong Ring Ho, staff 19 (including 15 researchers)			
1.1. Development of the NC lathe prototype			
a) Designing (cooperation with the Designing Office)	============		
b) Manufacturing (Kusong Factory)		============	
c) Testing			============
Involved: 5 researchers and following equipment: # 1(all),3,4,5.7, 7(all),44,45(all) and 46(all).			
1.2. Application of CAD for investigation of specific problems in machine-tool designing	app. 3 - 4 analyses per year		
a) Investigation of gear-boxes for the machine-tool industry	============	============	============
	app. 3 - 4 analyses per year		
b) Investigation of spindles for the machine-tool industry.	============	============	============
Involved: 1 researcher and following equipment: # 15, 16(all), 17.1, 18 and 19 (all)			
c) Adaptation of the finite element method software package = = =	============		
for local needs;	app. 5 analyses per year		
d) Investigation of static displacements, stresses and dynamic time responses using the finite element method for machine-tools, robots and other applications.	=====	============	============
Involved: 1 researcher and equipment listed above.			
e) Investigation of dynamic characteristics of machine-tools and	app. 2 - 3 analyses per year		
servo-drives	============	============	============
Involved: 1 researcher, equipment listed above and cooperation with the Servo-drive Laboratory.			

Specification	1988	1989	1990
1.3. Manufacturing of control tapes for NC machine-tools			
a) Development of postprocessors for specific NC machine-tools:			
- Testing the postprocessor #16.5 with the #12 NC milling-machine delivered through the project = = =	=====		
- For one imported NC lathe	============		
- For the NC lathe prototype (see 1.1 above)	============		
- For the new 16-bit control unit		============	
- For one machining centre[1]			============
b) Manufacturing of control tapes			
- For # 12 the WMW NC milling-machine (10 programs each year)	============	============	============
- For a NC lathe (10 programs each year)	============	============	============
- For a machining centre (5 programs)[1]			============
Involved: 3 researchers, #15 main-frame computer, #19.5&19.6 APT software and # 12 NC milling machine.			
1.4. Testing of machine-tools			
- standard machine-tools: Kusong #3 lathe and Huichon milling-mach.	============		
- the machining centre prototype			
- samples from the pilot production of machining centres			============
- see also p.1.1c above			
Involved: 3 researchers, following equipment:#1(all),3,4,5(all),44,45 (all),46(all) and cooperation with the Measuring Laboratory.			
1.5. Trainings for designers and users of NC machine-tools			
a) Structure and operating principles of mechanical parts of the NC milling-machine	===	===	===

[1] To be done by personnel of the Ministry's of Machine Building Industry organizations.

Specification	1988	1989	1990
80 hrs of lectures and practice for app. 20 persons each year			
b) Structure and operating principles of the control unit for the NC milling-machine	======	======	======
100 hrs of lectures and practice for app. 60 persons each year			
c) Programming and operating of the NC milling-machine	===	===	===
120 hrs of lectures and practice for app. 20 persons each year			
Involved: mainly #12 NC milling-machine			
d) Using of the PAMES software for the finite element method analysis			
- Composition of the PAMES software package	===	======	===
70 hrs of lectures for app. 20 persons each year			
- Programming in the PAMES package		======	======
120 hrs of lectures and practice for app.20 persons each year			
- Running of the PAMES program and analysis of results		======	===
80 hrs of lectures and practice for app. 20 persons each year			
Involved: # 15 & 17.1 computers and 16.1 & 19.3 scftware			
e) Using of the UNISYS, SPIDIS, SPIEIG and ADAPT software packages for CAD of NC machine tools			
- Field and methodes of application	===	===	===
150 hrs of lectures for app. 20 persons each year			
- Programming in thir software	===	===	===
120 hrs of lectures and practice for app. 20 persons each year			
Involved: #17.1 minicomputer and #19.4, 19.5 and 19.6 software			
f) Using of the APT software system for creation of control tapes for NC machine-tools			
- Structure of the system and preparation of data for this system	===	===	===
100 hrs of lectures for app. 20 persons each year			
- Programming in this system	===	===	===
120 hrs of lectures and practice for app. 20 persons each year			
Involved: #15 main-frame computer and #16.4 & 16.5 software			

Specification	1989	1989	1990
2. <u>Control Unit Laboratory</u> Head: Kim Young In, staff: 16 (including 7 hardware and 5 software researchers)			
2.1. Development of the CNC control unit for lathes			
a) Assembling and testing of the prototype	===========		
b) Integration of the prototype with the lathe and testing	==	=	
c) Introduction of production of the lathe control units into the factory (future production of app. 20 pcs per year)		======	
2.2. Development of the CNC control unit for machining centres			
a) Designing of the unit	==	==	
b) Assembling and testing		======	
c) Integration with the machine-tool		======	
d) Introduction of production of the machining centre control units into the factory		(	===
Pos.2.1 and 2.2 involve whole staff of the laboratory and following equipment: #25.1 microcomputer and instruments #6.4,17.3,25(all),26.2, 29,32,33 and 34		above (100 pcs ((	
2.3. Manufacturing of control units for lathes, and machining centres in the factory Additional researchers will be involved in this activity.		((	=========
2.4. Designing and manufacturing of the PROM programmer (#25.3) Involved: 1 hardware, 1 software researchers and 1 worker	======		
2.5. Trainings on the structure and designing of numeric control units			
a) Structures and application of the NC units using the modular system with 16-bit microprocessors 120 hrs of lectures for app. 50 persons each year	======	======	===
b) Designing of additional modules for numeric control units 80 hrs of lectures for app. 50 persons each year	===	===	===

