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DP/ID/SER.B/574
29 April 1987

ENGLISH

STRENGTHENING OF THE INSTITUTE FOR INDUSTRIAL CYBERNETICS AND ROBOTICS

DP/BUL/81/002

BULGARIA

Terminal report

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

Based on the work of N. Shivarov,
executive national project manager

Backstopping officer: V. Smirnov, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

V.87-84650
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Explanatory notes

The monetary unit in Bulgaria is the lev.

Mention of dollars ($) refers to United States dollars.

IICR stands for Institute for Industrial Cybernetics and Robotics.

ABSTRACT

The project "Strengthening of the Institute for Industrial Cybernetics and Robotics" (DP/BUL/81/002) was approved by the United Nations Development Programme (UNDP) in December 1981, and the United Nations Industrial Development Organization (UNIDO) was designated as executing agency. Implementation of the project in Bulgaria began in January 1982.

The objectives of the project were as follows:

(a) To assist in the realization of the government policy regarding the applications of electronics and robotics in industrial processes with a view to increasing labour efficiency and quality of production and relieving people doing work involving processes harmful to their health or monotonous in character;

(b) To play a leading role in the government policy regarding the introduction of various means of mechanization and automation to the industrial, agricultural and other sectors of the national economy;

(c) To strengthen the Institute for Industrial Cybernetics and Robotics (IICR) so that it could render services and technical assistance, to Bulgaria as well as developing countries, in various fields of robotics and industrial cybernetics.

The latter objective included extending the activities of the IICR pilot plant in order to meet the requirements of mecatronics and telematics; regularly conducting training courses and conferences; improving the capabilities of IICR regarding technical documentation and information retrieval; establishing a laboratory providing precise measurements and testing of static and dynamic parameters of industrial robots; strengthening certain sections and departments at IICR.

The following recommendations were made:

(a) IICR should carry out consultancy services aimed at introducing industrial robotics, flexible manufacturing systems and other systems related to these new technologies;

(b) IICR should develop microprocessor-based automated process control systems and implement robots in key industries;

(c) IICR should contribute to the elaboration of training programmes for specialists from developing countries in the fields of industrial robotics and industrial cybernetics.

CONTENTS

INTRODUCTION

The project "Strengthening of the Institute for Industrial Cybernetics and Robotics" (DP/BUL/81/002), a joint effort carried out by the United Nations Development Programme (UNDP) and the United Nations Industrial Development Organization (UNIDO), was approved by all parties in December 1981. Implementation of the project in Bulgaria began on 1 January 1982.

The present report deals with the objectives of the project, the activities carried out and the outputs produced, the achievement of the immediate objectives, the utilization of the project results, and the findings and recommendations. The annexes give detailed information on services and equipment provided in accordance with fixed time schedules and expenditures.

The main objectives of the project can be summarized as follows:

(a) To assist in the realization of the government policy regarding the applications of electronics and robotics in industrial processes with a view to increasing labour efficiency and quality of production and relieving people engaged in work involving processes harmful to their health or monotonous in character, such as vibration, dust, high temperature, repetitive manual operation, visual inspection, conveyor work etc.;

(b) To play a leading role in the government policy regarding the "intellectualization" of the economy;*

(c) To strengthen the Institute for Industrial Cybernetics and Robotics (IICR) so that it may render services and technical assistance, both in Bulgaria and in developing countries, in various fields of robotics and industrial cybernetics.

The UNDP made the following contributions (in dollars):

Purpose	Amount
Expert personnel	20,304
Training staff abroad	188,210
Equipment	94,337
Miscellaneous expenditures	47,077

For a list of the equipment financed by UNDP see annex I.

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*"'Intellectualization' of the economy", in the context of the government policy, means a broad introduction of various means of mechanization and automation (such as industrial robots, numerically controlled machine tools, computers for process control automation and semi-automated machines) to industry, agriculture, construction and other sectors of the national economy. This is combined with the national programme in the field of general and professional education and training, which is directed towards mastering modern technologies.

