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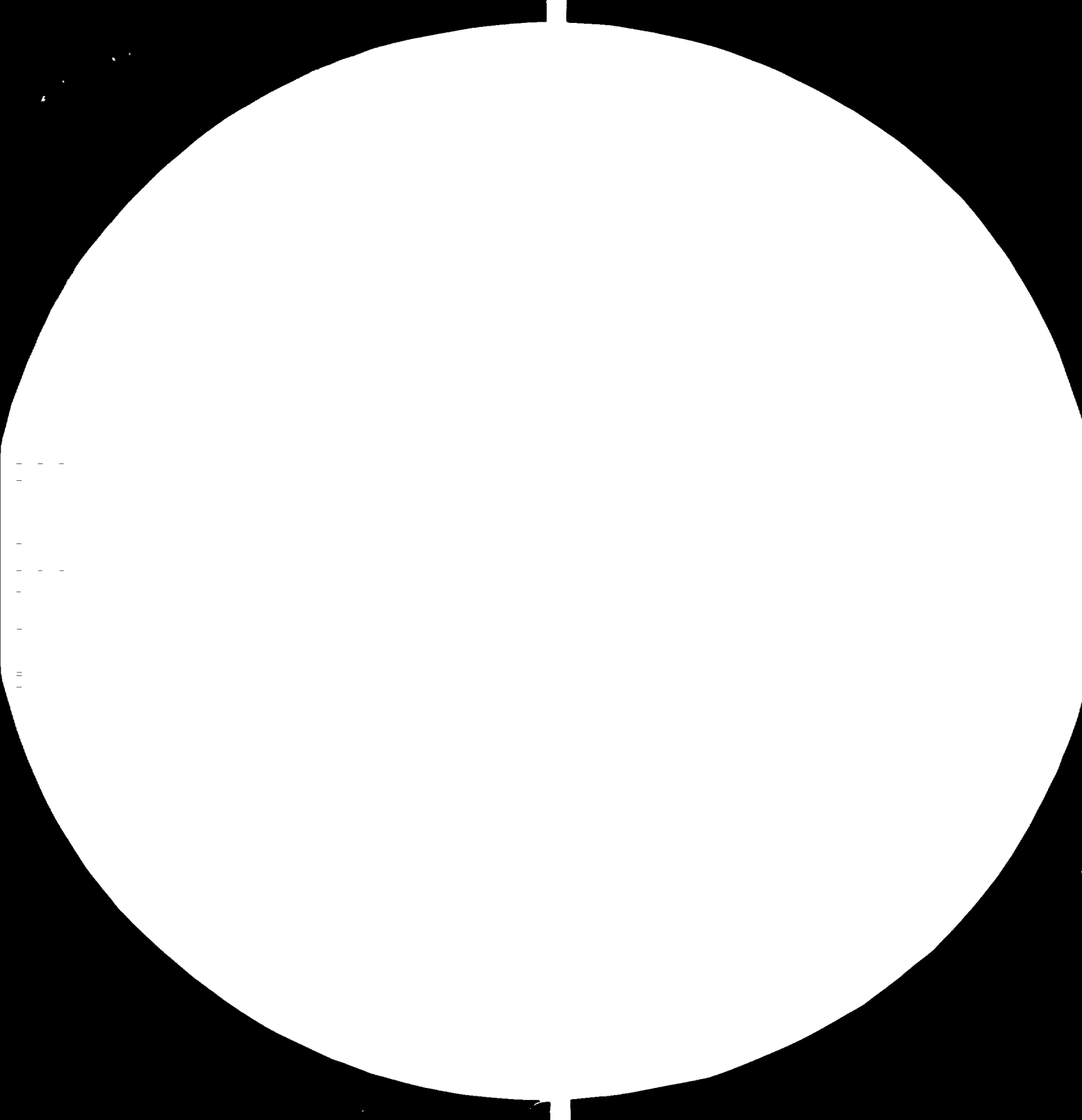

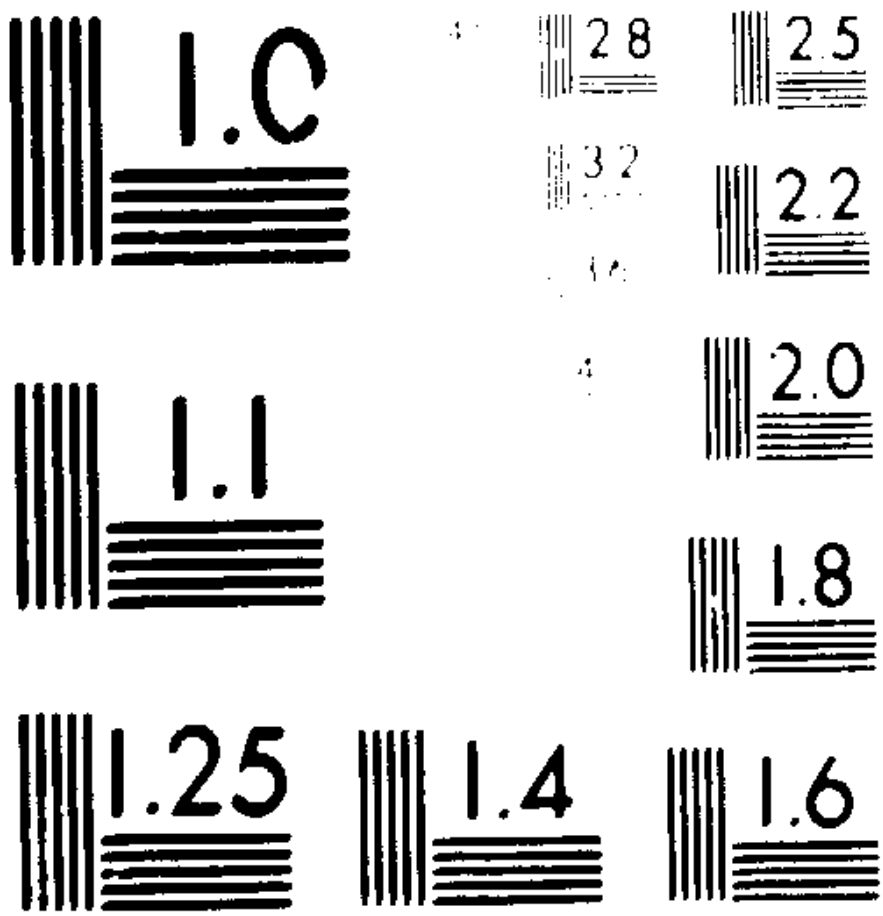

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RESTRICTED
18 December 1979

NUMERICAL CONTROL/COMPUTER-AIDED MANUFACTURING
METALWORKING DEVELOPMENT CENTER

PEOPLE'S REPUBLIC OF BULGARIA
(DP/BUL/76/003/11-03/31.9.B)

Project findings and recommendations

Mission report prepared for
the Government of Bulgaria

by

John A. Moorhead

expert of the United Nations Industrial Development Organization acting as Executing Agency for the United Nations Development Programme

This report has not been cleared with the United Nations Industrial Development Organization which does not therefore necessarily share the views presented.(1)

(1) To be omitted after clearance by UNIDO

TABLE OF CONTENTS

I. ACKNOWLEDGEMENTS

The author would like to express his gratitude and sincere thanks to the STATE ECONOMIC CORPORATION's "MACHINE TOOL PLANTS" organization (DSO-ZMM) and to the MACHINE TOOL RESEARCH INSTITUTE (IMM) for their continued assistance in this activity and for providing the facilities and support which were necessary to make this mission successful.