Specification	1988	1989	1990
c) Preparation of software for the numeric control unit 120 hrs of lectures and practice for app. 20 persons each year Involved: Mainly #25.1 microcomputer, #25.2 & 25.3 programmers and the control unit prototype built through the project.	======	===	===
Remark: Designing of the control unit for a lathe is planned in 1987.			
<u>3. Servo-drive Laboratory</u> Head: Kim Won Gol, staff 18 (including 14 researchers)			
3.1. Testing of dynamic parameters of the locally developed servo-drive for the NC lathe feed drive Involved: 5 researchers, 2 workers and following equipment:#5(all),10 (all),6.1,7.9,27,30 and 32.	============		
3.2. Development of the microprocessor servo-drive			
a) Designing and manufacturing		============	
b) Testing Involved: 6 researchers and 2 workers and eqipment as for p.3.1.			============
3.3. Exploatation of the cross-table testing stand			
a) Testing of the servo-drives developed outside the Institute (for lathes, milling-machines and machining centres)	app. 20 tests each year ============	============	============
b) Trainings on testing of servo-drives provided for customers from other organizations Annually two one week trainings for app. 20 persons each. Involved: 3 researchers and 5 operators and the testing stand (#5(all),#10(all))	============	============	============
Remarks: 1) Other researchers of the Servo-drive Laboratory will deal with research for industrial robots drives. 2) This plan was established on the assumption that the SIS project for these activities would be granted.			

Specification	1988	1989	1990
4. Measuring Laboratory			
Head: Li Bion Tae, staff: 3 researchers, in the near future will be extended up to 5 researchers.			
4.1. Establishing the facilities for measuring of: a) vibration b) displacement c) noice This activity includes calibration of instruments and developing of measuring methods.	============		
4.2. Testing of industrial robots developed in the Institute		============	
4.3. Measuring of prototypes presented by industry and outside research organizations		app. 3-5 problems/year ============	============
Pos.4.1 to 4.3 involved 3-5 researchers and equipment of this laboratory.			
4.4. Investigation of dynamic characteristics of NC machine-tools and industrial robots using vibration and sound measuring equipment, computer programs for processing and analysing of measured data (to be developped). Automatic fault diagnosis and correction are assumed. Involved: New research group, to be established.			============
4.5. Trainings on using of the measuring instruments			
a) Operating principles, structure and applications of the laser interferometer 60 hrs of lectures and practice for app. 20 persons each year Involved: #3 laser interferometer.	=== ===	===	===
b) Operating principles, structure and methods of using the type UPM60 multi-point measuring instrument 60 hrs of lectures and practice for app. 20 persons each year Involved: # 1 & 1.1 to 1.15 instruments.	=== ===	===	===
c) Operating principles, structure and methodes of application of the type B8011 system controler	======	===	===

Specification	1988	1989	1990
80 hrs of lectures and practice for app. 20 persons each year Involved: # 1, 1.13.2 and 44 instruments.			
<u>5. Sensor Laboratory</u> Head: Li Zu Op, staff: 19 (including 12 researchers)			
5.1. Manufacturing of the pilot lot of 10 micrometer inductosyne scales and slides	============		
		150 pcs/year	
5.2. Manufacturing and application in the industry of 10 micr. inductosynes Pos.5.1 & 5.2 involve 3 researchers, 3 operators and # 22.1 photoplotter and the PCB workshop equipment.		============	============
5.3. Testing of inductosyne scales and slides using the cross-table measuring stand Involved: 2 researchers, 1 operator and the cross-table, the #10 measuring system for inductosynes and #3 laser interferometer.	============	============	============
Remark: One piece means one inductosyne scale element (200 mm long) or one slide.			
<u>6. Computer Laboratory</u> Head: Song Jae Gung, staff 18 (including 14 researchers)			
6.1. Running and maintenance of the SM-4 minicompter system	990	1540	1540
a) Running of the SM-4 computer (useful working hours)	============	============	============

Specification	1988	1989	1990
b) Foreign training of the personnel (1 hardware, 1 software, 6 months each)	======		
c) Training of the personnel in the Computer Institute (1 hardware, 1 software, 2 months each)	==		
d) Training of the personnel in the Railway College (the SM-4 minicomputer is there; 1 hardware, 1 software, one month each)	=		
e) Visits of the SM-4 minicomputer system foreign consultants (billateral exchange; 4 men for one month each)	= = = = = = >		
Involved: 2 researchers and 1 operator (from 1989 additionally 2 researchers and 2 operators) and following equipment: # 17 minicomputer system, #22 Benson flat-bed plotter, #30 oscilloscope			
6.2. Utilization of CAD system for PC board designing			
a) Designing of PC boards for other laboratories and outside customers (number of pieces)	70 ============	100 ============	100 ============
b) Application of the di 'tizer for the CAD system	======		
c) Development and assembling of the off-line system for control of the photoplotter		============	
d) Extension of the CAD system data base			
- electronic elements (now 200 types introduced)	200 more ============	300 more ============	400 more ============
- standards of PC boards (now 5 introduced)	20 more ============	20 more ============	30 more ============
- production data (now 3 entries)	10 more ============	10 more ============	10 more ============
e) Trainings on application of the PROGRAF CAD system for PCB's designing			