The host Government made the following contributions (in thousands of leva):

Purpose	Amount
Project personnel	3,000
Training personnel abroad and within the host country	210
Equipment	3,000
Equipment maintenance	30
Miscellaneous expenditures	20

The equipment financed by the host Government included devices for mechanical and thermodynamic measuring and for electrical and radiotechnical measuring; oscilloscopes; multimeters (digital analogue); generators; lathes; machines for milling, grinding and polishing; various machine tools; locksmith's equipment; presses; equipment for spot welding, arc welding and spray-painting; mechanical measuring instruments; galvano-technical equipment for metal coating etc.

Despite the relatively small amount of equipment purchased for the project, it was considered of great importance to begin actual activities in the area of robotics and industrial cybernetics.

The installed equipment offered a useful base for the successful implementation of the goals specified in the project document. It included a lot of advanced features and operated in the interactive mode; and the application software proved to be user friendly. Training courses were easily conducted and trainees were able to acquire the necessary knowledge and experience within a short period of time.

The above-mentioned inputs were used to carry out the following activities: one expert was invited to Sofia for three man-weeks; one expert and a team of consultants were invited to Sofia for two man-weeks; nine staff members were sent to five countries for fellowship training for 25 man-months; 196 staff members and top managers were sent on study tours for 184 man-weeks.

The immediate objectives of the project can be summarized as follows:

(a) Strengthening the departments developing industrial robots;

(b) Organizing and establishing a modern laboratory providing precise measurements and testing of static and dynamic parameters of industrial robots and robot systems;

(c) Strengthening the departments of industrial cybernetics and robotics;

(d) Strengthening the sections dealing with software for control and industrial robot systems;

(e) Extending the activities of the Institute pilot plant in order to meet the requirements of new trends in science and technology - mecatronics and telematics;

(f) Broadening and strengthening the capabilities in the field of technical documentation, technical information, information retrieval and dissemination;

(g) Improving the connection between development activities and production of electronic and robot systems by regularly organizing and conducting training courses, seminars, scientific conferences and symposia.

RECOMMENDATIONS

The following recommendations were made:

1. IICR should train specialists in the following fields:

   (a) Microprocessor systems for controlling industrial processes;

   (b) Programming and applications of personal computers;

   (c) Industrial robots and their applications.

For the best organization of such training, the demonstration hall for microprocessor applications and the demonstration hall for robotics need to be equipped with audio-visual apparatus and word processors. Technical video films of an educational nature and the necessary literature, including technical magazines, should also be made available. These minor tasks could be accomplished by means of a small project financed by UNIDO, which should also include the training of trainers.

2. Within the framework of the fourth programming cycle, a project entitled "Establishment of a training and consultancy centre for advanced manufacturing technologies" will be carried out in Bulgaria as a logical continuation of the activities implemented so far. IICR should go on with the training activities of the above-mentioned project, with special emphasis being placed on the following:

   (a) Establishing all prerequisites for further development in the field of industrial cybernetics and robotics;

   (b) Ensuring that the results from the training have a multiplying effect, especially in the least developed countries, by, inter alia, including the training of trainers from those countries;

   (c) Obtaining feedback from industry through pilot implementation of the project outputs in industry and to use those facilities for training specialists from other countries.

3. With UNDP/UNIDO assistance, IICR should continue the research and development programmes in the field of industrial cybernetics and robotics, following international trends in the field and implementing new materials and technologies in it. As the IICR-Bulgaria and Instruments Design Development and Facilities Centre-India joint project (UC/INT/84/261) shows, some teams from other countries could participate using UNDP and UNIDO as an umbrella.

4. IICR should be the host of the proposed UNDP/UNIDO regional project in robotics for the period 1988-1990. IICR should do its utmost to assist in the realization of regional and interregional activities.

I. ACTIVITIES AND OUTPUT

To achieve the goals specified in the project document, activities were concentrated and carried out in the areas listed below.

A. Expert services provided by the United Nations Development Programme

Detailed information concerning what was furnished by the international experts can be found in their mission reports. The project was assisted by two internationally known experts: H. Makino of Japan and B. Roth of the United States of America, together with his team of consultants: J. Craig, J. Burdick and O. Khatib of Stanford University in California (see annex II).

Mr. Makino was assigned a post as an expert in robot development. He presented 11 lectures to the IICR staff, gave theoretical and practical advice to all units concerned and summarized his findings and recommendations to IICR in a detailed technical report.