Special thanks are directed to Mr. Schtilian Petrov, General Director, DSO-ZMM; Mr. Lyubomir Moinov, Director, IMM; Mr. Nicola Todorov, Division Chief, IMM; Mr. Dimiter Penkov, Project Manager for UNIDO and Manager of the Numerical Control/ Computer-Aided Manufacturing (NC/CAM) Metalworking Development Center and the Center's staff.

The author would also wish to thank Mr. Metodi Bitrakov, Mr. Dimo Tchernev, and Mr. Emilian Milushev for the many services they provided.

II. SUMMARY OF FINDINGS AND RECOMMENDATIONS

FINDINGS. The major problem has been delivery delays and the subsequent delay of fellowships. The first Project Progress Report was completed and updated gannt charts were prepared. The Center has developed a productivity cell and has conducted a wide-range of training and other services for industry.

RECOMMENDATIONS. It is recommended that the Center implements the UNDP-furnished equipment and fellowships as soon as practical. Also, computer programs for NC, CAM and internal records were suggested. Finally, recommendations for initial subjects for the training equipment and for an investigation of computer-aided design were made.

III. INTRODUCTION AND OBJECTIVES

Beginning in 1972, UNIDO provided fellowships for Bulgarian personnel to initiate a detailed study of the numerical control (NC) potential. The resultant project document (DP/BUL/76/003) was approved 1 July 1978.

Specific requirements for this mission were as follows:

A. Complete the first Project Progress Report.

B. Revise the gannt charts of the project document and supply information on equipment, experts and fellowships.

C. Organize the specifications and requisitions for all equipment to be ordered in 1980.

D. Request action on the candidate submitted for post 11-02.

IV. FINDINGS AND CONCLUSIONS

A. The Project Progress Report was delivered to UNIDO along with this report. Essentially, the report was prepared by the Project Manager and his staff.

B. The gannt charts were revised and constitute Annex B1,2,3,4.

C. The planned requisitions for 1980 have been reviewed in detail. A time interval is involved to update the technical specifications/current prices.

D. Of the three candidates submitting qualifications for post 11-02, only one was deemed capable for the Center's requirements. The acceptable individual withdrew his acceptance as he had opted for another UNIDO position of greater duration. It was requested that recruitment of individuals be continued, based on the job description in the project document.

E. The major difficulty has been the delayed deliveries of equipment requisitioned and ordered in 1978 and 1979. These long delays would have curtailed the activity of a lesser organization. The adjustments, in both equipment selection and personnel placements, has been superior in the continual utilization of the resources at hand.

Closely associated with the delivery delays has been the subsequent delay in the awarding of fellowships. Utilizing fellowships prior to the installation of the equipment would have been counter-productive. The objective is to have the fellows put their newly learned knowledge and skills to immediate, practical application.

Fortunately, this problem has been resolved and this resolution could have been the source of a second problem. Though the requisitions and purchase orders were issued over a 15-month period, over 80% of the dollar-value of the UNIDO-furnished equipment will be received in the first quarter of 1980. The Center's staff is organized to implement all of this equipment per project revision G.

F. During the mission, a requisition was submitted for a total of eight (8) hand-held calculators. Submitted with the requisition was a note from the author agreeing with the need for the equipment. The note also stated that a detailed explanation would accompany this report. The explanation appears as Annex C.

G. The volatility of the electronics and the computer industries has forced the Center to constantly reappraise

their equipment needs and applications. In this reappraisal, the Center has greatly enlarged their computing power, while actually reducing expenditures.

H. Faced with the common problem of convincing manufacturing personnel of the effectiveness of NC, the Center has set up a Productivity Cell. Skilled and semi-skilled workers, from the plant in which the NC machines will eventually be installed, are turning out production parts. Daily records are carefully kept on any non-production times and corrective action is taken to insure the best possible productivity at the final destination. More detailed information on the Productivity Cell appears in Annex D.

I. Training activities have been underway since early 1978. In 1979, the Center increased the training hours by 43% and the number of people trained was raised by 53%. Overall, 11 courses have been developed, 22 classes presented and 204 people have been given a total of 16,249 man/hours of training. The attendance figures appear in Annex E.

J. A number of additional services have been performed by the Center staff for industry. These include surveys to determine NC potential, assistance in implementing NC within a plant, programming services, NC familiarization seminars and NC justification services. Statistical and descriptive information on these services appears in Annex F.

K. On 13 December 1979, the author presented a course on utilizing audio cassettes in training. Briefly, the presentation dealt with adult education, cassette shortcomings, selecting subjects, manuscript formats

and development, production, testing, duplication, and costs (see Annex G).

L. It should be noted that the Government contribution in equipment and personnel was either on or ahead of schedule and, in some cases, the contribution was greater than stated in the Project Document.

V. RECOMMENDATIONS

1. Implemetn the incoming equipment into production status at the earliest possible date.

2. As Center personnel return from fellowships, classes for other staff members should be initiated as soon as possible.

3. Develope postprocessors and initiate training (internally within the Center) at the earliest practical date.

4. Initiate a computer-aided manufacturing system based on proven software. The software must be able to interactively retrieve, sort and update data; generate summary and detailed reports, titles, headings, footnotes, etc. to report both group and report totals and allow for the creation, maintenance and access to a record management system.

5. Enlarge and detail the current recording methods for detailing training and other services performed by Center personnel.

6. Based on the class presented by the author (Utilizing Audio Cassettes in Training), the programs of training and information dissemination should be initiated for both the teaching machines and the video training equipment. For both systems, a description of the UNIDO project of no longer than 20 minutes should be the first order of business. When this has been completed, emphasis should be on NC familiarization, and then on courses intended for Center staff personnel. Examples: hand-held calculators, coordinate measuring machine, laser interferometer, teaching machines, video system, etc.

7. Due to the delays in starting the Project and in securing equipment, 1980 will be an extremely busy and important year. The developing fields of computerized numerical control (CNC), and computer-aided design (CAD) should become a matter of study. The CAD system will be utilized by the entire Bulgarian

metalworking industry. This will necessitate time-consuming investigations into a great number of industrial sectors, so that the end system can meet the needs of all. The coordination and implementation of the CAM and CAD systems may require an extension of the Project.

VI. ANNEXES

ANNEX A

JOB DESCRIPTION

POST TITLE: Numerical Control Communication and Implementation Adviser.

DURATION: One month, with a possible extension of two weeks.

DATE REQUIRED: Each year.

DUTY STATION: Sofia, with some travel within the country.

DUTIES: The expert is expected:

To assist the Project Manager in the improvement of the NC Center's total system.

To train local staff personnel in the methods of communications as it applies to NC.

To assist in the development and/or updating of the NC Coordination communications.

To provide consultancy assistance to the NC Center and/or production facilities in the total field of NC as well as training activities.

QUALIFICATIONS: Must have experience in the conduct and management of NC machine operations, manual and computer-assisted part-programming, management, technical tours and NC coordination. Should have experience in communications activities associated with NC drilling, milling, turning and machining centers.

Must have at least five years experience in technical writing on NC subjects.