Specification	1988	1989	1990
- Principles of PCB's designing	===	===	===
70 hrs of lectures for app. 50 persons each year			
- Structure and properties of the PROGRAF system	===	===	===
100 hrs of lectures for app. 50 persons each year			
- Programming in the PROGRAF system	======	======	======
120 hrs of lectures and practice for app. 70 persons each year			
Involved: 3 researchers and #17.1,17.2,18,20,22,40.1 instruments/machines and #21 software.			
6.3. Interfacing the SM-4 minicomputer with the main-frame computer	======		
- Adaptation of the APT and PAMES software packages to work in the main-frame computer through terminals connected to the SM-4 minicomputer system		============	
Involved: the same personnel as for p. 6.1 (in future one more researcher also) and following: equipment # 15, 17 and 18.			
6.4. Trainings of the SM-4 minicomputer system users.			
a) Training on application of the SM-4 computer (for 10 persons)	=		
b) Training on the PC board designing (for 15 persons)	=		
Involved: Personnel and equipment as for pp. 5.1 and 5.2.			
6.5. Development of internal (basic) software for the CNC control units			
a) Software for a machining centre	============		
b) An interactive programming system		============	
c) Software for automatic determination of cutting conditions			
Involved: 5 researchers, 1 operator and a microcomputer (Government's input)			
<u>7. Main-frame Computer Laboratory</u>			
This laboratory is being organized. Because its purpose is to serve not only the Institute of Controlled Machines but also to whole site of the Academy of Sciences in Pyongsong, it will be probably arranged as an			

Specification	1988	1989	1990
independent unit. Presently the Deputy Director of the Institute of Controlled Machines Mr. Li Ui Gu is responsible for installation of the main-frame computer and all preparatory work. The staff at present consists of 11 persons, being trained (6 abroad). In future 40 persons will work, 30 of them for management, oparating and maintenance and 10 for software.			
7.1. Preparation of a room and electric installation =======	==		
7.2. Installation of the computer	====		
	8 hrs/day		24 hrs/day
7.3. Operating of the computer	======	============	============
7.4. Transfer of the PAMES and APT software packages to this computer (8 terminals will be placed in the Institute of Controlled Machines)	==		
7.5. Training of computer users on Operating System, JCL, Assembler Language and high-level programming languages (e.g. Fortran)			
- run by the supplier and foreign consultants (for 40 persons)	======		
- run by the local staff (for 400 persons in total)	======	============	============
<u>8. Printed Circuit Board Workshop</u> Head: Go Yong Chol, staff 18 (including 6 researchers)			
8.1. Production of PC boards		100 sq.m/year	
- Single sided	============	============	============
	150sq.m/year	170sq.m/year	200sq.m/year
- Double sided	============	============	============
Involved: 12 workers + 2 engineers and equipment of the PCB workshop			
8.2. Maintenance and deep study of operation of instruments and installations			
- Maintenance	============	============	============

Specification	1988	1989	1990
- Study Involved: 2-3 researchers	============		
8.3. Establishing of manufacturing facilities for gold plating Involved: 1 researcher and the Government's equipment	============	============	
8.4. Replacement of imported materials for production by the locally made (Replacement of 16% of materials is planned at that time) Involved: 6 researchers and #40.17,40.A equipment			============

<u>General remarks:</u>

i) All laboratories listed here belong to the Institute of Controlled Machines of the DPR of Korea Academy of Sciences in Pyongsong. The Designing Office and listed factories belong to the Ministry of Machine Building Industry.

ii) For management reasons the plan is arranged according to laboratories involved in its realization.

iii) Numbering of equipment involved in specific activities follows listing in the UNIDO Purchase Specification for the project DP/DRK/84/001.