Mr. Roth and his team of consultants presented lectures and held numerous discussions during the two weeks allotted to them. The consultants generated a list of specific recommendations and suggestions.

IICR is particularly grateful to UNDP and UNIDO for their assistance concerning the recruitment of the highly qualified experts.

B. Personnel provided by the Government

IICR employs some of the best Bulgarian specialists in the field (1,173 staff members, including 275 with university degrees, technicians and skilled workers, and 76 administrative staff members (see annex III)). They were appointed on 1 December 1978 in accordance with government decree No. 73 of 1978. Many of them had worked at the old Institute for Technical Cybernetics of the Bulgarian Academy of Sciences.

C. Fellowships, study tours and training provided by the United Nations Development Programme

Fellowships

The fellowship programme covered altogether 25 man-months of training (see annex IV). Considerable pre-fellowship preparatory activities were carried out so that the participants could respond faster to the requirements and get accustomed easier to the local environment once training began. Nine fellowships were prepared and conducted in the most prestigious educational and research establishments in Germany, Federal Republic of, Netherlands, Switzerland, United Kingdom of Great Britain and Northern Ireland and United States. It should be mentioned here that the organization of the fellowship programme as marked by great efforts on the part of UNDP and UNIDO and the management of IICR and, when the obstacles
were beyond the capabilities of the organizers, by a certain delay.

Study tours

A detailed list of the study tours conducted throughout the project is provided in annex V. Some 196 participants, including individuals from IICR and a select group of managers, took part in 1,291 days of study tours. They visited a number of significant international events in the field of industrial

cybernetics, robotics, electronics and computer systems, as well as various companies and users of advanced equipment. The long discussions that ensued, together with the great amount of pertinent information that was collected, helped in the preparation of the equipment specifications. Such undertakings also contributed towards the finalization of the required services to be delivered by UNIDO experts, as well as the selection of suitable candidates for the IICR fellowship programme organized by UNDP and UNIDO.

Training

The training programme at IICR ran quite smoothly. The training of local personnel in industrial cybernetics and robotics may be outlined as follows:

(a) Training at higher technical institutes, involving participation in post-graduate courses with a duration of 7-45 days on the following subjects:

(i) Industrial manipulators and robots (6 participants);
(ii) Applications of microprocessor technology (3 participants);
(iii) Modern computer languages (4 participants);
(iv) Automation of discrete production (2 participants);

(b) Training under the auspices of the Scientific and Technical Union, involving participation in training courses on the following:

(i) Applications of personal computers (3 participants);
(ii) Modern means and methods of planning technical and scientific research (1 participant);
(iii) Micro-electronics (1 participant);
(iv) Automation of industrial enterprises (4 participants);

(c) Seminars on the following topics:

(i) Current problems in robotics;
(ii) Microprocessor controllers for industrial robots;
(iii) Problems involving mounting robots;
(iv) Passive and active adaptors in robotized systems;
(v) Robotization in arc welding.

International participation also increased in the course of the project: there were participants from Cuba, Egypt, India, Morocco, Nigeria and Viet Nam. As a result of these activities, IICR can offer different training programmes designed to suit the participants' level of knowledge and education in the fields of industrial cybernetics and robotics. Such programmes may be offered within the framework of the project entitled "Establishment of a training and consultancy centre for advanced manufacturing technologies".

II. ACHIEVEMENT OF IMMEDIATE OBJECTIVES

The main immediate objective of the project was to strengthen IICR in the following manner:

(a) By developing its capability to apply new technologies, methods and means for accelerating the development of new and highly efficient industrial cybernetic units, devices, robots and robotized complexes;

(b) By ensuring that all prerequisites, such as equipment and laboratories, were fully operational and that the personnel was well trained.