ANNEX B-1

ASSIGNMENT OF INTERNATIONAL EXPERTS

COUNTRY: BULGARIA

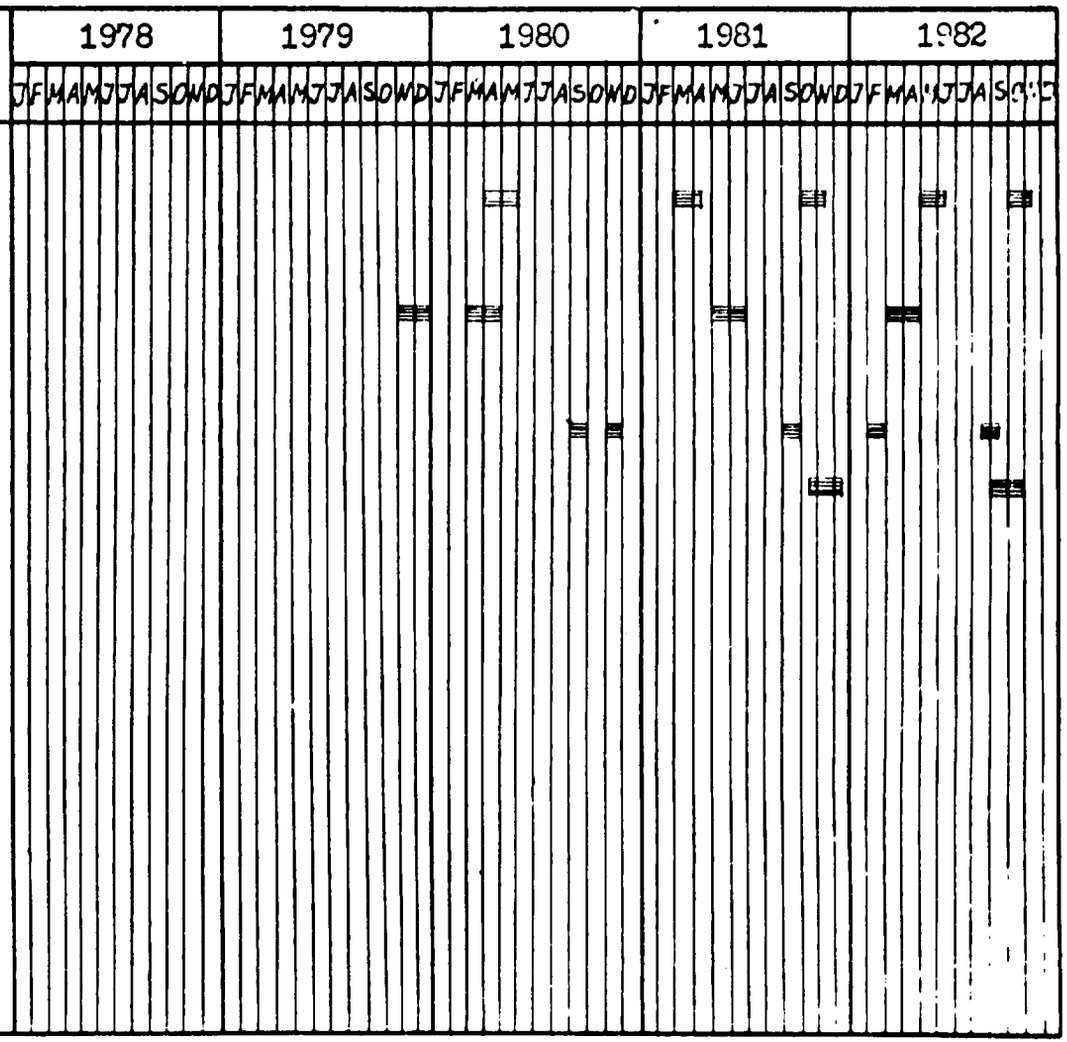
PROJECT No: BUL/76/003/G/01/37

TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

PART II.H1 WORK PLAN - BAR CHART

ASSIGNMENT OF INTERNATIONAL EXPERTS

EXPERTS	SUBJECT	m/m
11-02	Senior Numerical Control Adviser	8
11-03	Numerical Control Communications and Implementation Adviser	8
11-04	Programming and Computer-Aided Design Adviser	5
11-05	Short Term Consultants	4



ANNEX B-2

UNDP EQUIPMENT/FELLOWSHIP IMPLEMENTATION SCHEDULE

COUNTRY: BULGARIA

PROJECT No: BUL/76/003/G/01/37

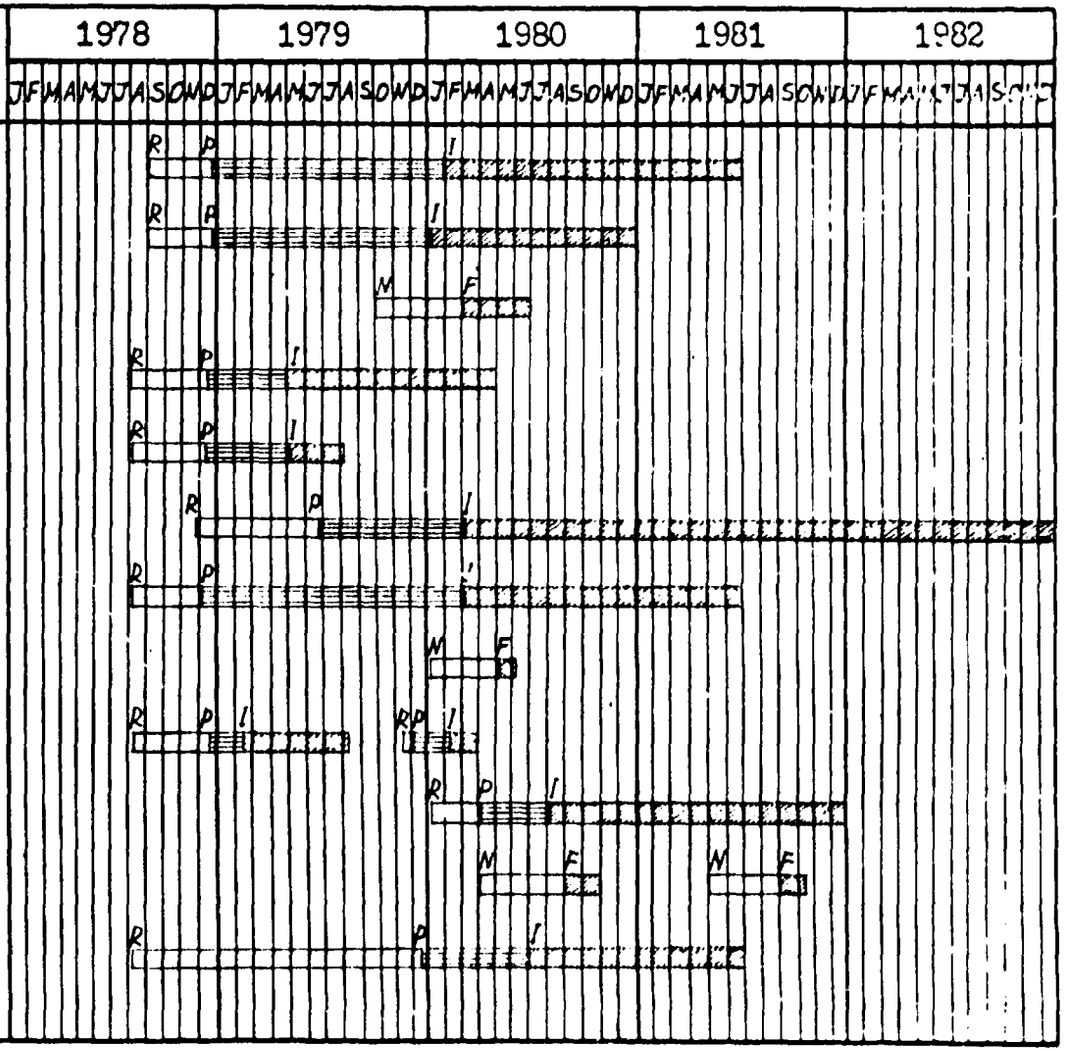
TITLE: NC/C.A.L METALWORKING DEVELOPMENT CENTRE

PART II.H1 WORK PLAN - BAR CHART

UNDP EQUIPMENT/FELLOWSHIP IMPLEMENTATION SCHEDULE

R = Requisition Form N = Nomination Form Subm.
P = Purchase Order F = Fellowship Begin
I = Implementation