CAD - Computer Aided Designing
CAM - Computer Aided Manufacturing
CNC - Computer Numerical Control
NC - Numerical Control
PC board, PCB - Printed Circuit Board
PROM - Programmable Read Only Memory

....
Li Jong Dok
Director of the Institute of Controlled Machines
National Project Director

Annex III

LIST OF THE NON-EXPENDABLE EQUIPMENT DELIVERED FOR THE PROJECT

Item	Specification	Unit	Qua	Man./Supp.	Origin	Lab	Worth $	Remarks
1.1.4,1.5,1.9,1.13A.	16-point type UM 60-0 measuring unit	set	1	Hottinger	FRG	ML	14731	
1.1A	Force transducers	pcs	10	"	FRG	ML	3836	
1.1B,C	Displacement transducers	pcs	25	"	FRG	ML	8161	
1.1D	Vibration transducers	pcs	9	"	FRG	ML	4477	
1.1E	Temperature transducers	pcs	10	Wahl	USA	ML	833	
1.1F	Sound measuring equipment type 00037	set	1	Robotron	GDR	ML	8036	
1.1G	Torque transducers and couplings	pcs	9	Hottinger	FRG	ML	15770	
1.1H&48.1.	Strain gages	pack	53	Kyowa	Japan	ML	2425	
1.1J	Rotary transducers with preamplifiers	pcs	9+3	Hottinger	FRG	ML	1966	
2,1.8,7.6.	Amplifiers	pcs	5	"	FRG	ML	20763	
7	Vibration exciter system	set	1	B & K	Denmark	MTL	19609	
.1.10	Contactless transmission devices	set	3	Hottinger	FRG	ML	2603	
1.11	Analog 14-channel type RTP-600 recorder	pcs	1	Kyowa	Japan	ML	14510	
1.13.1	Analog type PL3 X-Y plotter (size A3)	pcs	1	Lloyd	UK	ML	1267	
13.1.2	Digital type PM8154/01 X-Y plotter (size A4)	pcs	1	Philips	Holland	ML	3133	
1.14	Cutting force measuring platform for milling-machin.	set	1	Kistler	Switzer.	MTL	19816	
1.15	18-channel register (galvanometer type)	pcs	1	Kyowa	Japan	ML	9404	
3	Laser interferometer	set	1	Alcatel	France	MTL	72235	
4	Dual channel type CF910 Fast Fourier Analyser	pcs	1	Tekeda-Rik.	Japan	MTL	17730	
5&10.6	Sinumerik control and drive-systems for the cross-t.	set	1	Siemens	FRG	SDL	27358	
	Assembling and installation			Koprotech	Poland	SDL		
5.5&5.6.	Inductosyns and encoders (as patterns)	set	6	Heidenhain	FRG	SL	2300	
5.7	Instrument for measurement of feed-drive fluctuations	pc	1	Koprotech	Poland	ML		
6.1	Load torque set	set	1	Vibrometer	FRG	SDL	15156	
6.2	Digital multimeters type H1002	pcs	7	Siemens	FRG	all	16369	
6.4	Frequency counter type B2032	pcs	1	"	FRG	CUL	667	
7.1	Portable durometer type HT	pcs	1	Akashi	Japan	ML	1970	

Item	Specification	Unit	Qua	Man./Supp.	Origin	Lab	Worth $	Remarks
7.3	Infrared thermometer type DHS-86C	pcs	1	Wahl	USA	ML	2779	
7.4	Type Talyrond 100 roundness measuring instrument	pcs	1	R-T-H	UK	ML	12643	
7.8	Surface measuring instrument type T6D	pcs	1	Hommel	FRG	ML	17271	
7.9	Digital frequency response analyser type SE2450	pc	1	EMI	UK	SDL	13492	
9.1	Electronic fluxometer type 3254-00	pc	1	Yokogawa	Japan	SDL	481	
9.2	Gauss-meter	pc	1	"	Japan	SDL	1491	
10	Measuring system for inductosynes	set.	1	Koprotech	Poland	SL	26145	
12	CNC milling-machine type FKR SRS 250/CNC-H646	pc	1	WMW	GDR	CUL	80530	
15	Main-frame computer type R-34	set	1	Elwro	Poland		Gov.'s contribution	
16.1	PAMES finite element software package	set.	1	Metronex	Poland	MTL	16505	
16.4&16.5	APT-like programming package and a postprocessor	set.	1	"	Poland	MTL	67666	
17.1	Mini-computer system type SM-4	set	1	"	Poland	CL	115376	
17.2	Graphical display for a minicomputer	pcs	1	Grossegger	Austria	CL	18575	
17.3&10.5	Paper tape punches	pcs	2	Facit	Sweden	CL	8438	
18	Remote terminal	pcs	1	Metronex	Poland	CL	5625	
19.3	Pre- and postprocessors for the PAMES software pack.	set.	1	"	Poland	MTL	3734	
19.4	UNISYS V.30 modelling software package	set	1	"	Poland	MTL	19396	
19.5	SPIDIS & SPIEIG spindle analysis software package	set	1	"	Poland	MTL	1868	
19.6	ADAPT power transmission (gear box) analy. soft.pac.	set	1	"	Poland	MTL	3113	
19.7	Machinability data & optimizat.of cutt. proces.soft.	set.	1	"	Poland	MTL	5734	
20	Flat-bed plotter type 1125	set.	1	Benson	France	CL	73711	
21	PROGRAF software package for CAD of PC boards	set.	1	Metronex	Poland	CL	17667	
22.1&22.2	Photoplotter type P20	set.	1	EIE	Switze.	CL	85530	
22.3	Spectra-proof darkroom	pcs	1	EIE	Switze.	PCW		
22.4	Camera type CL-3	pcs	1	Laif	FRG	PCW	3262	
25.1	IBM PC/AT-like microcomputer	set	1	local	Japan	CUL		
25.2	EPROM-programmer	set.	1	local	Poland	CUL		
25.3	PROM-programmer (to be built locally)	pcs	1			CUL		
	(UNIDO has delivered components)	set.	1	various	UK&Japan			