The following immediate objectives of the project were achieved:

(a) Strengthening the department developing industrial robots. The staff was trained and the department was equipped for developing and implementing electronic systems and robot systems, in particular, microprocessor control units for industrial robots, robots and robotized systems for arc welding, welding equipment and the software required for them. Most of the devices developed have already been put to use in serial production. Some of them, such as educational robots, have been introduced in many Bulgarian schools, implemented in other educational institutions in the country and used for training students and post-graduates. Thanks to the UNDP/UNIDO project, the department was supplied with certain types of electronic equipment that proved enormously useful for the everyday scientific work of the specialists from the department;

(b) Organizing and establishing a modern laboratory providing the capability for precise measurement and testing of static and dynamic parameters of industrial robots and robot systems. A central testing laboratory was organized and established. All the prerequisites for registering the laboratory with the corresponding government authorities were fulfilled so that tests of robotized and cybernetic systems and their components could be carried out. The equipment and furnishing in the laboratory are suitable for controlling the fundamental technical parameters of industrial robots and robot systems, as well as their safety, resistance to weather and safeness with regard to the environment. Through generous government contributions, the laboratory was supplied with many types of testing equipment;

(c) Strengthening the department of industrial cybernetics and robotics. This was achieved by tending the departments' capabilities for designing and developing microprocessor systems for process control. The following activities were conducted in the area of devices for controlling technological processes:

(i) Through visits to specialized international events, symposia and conferences, knowledge was gained in methodologies, technical solutions and complex systems for controlling technological processes. Up-to-date information was assured through scientific publications, discussions with leading specialists and representatives of firms, prospectuses and technical documentation;

(ii) Modules, devices and systems were developed for controlling technological processes;

Strengthening these departments increased the capacity of IICR to carry out scientific, methodological and organizational tasks connected with the creation of devices for the automation of technological processes. IICR has at its disposal the personnel, technical equipment and organizational structure necessary to enable it to advance to new stages in the development of devices for the automation of technological processes. Many specialists from developing countries and from Bulgaria will be given an opportunity to become acquainted with the facilities of these departments;

(d) Strengthening the sections dealing with software for control and industrial robot systems. A software section with highly qualified specialists was established within the department of industrial robots. It was supplied with up-to-date equipment for the development of software for industrial robot systems. The section was enlarged to form a robot control division in the beginning of 1986. The research work of the division included the following:

(i) Development of algorithms and methods for the control of mechanical systems. Original algorithms for motion control using direct current or stepping motors were developed. All theoretical results obtained in this direction were reported at the fourth and fifth Congresses on Theoretical and Applied Mechanics and at the fifteenth International Symposium on Industrial Robots, held in Tokyo in 1985;

(ii) Creation of software for the automation of design and development activities;

(iii) Development of communication links between the operator and the control unit. Unified programming languages for industrial robots, machine tools, automated storage etc. were created on the basis of the established language structures, as well as programming modules;

(e) Extending the activities of the IICR pilot plant in order to meet the requirements of the new trends in science and technology - mecatronics and telematics. The UNIDO project assisted in the work connected with the building of a modern, multifunctional mechanical shop. At the present time this pilot plant is equipped with appropriate machines, devices and units that have been put into regular operation. The mechanical shop gives IICR the opportunities to realize experimental models designed and developed by IICR research workers. The existence of such a pilot plant will enable IICR to meet the requirements of the new trends in scientific, technical and technological processes: mecatronics and telematics. The pilot plant of IICR will take on its final form in the next phase of the project, when various machines, devices and measuring apparatus will be set up with the help of a government contribution. This will enable it to respond quickly to developments in the field of industrial cybernetics and robotics;

(f) Broadening and strengthening the capabilities in the field of technical documentation, technical information, information retrieval and dissemination. The activities directed towards achieving this immediate objective included the following:

(i) Supplying information on the latest developments in the field of cybernetics and robotics;

(ii) Carrying out advertising and public relations activities;

(iii) Organizing exhibitions, symposia and conferences, as well as IICR participation in international fairs;

Largely as a result of UNDP/UNIDO assistance, the library now offers 27 titles of periodicals in various fields of science and technology and about 800 volumes of technical literature. These are accessible to all staff and scholarship trainees in IICR;

(g) Improving the connection between development activities and production of electronic and robot systems by regularly organizing and conducting training courses, seminars, scientific conferences and symposia.

Accomplishing the above-mentioned immediate objectives made a significant contribution towards the achievement of the goals articulated in the development objective, namely:

(a) Producing project outputs according to the project document and work plan. As a result of the experience gained and new trends in science and technology, many successful projects were carried out and many new developments were achieved;

(b) Increasing the technical and scientific content of labour in the field of machining, as stipulated in the eighth five-year plan of Bulgaria, for a rapid acceleration and improvement of the processes associated with the design of new, highly efficient cybernetic complexes and robot systems and new technologies for their manufacture;

(c) Placing emphasis on the new trends in designing automatic process control machines, process planning and their implementation in production, characterized by computer integration.