ORIGIN. BAR-CH. NUMBER.	UNDP EQUIPMENT + FELLOWSHIPS
8	1. Desk-Top NC Tape Preparation System
8.1	2. ELAN software for Desk-Top System
7	2.1. ELAN software for Desk-Top System
9	3. Visual Control Board
10	4. Office Copier
12	5. Transportation Package
14	6. Coordinate Measuring Machine
13	6.1. Coordinate Measuring Machine
15	7. Programmable Portable Calculators
16	8. Computational Package
17	8.1. Computational Package
18	9. Teaching Machines



COUNTRY: BULGARIA

PROJECT No: BUL/76/003/G/01/37

TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

PART II.H1 WORK PLAN - BAR CHART

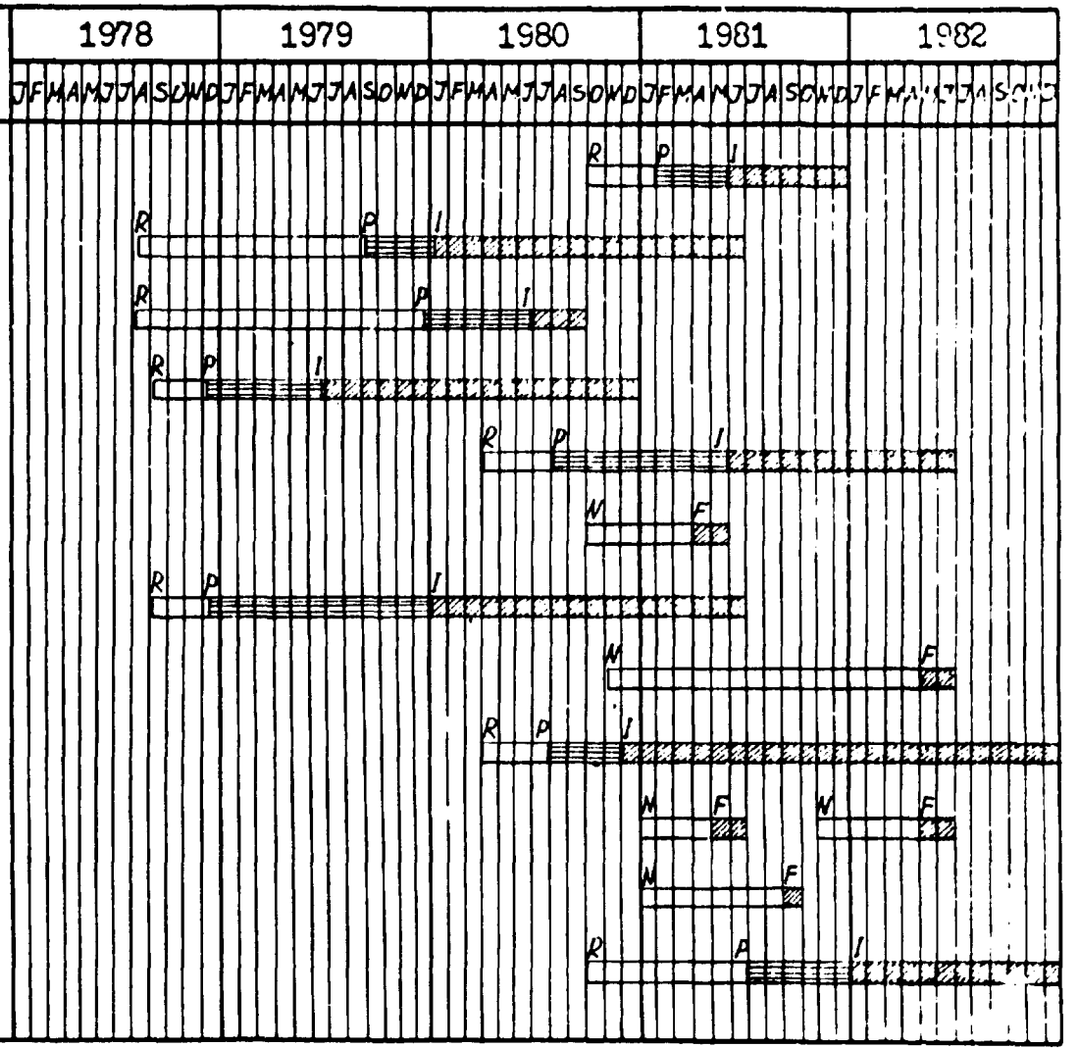
UNDP EQUIPMENT/FELLOWSHIP IMPLEMENTATION SCHEDULE

R = Requisition Form N = Nomination Form Subm.

P = Purchase Order F = Fellowship Begin

I = Implementation

ORIGIN. BAR-CH. REFER.	UNDP EQUIPMENT + FELLOWSHIPS
19	10. NC Tool Transport - Storage System
23	11. Color TV Videotape System
24	12. Slide Projectors + Photo Camera
25	13. Maintenance Package
33	14. CNC Machining Centre
47	14.1. CNC Machining Centre
38	15. Laser Measuring System
37	15.1. Laser Measuring System
40	16. Computer - Aided Design
39	16.1. Computer - Aided Design
48	17. NC Tape Production System - P
49	18. Digital Signal Analyzer