Item	Specification	Unit	Qua	Man./Supp.	Origin	Lab	Worth $	Remarks
26.1	Floppy disk drives	pcs	2	Metronex	Poland	CL	1506	
26.2	Alpha-numerical terminal with keyboard	set	1	"	Poland	CUL	1042	
26.3	Dot-matrix serial printer	pcs	1	"	Poland	CL	3174	
27	Function generator type D2001	pcs	1	Siemens	FRG	SDL	3101	
28	Pulse generator type D2100	pcs	1	"	FRG	SL	832	
29	100-MHz storage oscilloscope type 5277	pcs	1	Schlumber.	France	CUL	8181	
30	25-MHz storage oscilloscope type D1007	pcs	3	Siemens	FRG	SDL,CL,SL	9341	
32	Digital multimeter type B1011	pcs	2	"	FRG	SDL,CUL	1682	
33	Electronic counter type 2720	pcs	1	Schlumber.	France	CUL	2087	
34	Logic analyser type PM3551A/30	set	1	Philips	Holland	CUL	21610	
35	Logic probe	pcs	5	various		var	522	
36	RLC meter type 101	pcs	1	T.E.	UK	SL	1767	
39	Power supply unit type Stabizet 610/960	pcs	1	Siemens	FRG	SDL	1941	
40.1	NC drilling-machine type Compact 10	pcs	1	Schmoll	FRG	PCW	57144	
40.2	Manual drilling machine type PK-300E	pcs	1	Laif	FRG	PCW	12464	
40.4	Brushing machine type Junior I	pcs	1	Wesero	FRG	PCW	14605	
40.5&40.6.	Lines for plating, with "know-how" and materials	set	2	Metronex	Poland	PCW	58892	
40.7	Laminator type T-842	pcs	1	"	Poland	PCW	8341	
40.8	Exposure unit type PC-130	pcs	1	Du Point	USA	PCW	31728	
40.9	Developing machine type T-842/B	pcs	1	Metronex	Poland	PCW	8716	
40.10	Stripping machine type T-842/D	pcs	1	"	Poland	PCW	9894	
40.11	Etching machine type LSG14	pcs	1	Laif	FRG	PCW	10639	
40.12	Screen printing unit type DEK MP250	pcs	1	Instagraph.	UK	PCW	4546	
40.13	Guillotine	pcs	1	local		PCW		Gov.'s contribution
40.14	Triming and countour machine	pcs	1	local		PCW		Gov.'s contribution
40.15	Visual inspection apparatus	set	1	Moderne	FRG	PCW	3736	
40.17	Devices for servicing chemical processes	set	1	Metronex	Poland	PCW	1719	
40.17.1.	Bench magnifier	pcs	5	Instagraph.	UK	PCW,CUL	1750	
40.17.2.	Microsection kit	set	1	"	UK	PCW	3872	
40.17.3.	Spectrophotometer	pcs	1	Jenoptik	GDR	PCW	1433	

Item	Specification	Unit	Qua	Man./Supp.	Origin	Lab	Worth $	Remarks
40.17.4.	Laboratory magnetic stirrer	pcs	1	Moderne	FRG	PCW	513	
40.17.5.	Digital ph-meter	pcs	1	"	FRG	PCW	391	
40.17.6,13,15,16&63.	Devices for PCB manufacturing	set	1	Moderne	FRG	PCW	6772	
40.17.62.	Fume cupboard	pcs	1	Moderne	FRG	PCW	1065	
44	Data acquisition system(OscillostoreT & B8011contr.)	set	1	Siemens	FRG	ML	41633	
45.1	Vibration measuring case type 00060	set	1	Robotron	GDR	ML	3127	
45.2	Sound analyser type 00023 with accessories	set	1	"	GDR	ML	7032	
45.3	Digital thermometer	pcs	1	Wahl	USA	ML	1036	
45.4	" "	pcs	1	Yokogawa	Japan	ML	545	
46.1	Dial gauges (various types)	pcs	18	Baty	UK	ML	1090	
46.2	Magnetic stands	pcs	15	Baty	UK	ML	1004	
46.3	Digimatic indicator type 543-113 with a printer	set	1	Mitutoyo	Japan	ML	788	
46.4	Digital micrometers (various types)	pcs	1	"	Japan	ML	1099	
47	Office equipment(2 type writers,1 coppier,1 project.)	pcs	1	various	Japan	gen	5393	
55	Air-conditioning equipment	set	7	National	Japan	var		
55A	Dehumidifiers	pcs	4	Westingho.	USA	var		
56	Blowers	pcs	2	Siemens	FRG	PCW		
57.10	Vibration transducers type 4370S	pcs	2	B & K	Denmark	ML		
57.53	Piezoelectrical force transducer with a hammer(8202)	set	1	B & K	"	ML		
57.63	Wattmeter type LW-1 with a resistor	set	1	Metronex	Poland	SDL		
57.61	Universal NiCd battery charger	pcs	1	UISL	HongKo.	SDL		

Remarks:

i) The list includes also software and know-how bought by UNDP/UNIDO.

ii) Items are combined and listed according to their impact on the project activties and the numbering used in the original project document is preserved. Due to these reasons the list differs from the UNIDO equipment inventory list which follows the Purchase Orders' numbers and structure.

iii) "Worth" inputs include all costs, e.g. if applied transportation, installation, service, accessories and materials

iv) Worth is not indicated for few items because not all cost components were known when the list was created.