III. UTILIZATION OF PROJECT RESULTS

1. A modern, multifunctional mechanical shop was created as a pilot plant. IICR is now ready to consult and train specialists from Bulgaria and developing countries.

2. A large number of control devices for industrial robots, personal computers, systems for automation and electronization were developed and implemented in Bulgarian industry.

3. Thanks to the fellowship programme, training programme and study tours, the qualifications of the specialists at IICR were significantly raised.

4. As a result of the activities carried out in the course of the project, training possibilities were created for specialists from other countries. For example, seven specialists from India and four from Viet Nam were trained. The activities laid the groundwork for setting up IICR as a training and consultancy centre for industrial cybernetics and robotics, the logical continuation of the work carried out under the auspices of UNDP and UNIDO.

IV. CONCLUSIONS

The following conclusions can be drawn:

1. UNDP/UNIDO assistance is an extremely significant factor for the establishment and smooth operation of IICR.

2. All the outputs specified in the project document were achieved.

3. IICR is capable of carrying out (in addition to training) research and development in the field of industrial cybernetics and robotics, as well as implementing the devices resulting from such work in industry.

4. IICR is ready to advise and train specialists from Bulgaria and developing countries.

5. Based on the present project, UNIDO has prepared a regional project for the development of robotics, entitled "Robotics technology applications and demonstrations", involving the participation of the following countries: Czechoslovakia, Greece, Hungary, Poland, Portugal, Romania, Turkey and Yugoslavia. The experience gained from the present project will enable IICR to serve as a training base for specialists from the countries participating in the regional project. In the beginning of the regional project, IICR could provide secretarial and organizational service. It has been proposed that IICR serve as headquarters for the regional project.

6. Drawing on their newly acquired experience, specialists from the present UNIDO project can give consultancy services to UNDP/UNIDO projects or to countries showing interest in such services.

7. IICR can assist other United Nations organizations, for example, the United Nations Educational, Scientific and Cultural Organization using its newly developed range of educational devices for training in new technologies such as microprocessors, robotics and flexible manufacturing systems.

Annex I

LIST OF EQUIPMENT FINANCED BY THE UNITED NATIONS DEVELOPMENT PROGRAMME

Description of equipment	Manufacturer	Quantity	Cost (dollars)	Year of delivery
100 MHz dual trace oscilloscope, 465B OPT.A1	Rohde und Schwarz Oesterreich GmbH (Austria)	1	5 206	1982
VW 8-seater Kombi Bus, 253521, 2000 cc petrol engine, with accessories	Volkswagen (Federal Republic of Germany)	2	17 909	1982
Digital multimeter, model 3486A	Hewlett-Packard GmbH (Austria)	4	3 256	1983
100 MHz oscilloscope, 465B OPT.A1	Rohde und Schwarz Oesterreich GmbH and Tektronix GmbH (Austria)	2	8 160	1983
60 MHz oscilloscope, 2213 OPT.A1	Rohde und Schwarz Oesterreich GmbH and Tektronix GmbH (Austria)	2	2 900	1983
Probe, model P6062B, 010-6062-13	Rohde und Schwarz Oesterreich GmbH and Tektronix GmbH (Austria)	4	1 036	1983
60 MHz dual trace oscilloscope, 2213	Tektronix GmbH (Austria)	2	2 960	1984
100 MHz dual trace oscilloscope with delta time and digital multimeter, 2337	Tektronix GmbH (Austria)	6	25 920	1984
60 MHz dual trace oscilloscope, 2213	Tektronix GmbH (Austria)	6	8 880	1984
Hewlett-Packard multimeter, model 3468A	Hewlett-Packard GmbH (Austria)	1	828	1984

continued

Annex I (continued)

Description of equipment	Manufacturer	Quantity	Cost (dollars)	Year of delivery
Hewlett-Packard multimeter, model 3468A	Hewlett-Packard GmbH (Austria)	3	3 312	1984
Mitsubishi L300 Kombi Bus, petrol engine, standard type	Mitsubishi Motors Corporation (Japan)	2	11 042	1984
Typing heads for IBM typing machine model 670X	IBM Oesterreich (Austria)	4	112	1986
Canon PC-25 copying machine and consumables	Canon GmbH (Austria)	1	1 600 a/	1986

a/ Estimate.