COUNTRY: BULGARIA

PROJECT No: BUL/76/003/G/01/37

TITLE: NC/CNC METALWORKING DEVELOPMENT CENTRE

PART II.H1 WORK PLAN - BAR CHART

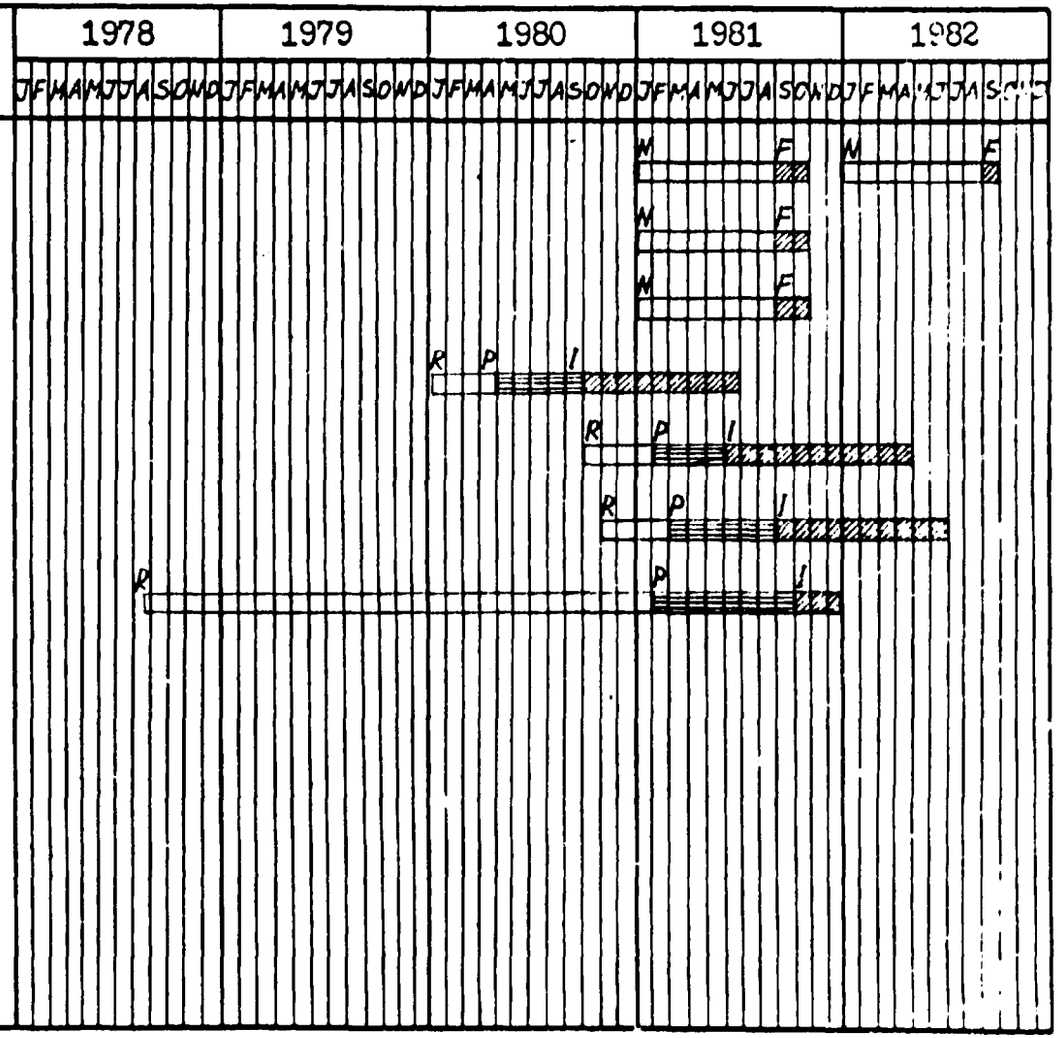
UNDP EQUIPMENT/FELLOWSHIP IMPLEMENTATION SCHEDULE

R = Requisition Form N = Nomination Form Subm.

P = Purchase Order F = Fellowship Begin

I = Implementation

ORIGIN. BAR-CH. REFER.	UNDP EQUIPMENT + FELLOWSHIPS
50	18.1. Digital Signal Analyzer
51	19. CNC Turning Machines
52	20. NC Tooling System
53	21. Wide - Band Noise Analizer
54	22. Small size powerful microcomputer
55	23. Universal Tooling Milling Machine
56	24. Station Wagon Car



ANNEX B-3

GOVERNMENT CONTRIBUTION - PROJECT PERSONNEL

COUNTRY: BULGARIA

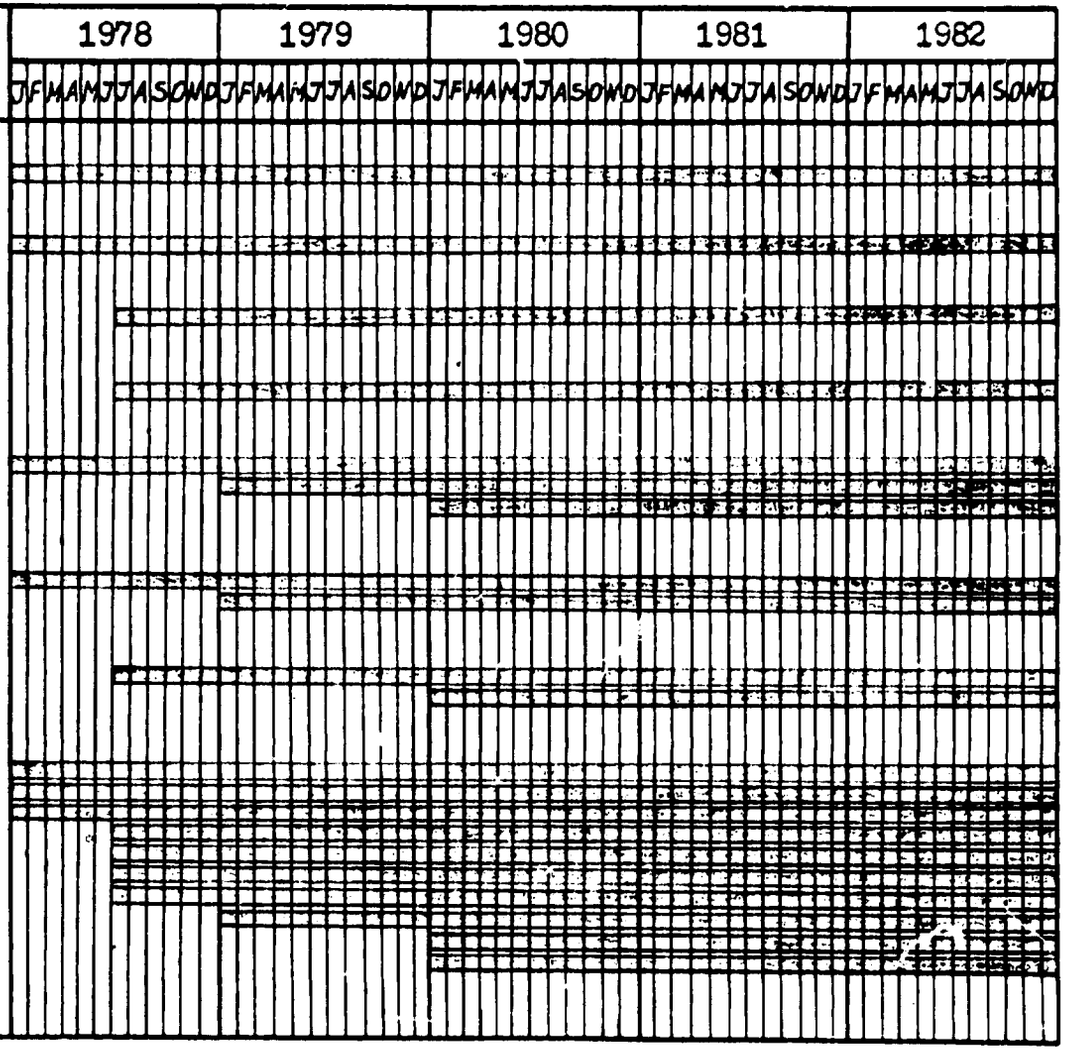
PROJECT No: BUL/76/003/G/01/37

TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

PART II.H2 WORK PLAN - BAR CHART

GOVERNMENT CONTRIBUTION - PROJECT PERSONNEL

	PROJECT PERSONNEL
A.	Project Manager
B.	NC Project Coordinator
C.	Administrative Coordinator
D.	Communication and Training Coordinator
E.	Secretary - Interpreters
F.	Accountants - Inventory
G.	NC Information / Library
H.	NC Part Programmers