Item	Specification	Unit	Qua	Man./Supp.	Origin	Lab	Worth $	Remarks

Laboratories:

CL - Computer Laboratory
CUL - Control Unit Laboratory
ML - Measuring Laboratory
MTL - NC Machine-Tool Laboratory
PCW - Printed Circuit Board Workshop
SDL - Servo-Drive Laboratory
SL - Sensor Laboratory

Manufactures & Suppliers

B & K - Bruell and Kjaer (Denmark)
R-T-H - Rank-Taylor-Hobson (United Kingdom)
T.E. - Telemeter Electronic (United Kingdom)
UISL - United International Suppliers Ltd. (Hong Kong)

Annex IV

LIST OF PERSONNEL OF LABORATORIES

Only graduated researchers involved in the project are listed.

1. NC Machine-tool Laboratory

1.1	Hong Lin Ho	prof.dr.	trained	head of the laboratory
1.2	Ko Sang Ho	M.Sc.		
1.3	Bak Song Gun	M.SC.	trained	
1.4	Hwang Zae Bok		trained	
1.5	So Hong Chol		trained	APT-software package
1.6	Li In Un		trained	
1.7	Han Kuk Se		trained	
1.8	Kim Chang Min		trained	PAMES software package

2. Control Unit Laboratory

2.1	Kim Yong In	dr.	trained	head of the laboratory
2.2	Li Le Sop			hardware
2.3	Li Un Gang			display designer
2.4	Pak Yong Hak			
2.5	Kim Yong Nam			
2.6	Hean Sung Jin			
2.7	Song Dong Jin			
2.8	Kim Song Gwan			
2.9	Byon Tai Sik	dr.	trained	WMW NC milling-machine

3. Servo-drive Laboratory

3.1	Kim Won Gol	trained	head of the laboratory
3.2	Choi Dong Chol	trained	
3.3	Choi Kwan Sung	trained	
3.4	Jon Sung Gwan	trained	

4. Computer Laboratory

4.1	Song Zai Gong	trained	head of the laboratory
4.2	Cha Gon Ii		
4.3	Li Ok Sun		
4.4	Bak Chan Un	trained	CAD of PC boards
4.5	Li U Byong	trained	
4.6	Kim Nam		
4.7	Pak Yong Loang		
4.8	Li Song Won		
4.9	Kim Ju Hwa		

5. Measuring Laboratory

5.1	Li Bion Tae		head of the laboratory
5.2	Li Ju Op		
5.3	Bak Myong Chun	trained	laser interferometer
5.4	Ham Se Yong	trained	modal analysis

6. Sensor Laboratory

6.1	Li Zu Op		trained as Ju Mu Ryul, head of the laboratory	
6.2	Che Dae Hean			
6.3	Jong Song Ho			

7. PC Board Workshop

7.1	Go Yong Chol			head of the workshop
7.2	Li Yong Zun	M.Sc.	trained	chemical processes
7.3	Bak In Su		trained	
7.4	Kim In Gyun		trained	electrical instruments
7.5	Kim Do Gwang			preparation of reagents
7.6	Poek He Gyong			
7.7	Kim Ik Hyoh			
7.8	Kang Hi Suk			

Annex V

LIST OF TRAINING PROVIDED THROUGH THE PROJECT

No	Name	Total	m/m	Subject of training	Place	Present place
1	Kim In Gyun	3	3.0	Machine treatment in PC board manufacturing	ITR-Poland	PCW
2	An Il Ung	6	6.0	NC lathe programming and utilization	WUT-Poland	2)
3	Ham Se Yong	12	6.0	Computer analysis of experimental data	PIMB-Poland	ML
			5.5	Designing and manufacturing of NC lathes	NILES-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
4	Kim Yong Bok	6	5.5	Designing and manufacturing of NC lathes	NILES-GDR	3)
			0.5	Practice in the machne-tool research centre	FC-GDR	
5	Li In Un	12	6.0	Design analysis of machine components	PIMB Poland	MTL
			5.5	Designing and manufacturing of NC lathes	NILES-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
6	Li Ui Gu	6	5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	1)
			0.5	Practice in the machine-tool research centre	FC-GDR	
7	Li U Byong	12	11.0	Computer graphics and modelling for design of the flexible manufacturing systems	PIBM-Poland	CL
			1.0	Methodology of NC machine-tool testing and CAM	Koprotech-PL	
8	Hwang Zae Bok	12	6.0	Design analysis of machine components	PIBM-Poland	MTL
			5.5	Designing and manufacturing of NC lathes	NILES-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
9	Song Zai Gong	12	6.0	NC milling-machine programming (geometry)	WUT-Poland	CL
			5.5	Post-processors and CAM software	"	
			0.5	Methodology of NC machine-tool testing and CAM	Koprotech-PL	
10	Choi Kwan Sung	6	5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	SDL
			0.5	Practice in the machine-tool research centre	FC-GDR	
11	Im Yun Hyok	6	5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	2)
			0.5	Practice in the machine-tool research centre	FC-GDR	

No	Name	Total	m/m	Subject of training	Place	Present place
12	Bak Myong Chun	12	6.0	Computer analysis of experimental data	PIMB-Poland	ML
			5.5	Designing and manufacturing of NC milling-machines	UNION-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
13	Kim Hwa Il	6	5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	4)
			0.5	Practice in the machine-tool research centre	FC-GDR	
14	Ju Mu Ryul	6	5.5	Designing and manufacturing of NC milling-machines	UNION-GDR	SL
			0.5	Practice in the machine-tool research centre	FC-GDR	
15	Kim Yong In	6	5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	CUL
			0.5	Practice in the machine-tool research centre	FC-GDR	
16	Bak Chan Un	12	6.0	Computer graphics	PIMB-Poland	CL
			3.0	Designing of layouts of printed boards	Era-Poland	
			3.0	Computer Aided Designing of PC boards	IMM-Poland	
17	Hong Lin Ho	12	6.0	Design analysis of control and driving systems	PIMB-Poland	MTL
			5.5	Designing and manufacturing of NC milling-machines	UNION-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
18	Choi Dong Chol	12	6.0	Design analysis of control and driving systems	PIMB-Poland	SDL
			5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
19	Bak Song Gun	12	6.0	Design analysis of machine components	PIMP-Poland	MTL
			5.5	Designing and manufacturing of NC milling-machines	UNION-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
20	Han Kuk So	12	6.0	NC lathe programming and utilization	WUT-Poland	MTL
			5.5	Designing and manufacturing of NC milling-machines	UNION-GDR	
			0.5	Practice in the machine-tool research centre	FC-GDR	
21	Kim Chang Min	12	6.0	NC milling-machine programming (geometry)	WUT-Poland	MTL
			5.0	Design analysis of machine components	PIMB-Poland	
			1.0	Methodology of machine-tool testing and CAM	Koprotech-PL	

No	Name	Total	m/m	Subject of training	Place	Present place
22	So Hong Chol	12	11.0	Computer Aided Manufacturing	WTU-Poland	MTL
			1.0	Methodology of machine-tool testing and CAM	Koprotech-PL	
23	Byon Tai Sik	12	6.0	Computer integrated manufacturing	WUT-Poland	CUL
			5.0	Postprocessors and CAM software	WUT-Poland	
			1.0	Methodology of machine-tool testing and CAM	Koprotech-PL	
24	Kim Won Gol	6	5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	SDL
			0.5	Practice in the machine-tool research centre	FC-GDR	
25	Jon Sung Gwan	6	5.5	Designing and manufacturing of CNC-600 NC units	NUMERIK-GDR	SDL
			0.5	Practice in the machine-tool research centre	FC-GDR	
26	Won Zun Yong	12	6.0	NC milling-machine programming	WUT-Poland	3)
			6.0	Cutting and welding methods	THM-GDR	
27	Bak In Su	1	1.0	Chemical processes in PC board manufacturing	ITR-Poland	PCW
28	Li Yong Zun	3	3.0	Photoprinting in PC board manufacturing	ITR-Poland	PCW

Grand total: 250, including in GDR: 108 m/m and in Poland: 142 m/m.

Remarks:
1) Now works as Deputy Director.
2) Still works in the Institute of Automation.
3) Works in Kusong Machine Building Factory.
4) Now works in the office of the Academy of Sciences.

Era	- ERA Instrument and Computer Factory - Warsaw - Poland
FC	- Research Centre of Machine-Tool Building - Karl-Marx-Stadt - GDR
IMM	- Institute of Mathematical Machines - Warsaw - Poland
ITR	- Institute of Tele- Radiotechnique - Warsaw - Poland
Koprotech	- Research and Training Centre of Machine-Tools - Warsaw - Poland
NILES	- Betrieb "8. Mai" Grossmachienenbau - Karl-Marx-Stadt - GDR

NUMERIK	- Betrieb "NUMERIK" - Karl-Marx-Stadt - GDR
PIMB	- Industrial Institute of Construction Machines - CAD Centre - Warsaw - Poland
THM	- Technische Hochschule - Magdeburg - GDR
UNION	- Betrieb "UNION" - Karl-Marx-Stadt - GDR
WUT	- Warsaw University of Technology - Warsaw - Poland
CL	- Computer Laboratory
CUL	- Control Unit Laboratory
ML	- Measuring Laboratory
MTL	- NC Machine-Tool Laboratory
PCW	- PC Board Workshop
SDL	- Servo-Drive Laboratory
SL	- Sensor Laboratory