COUNTRY: BULGARIA

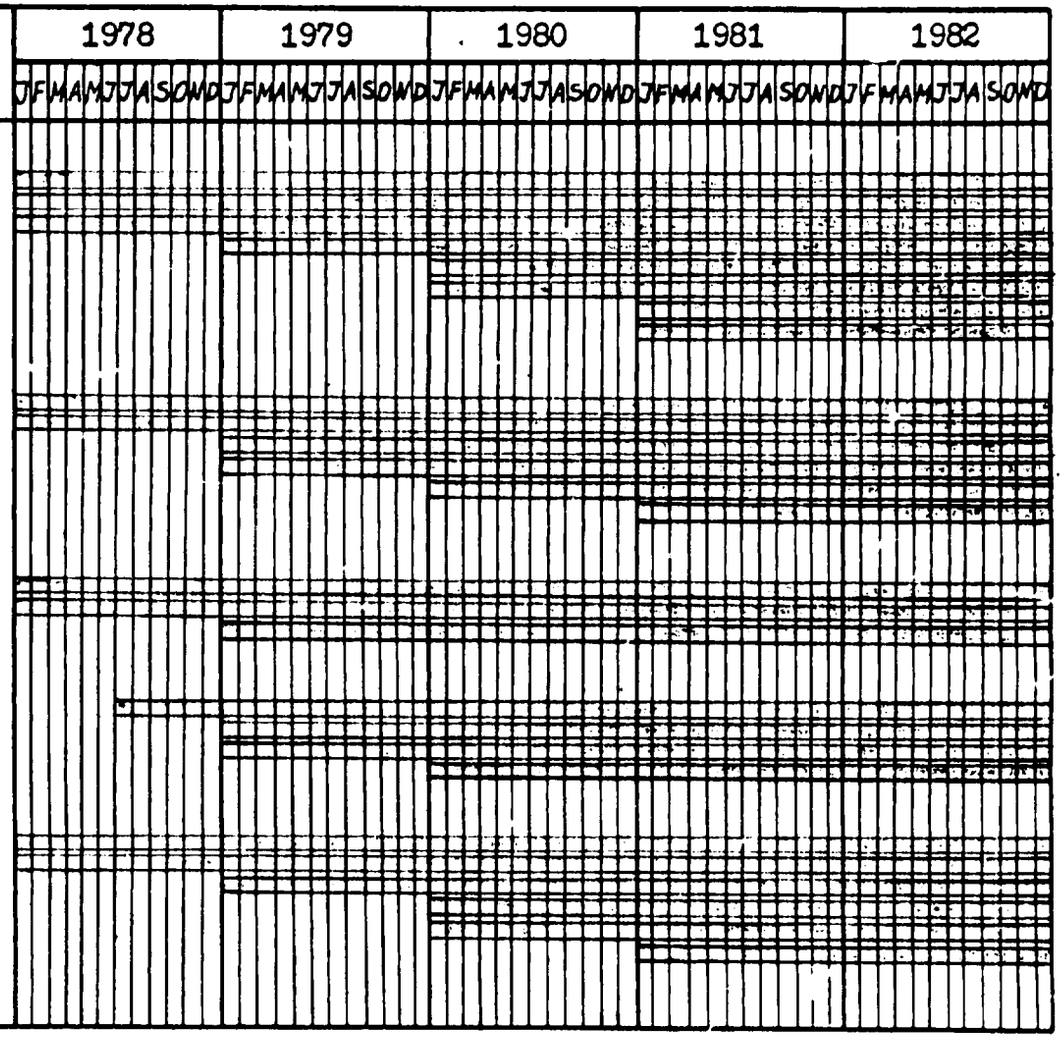
PART II.H2 WORK PLAN - BAR CHART

PROJECT No: BUL/76/003/G/01/37

GOVERNMENT CONTRIBUTION - PROJECT PERSONNEL

TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

	PROJECT PERSONNEL
I.	NC Operators / Tool Setters
J.	NC Maintenance Specialists
K.	NC Inspection Specialists
L.	NC Coordinators
M.	CAD Specialists



COUNTRY: BULGARIA

PROJECT No: BUL/76/003/G/01/37

TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

PART II.H2 WORK PLAN - BAR CHART

GOVERNMENT CONTRIBUTION - PROJECT PERSONNEL

	PROJECT PERSONNEL	1978	1979	1980	1981	1982
		J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
N.	Other Employees					
	TOTAL	26	41	54	60	60

ANNEX B-4

GOVERNMENT EQUIPMENT/ACTIVITIES

COUNTRY: BULGARIA

PROJECT No: BUL/76/003/G/01/37

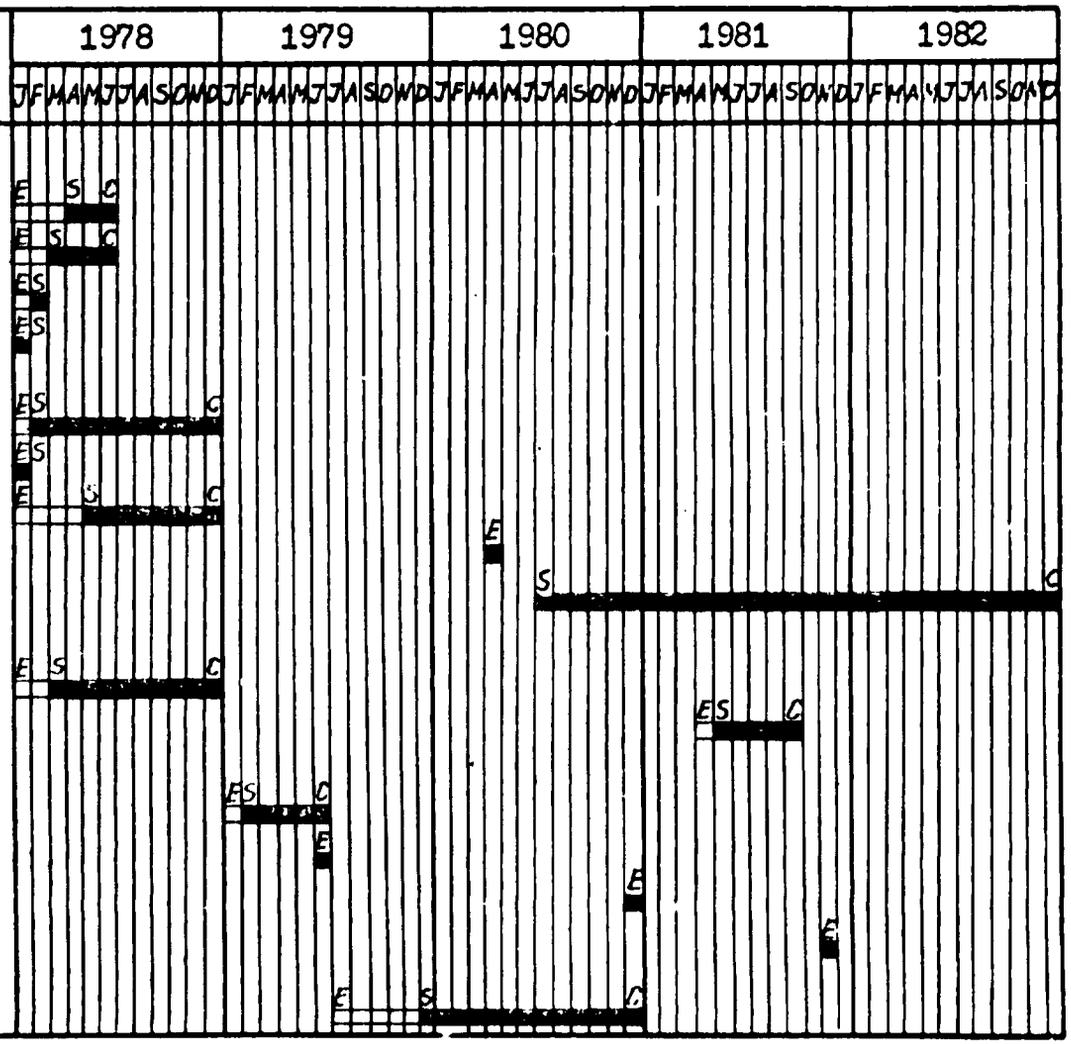
TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

PART II.H2 WORK PLAN - BAR CHART

GOVERNMENT EQUIPMENT/ACTIVITIES

E = Equipment Installed S = Activity Started C = Activity Completed

ORIGIN. BAR-CH. REFER.	GOVERNMENT EQUIPMENT/ACTIVITIES
1	1. Medium Size NC Turret Drilling Boring and Milling Machine RV 001
2	2. NC Turret Drill
3	3. NC Tape Package EC 8501
4	4. Overhead Projectors
5	5. 16-mm Motion Picture Camera Projector and Screen Set
6	6. Microfishe Reading Equipment
20	7. Medium Size Chucking NC Lathe
21	8. One Small Car
22	9. Start Building New Center Complex
28.1	10. Plug Board Program Controlled Lathe CE 081.01
29	11. Universal Cutting Tool Grinder
30	12. Hydraulic Tool Holder's Assembling Stand
31	13. Small Fork Lift
35	14. One Small Car
36	15. One Platform Electrocar
43	16. Medium Size NC Lathe with Automatic Toolchanger