Annex VI

TRAINING COURSES HELD IN THE INSTITUTE OF CONTROLLED MACHINES IN 1987

No	Name	Form	Partic-cip.	Duration (hours)	Participants
1.1	On the structure and operating principle of the control unit	lecture	20	20	Institute's staff
1.2	for NC milling-machines Teacher: Byong Tai Sik		60	60	Researchers & engineers from other institutes and factories (+)
1.3		practice	30	30	Institute's staff
1.4			60	10	As (+)
2.1	User's programming methods for NC milling-machines	lecture	5	20	Institute's staff
2.2	Teacher: Cha Gon Il		10	20	As (+)
2.3		practice	5	20	Institute's staff
2.4			10	20	As (+)
3	On the structure, designing and calculating methods for NC machine-tools Teacher: Hong Lin Ho	lecture	10	100	Engineers from Huichon and Kusong m.t. factories
4.1	On the Computer Aided Designing system and methods for design-	lecture	5	30	Institute's researchers and operators
4.2	ing of PC boards Teacher: Bak Chan Un	practice	5	50	
5.1	On the structure and operating principles of the UPM-60	lecture	3	10	Outside researchers
5.2	Teacher: Li Bion Tae	practice	3	25	
	Total:		226	415	

Annex VII

LIST OF PROVIDED EXPERTISE

No.	Name of the post	Consultant's name	Total	1984	1985	1986	1987	1988
			m / m					
11-01	Chief Technical Adviser, Microprocessor control systems	H.Orlowski	22.9*	1.5	3.4	8.5	8.4	1.1
11-02	Interpolation in control systems	J.Franczak	4.5*			2.0	2.5	
11-03	Control systems	J.Kaczynski	6.0*			4.0	2.0	
11-04	Computer Aided Designing	M.Bossak	1.0				1.0	
11-05	Computer Aided Manufacturing	S.Zietarski	1.0				1.0	
11-06	NC lathe and cross-table designing	A.Mankowski	7.0		2.0	5.0		
11-07	NC milling-machine designing and NC machine-tool testing	J.Gaciag	3.0			1.0	2.0	
11-08	Machine-tool servo-drives	S.Maliszewski	1.5			1.3	0.2	
11-11	Feed-back in control systems and their integration with machine-tools	T.Pawelec	6.5*			2.9	5.0	
11-12	Interpolation and interfacing programming	D.Krzywoblocki	3.4*			1.1	2.3	
11-13	Software for NC systems	J.Bienkowski	6.0*			1.1	3.9	1.0
11-14	PC board manufacturing	J.Michalski	4.9			2.9	2.0	
11-15	CAD for PC boards	P.Perkowski	2.0				2.0	
11-19	Mechanical structures for electronic circuits	J.Rudzki	3.0			2.0	1.0	
11-20	Measurement of mechanical parameters	J.Szymkowski	2.5				2.5	
11-21	Assembling of electronic circuits	K.Budny	1.0				1.0	
11-53	Short term consultant	R.Zielinski	0.7					
		Total:	76.9*	1.5	5.4	31.8	36.1	2.1

Remark: When prompt placements were required, some consultants were placed initially as "short term consultants". Here these posts are combined with the respective consultants' lines.

Annex VIII

LIST OF EQUIPMENT NOT YET DELIVERED BY UNIDO
(Status 15 January 1988)

Item	Position	Name	Quantity	PO	Supplier	Remarks
40.5		Transformer and spare parts for plating lines	1set		Metronex	Sent by railway on 14 October 1987
41		Test disk for B 8011 controller	1	15-4-C1516	Siemens	Oryginal was destroyed, besides it was in German while English ordered
51	1	Op-amplifier type uA725	4	15-7-C0968	ADO	Ordered, status unknown
	2	Op-amplifier type 084	60	15-7-C0925	RS	Despatching expected before 15 Jan.1988
	18	Photocoupler type IL1			Behr	UNIDO are ordering
	12	IC type Bd1100011BP	15	15-7-C0968	ADO	Ordered, status unknown
	181	Diode BYT08-200	22		Topasan	Despatched on 21 December 1987
	183	Diode 1N3900(R)	70		"	"
	181	Diode BYT30-600/15.3	22		"	"
	193	Resistor # 955-950	6packs	15-7-C0925	RS	Despatch expected before 15 January 1988
	372	Solvent cleaning fluid	5	"	RS	"
52	68	De-soldering bit # 541-191	1	15-7-C0881	RS	Pouched before 15 January 1988
53	308	Wire 30 AWG white #359-908	5reels	15-7-C0312	RS	One reel received instead of 6 ordered
	407	Capacitor 220 pf 20%	10pack	15-7-C0312A	RS	Status unknown
	412	Reed relay # 345-555	20	15-7-C0312	RS	"
	420	Plug 9-way # 466-179	5	15-7-C0312B	RS	"
	421	Plug 15-way # 466-185	8	"	RS	"
	422	Plug 25-way # 466-222	12	"	RS	"
	423	BNC socket 75 ohm # 455-826	5	"	RS	"
	424	Hood 25-way # 469-588	5	"	RS	"
	430	Hood for QM 19-way	10		RS	Status unknown
	431	Hood for QM 35-way	10		RS	"