COUNTRY: BULGARIA

PROJECT No: BUL/76/003/G/01/37

TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

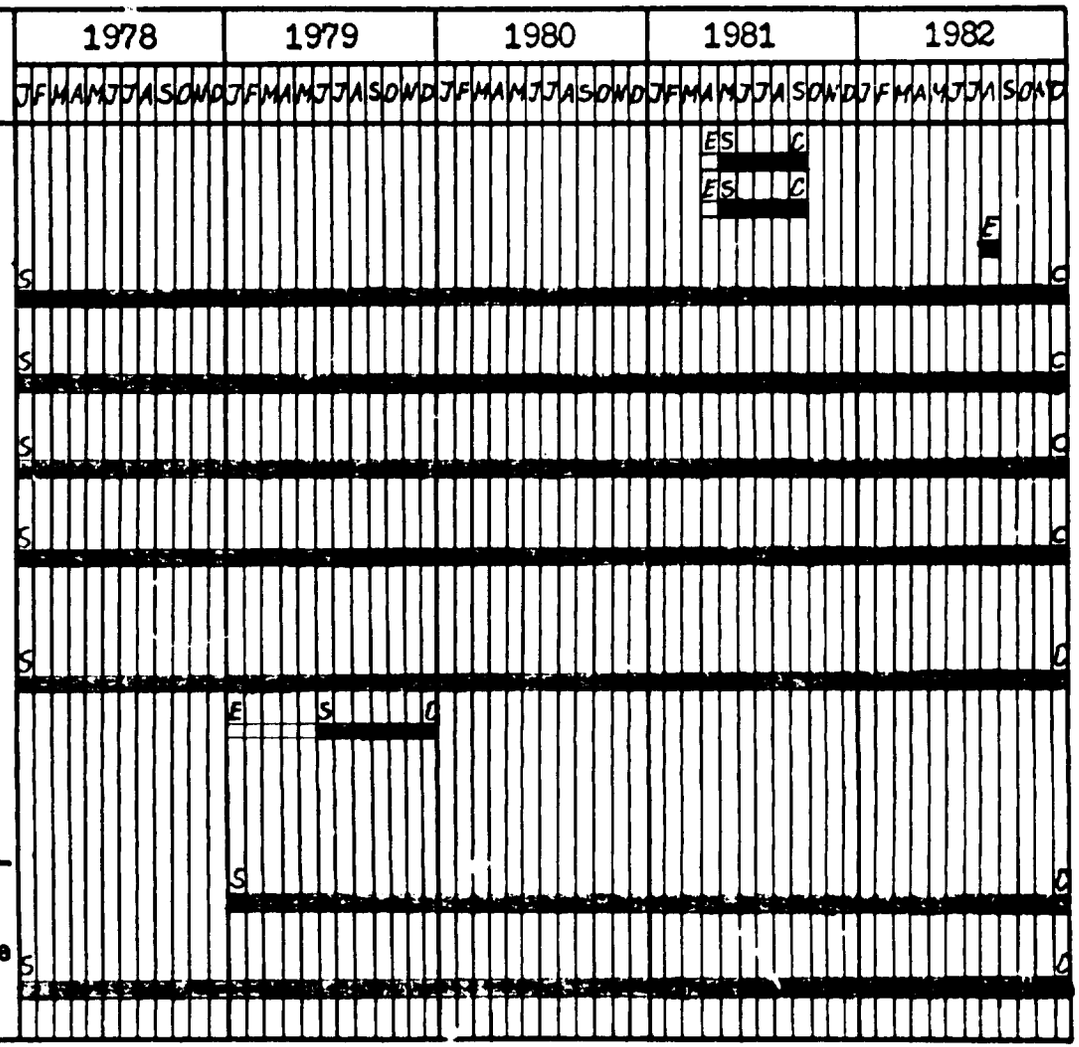
PART II.H2 WORK PLAN - BAR CHART

GOVERNMENT EQUIPMENT/ACTIVITIES

E = Equipment Installed S = Activity Started

C = Activity Completed

ORIGIN. BAR-CH. RETIR.	GOVERNMENT EQUIPMENT/ACTIVITIES
44	17. Tool Presetting Machine
45	18. Tool Presetting Machine
46	19. One Small Car
57	20. Establishment of an NC/CAM CENTRE
58	21. Recruitment of the Full-Time Government Personnel
59	22. Training Courses organized and conducted
60	23. NC/CAM CENTRE serve as an NC Advisory Service to Industry.
61	24. Intensive Preparation of NC Control Tapes (part-programs) and Technological Documentation
62	25. "ISOT-0310" Minicomputer
63	26. BASIC Language mastered trough "ISOT-0310" and implemented for Development of Computer-Assisted Part-Programming Systems
64	27. Language Training of the NC/CAM Centre Staff Members



COUNTRY: BULGARIA

PROJECT No: BUL/76/003/G/01/37

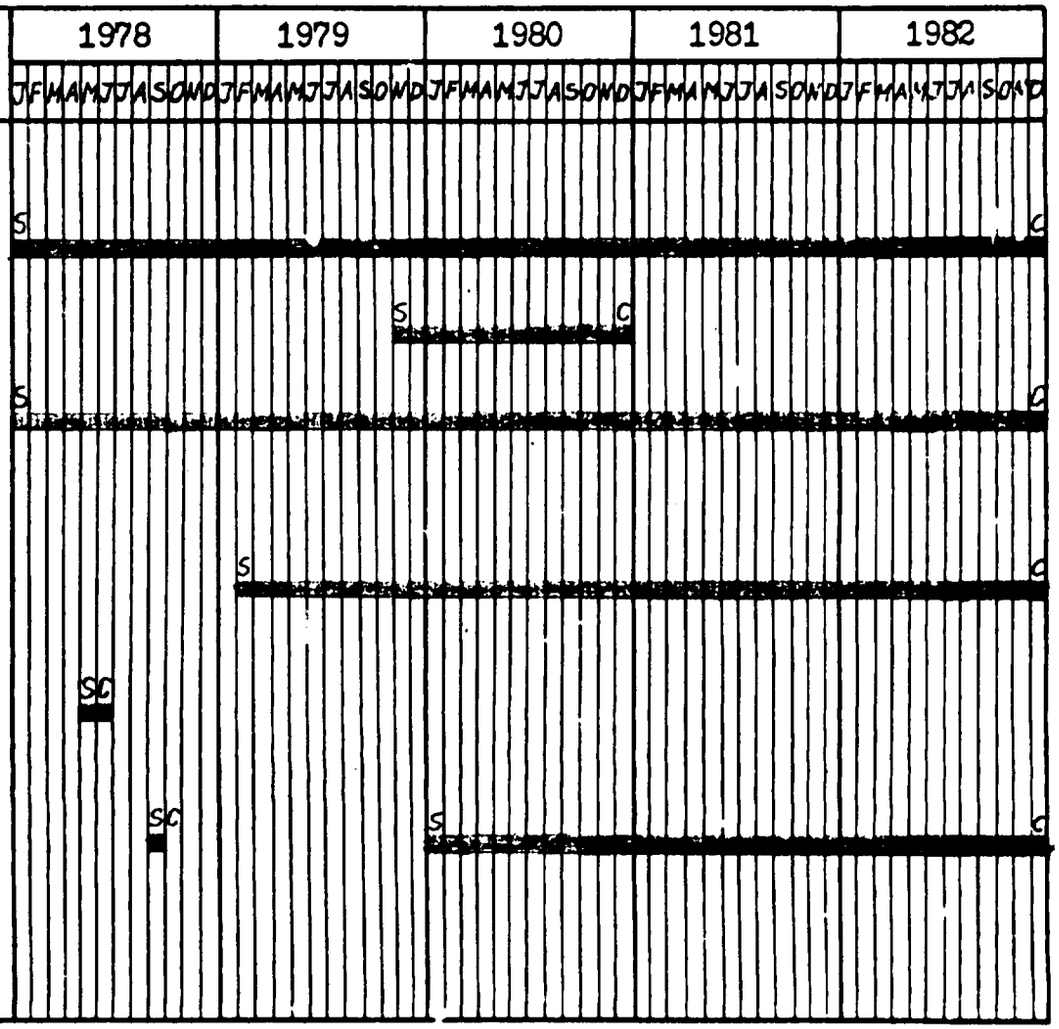
TITLE: NC/CAM METALWORKING DEVELOPMENT CENTRE

PART II.H2 WORK PLAN - BAR CHART

GOVERNMENT EQUIPMENT/ACTIVITIES

E = Equipment Installed S = Activity Started C = Activity Completed

ORIGIN. BAR-CH. REFER.	GOVERNMENT EQUIPMENT/ACTIVITIES
65	28. NC Coordinators' Activities. Introduction of NC Machine Tools in Industry
66	29. NC Justification System Development to be Adjustable to Local Conditions
67	30. NC Seminars organized and conducted at other locations
68	31. Translation and Publication of Training Materials and Manuals for NC Machine Tools and Support Equipment
69	32. Organization and Carrying-out of an UNIDO In-plant Training Course on Tooling
70	33. Study Tours, Seminars, Conferences, International Shows and Fairs, Plant Visitations



ANNEX C

The Center has an immediate need and application for an additional eight (8) hand-held calculators. Based on the successful utilization of their current calculators and the effective progression to more effective computation aids, the Centre can use these units for both training and practical applications.

The Centre has made excellent use of the five (5) hand-held calculators, which were purchased through UNIDO, and received in March, 1979. Delivered with the calculators was a library of 25 standard programs; about ten (10) of which dealt with tax computations, banking interest rates and similar subjects of little or no value to the Centre. To enlarge the library of usable programs, the Centre engineers, (though the number of calculators available is minimal), have developed 82 programs to date. The programs range from 30 to 700 steps; with the average ranging from 320 to 360.

In addition, each newly-created program is cataloged by title, area of application and is accompanied with a brief description of the methodology. This makes the programs available to other Center personnel and avoids duplication of effort.

As training is a major activity of the Center, the entire Operation Manual for the current calculators has been translated into the Bulgarian language. The result of the four man/months translation effort and two man/months of editing and typing is a detailed, two-volume manual of over 400 pages.

The five, in-house calculators have been used extensively by 17 engineers and statisticians. Use has been restricted to those problems which utilize most or all of the calculating capabilities of the units on hand.

To date, the calculators have proven to be excellent in "sharpening" and extending the mathematical skills of the engineers and are training them at the machine level language. From a practical, mathematical basis, they are preparing themselves for computers; which have already been requisitioned through UNIDO.

In the continued use of the calculators, two important findings have been made. First, many more engineers would use them, if they were available. Secondly, there are many problems which, by complexity and/or size, require greater calculator capacity.

Based on the above reasons, the addition of eight (8) hand-held calculators is recommended. Six of these are to be identical to the five units already on hand. The overload on the current calculators, plus the ability to readily train additional personnel, makes this extremely practical. The other two calculators would relieve the capacity problem.

These eight, hand-held calculators are neither a stop-gap nor an interim move. The calculators will have a continuing application to the on-going operations of the Center for years. As well, the two enlarged-capacity calculators will improve the engineers' mathematical abilities. This is in keeping with the planned advancement of the staff to the use of electronic computing devices. These eight units will greatly help the advance of the staff with training minimized and the problem-solving activities maximized. Training activities have been developed to reduce the "practice time" on the calculators, so that their major use will be on current and future problems.

ANNEX D

A specific area within the IKM plant has been set aside for use as a productivity cell. The productivity cell serves two major purposes: (1) to aid management and operational personnel in gaining confidence in NC and their own abilities to successfully utilize the concept and (2) to gather detailed information on the productivity of the NC machines.

Currently, the productivity cell is completing a four-month study of four NC lathes, which were ordered by a gear manufacturer. Earlier, three tool setters and a part programmer came to Sofia for classes at the Center. When the NC lathes were installed in the productivity cell, the part programmer has been at IKM for the duration of the study. The tool setters rotate on the basis of one week at the productivity cell and two weeks in the gear plant. Center staff members are available throughout the early stages of the study and are immediately available as the study progresses and they are needed. At the present time, the part programmer is working on his own and has produced 26 acceptable tapes, so far.

Four operators from the gear plant were given minimal in-plant training before being sent to the productivity cell. Their responsibilities include loading/unloading the machine, monitoring operations and making specific inspection of the finished parts. When there is a change-over to a new job, the tool setters make the new setup and check out all of the cutting tools.

Throughout the study, the Center has two, highly skilled technicians on duty in the productivity cell. They assist the gear plant personnel in programming, tool setting, cutting technology, machine operations etc.

A third productivity cell staff member records all non-production times and their causes, he also accounts for the

time required for corrective measures to be taken. Through this recordkeeping system, the Center can account for lost productivity due to failures/repairs, organizational reasons or preventive maintenance. The failures/repairs section goes into detail on data input, internal processing, feed drives, main drive, etc. The organizational reasons section covers the unavailability or incorrect personnel, materials, cutting tools, inspection equipment, etc. The preventive maintenance is scheduled often in the early stages and, in the future, will be designed around the individual machines.

ANNEX E

Training Activity	Duration (hours)	Number of Participants
1	2	3
NC Lathe Programming	65	13
NC Lathe Tool Setting	70	11
NC Lathe Programming	65	11
NC Lathe Electrical Interface Maintenance	79	11
NC Lathe Electrical Interface Maintenance	79	11
NC Lathe Electrical Interface Maintenance	79	13
NC Drill-Bore-Mill Setting	70	3
NC Drill-Bore-Mill Programming	65	4
NC Machine Center Setting	81	6
NC Machining Center Programming	77	4
NC Machining Center Electrical Interface Maintenance	70	3
NC Machining Center Setting	81	4
NC Lathe Programming	65	4
NC Lathe Tool Setting	70	11
NC Lathe Programming	65	11
NC Lathe Electrical Interface Maintenance	79	13
NC Lathe Tool Setting	70	16
Sequence Plug-Board Lathe Electrical Interface Maintenance	38	11
NC Drill-Bore-Mill/Lathe Electronic Maintenance	205	18
"BASIC" Language Introduction	25	6
Design and Utilization of Tooling in Metalworking Industries	114	12
Management Study Tour - International Machine Tool Show in Chicago	22 days	7

ANNEX F

The additional services of the Center, which are provided to industry, are many and varied. Requests from 18 different plants resulted in staff members making surveys at each installation to determine NC potential. The Center produced over 600 programs and control tapes for some 30 plants. The NC Familiarization seminars were attended by more than 350 people from 40 different plants. They aided 17 companies in implementing the NC concept into their shops.

ANNEX G

R O L L

of the participants of the lecture on utilizing audio cassettes in training

13. December 1979

1. Dimiter Penkov, Mech. Eng., M. Sc., R. Eng.
2. Vladimir Tcheshmedjiev, Mech. Eng., M. Sc., R. Eng.
3. Metodi Bitrakov, Mech. Eng., M. Sc., R. Eng.
4. Emilian Milushev, Elec. Eng., M. Sc., R. Eng.
5. Ognyan Petrov, Mech. Eng., M. Sc.
6. Roussy Michailov, Mech. Eng., M. Sc.
7. Nedyalko Yotkov, Mech. Eng., M. Sc.
8. Rumen Latinov, Electronic Eng., M. Sc.
9. Dimiter Dimitrov, Mech. Eng., Ph. D., R. Eng.
10. Petyo Tsankov, Mech. Eng.