Annex II

INTERNATIONAL EXPERTS

Post description	Name (and nationality)	Duration (man-weeks)	Period
11-01/A-Robot development	H. Makino (Japan)	3	May-June 1984
11-51-Software	B. Roth (United States)	2	August 1986
11-52-Consultant	J. Craig (United States)	2	August 1986
11-53-Consultant	J. Burdick (United States)	2	August 1986
11-54-Consultant	O. Khatib (United States)	2	August 1986

Annex III

GOVERNMENT PERSONNEL

Post description	Name
Project Co-manager	A. Anguelov
Executive National Project Manager	N. Shivarov
Project Administrative Officer	B. Christova
Deputy Directors	
Implementation	B. Stoyanov
Pilot Plant	A. Kephsizov
Department Chiefs	
Financing	A. Nagibin
Planning	C. Marintchev
Marketing	C. Serbezov
Industrial Robots	G. Natchev
Cybernetics	V. Sgurev
Electronics	N. Iliev
Economist	S. Roussinova
Support Personnel	E. Vodenitcharova
Librarian	T. Endovitzka

Annex IV

FELLOWSHIPS

Subject	Recipient	Place	Duration (man-months)	Training period
Marketing	C. Serbezov	Webster College, Switzerland	4	13 Mar.-23 July 1983
Software for personal computers	C. Christov	University of Strathclyde, United Kingdom	1.5	29 Oct.-8 Dec. 1984
Assembly automation	S. Jorev	University of Birmingham, United Kingdom	3	7 Jan.-6 Apr. 1985
Technological programming of robotic systems for welding (MIG/MAG)	S. Puntchev	Brunel University, United Kingdom	3	10 Jan.-13 Apr. 1985
Control systems for industrial applications	A. Tomov	Coventry Polytechnic, United Kingdom	2	31 Jan.-6 Apr. 1985
Computer graphics (CAD/CAM)	Z. Markov	Technical University of Darmstadt, Federal Republic of Germany	3.5	14 Jan.-28 Apr. 1985
Bus systems, personal computers, local area networks	J. Kissiov	University of Karlsruhe, Institute of Informatics, Federal Republic of Germany	3	5 Sept.-6 Dec. 1985
Modelling of high-power pulse regulators	V. Ivandjiiski	KRP Power Source, Netherlands	2	30 Sept -30 Nov. 1985
Industrial robot applications	G. Doychinova	University of Maryland, United States	3	1 May-2 Aug. 1986
Marketing a/	B. Katzarov	-	-	-
Industrial robot elements and mechanisms a/	K. Belov	-	-	-
Total			25	

a/ Cancelled.

Annex V

STUDY TOURS, 1982-1986

Event	Place	Number of participants	Duration (man-days)
	1982		
Conference on Robots in the Automobile Industry	Birmingham, United Kingdom	2	10
IFSSEC '82	London	4	14
Hannover Fair	Hannover, Federal Republic of Germany	4	28
VI International Exhibition on Automated Measurements and Process Control	Birmingham, United Kingdom	1	5
3rd Conference on Mounting (Assembly) Automation	Stuttgart, Federal Republic of Germany	3	15
Periodical Exhibition and 12th Symposium on Metalworking Machines and Robots	Paris	2 4	22 24
EUROCON '82	Copenhagen	1	6
International Conference on Systems Engineering II	Coventry, United Kingdom	2	10
SOCOCO '82	Madrid	3	15
International Conference on Flexible Manufacturing systems	Brighton, United Kingdom	2	8
ELECTRONIKA '82	Munich	4	20
Complex/Europe '82	Amsterdam	2	8
Control and Instrumentation Exhibition	Harrogate, United Kingdom	6	30
International Federation on Automatic Control (IFAC) Symposium on Components and Systems	Paris	3	12

continued

Annex V (continued)

Event	Place	Number of participants	Duration (man-days)
Measurement, Control Regulation and Automation (MESUCORA '82)	Paris	6	30
70e Exposition de Physique	Paris	4	20
ELEC '82	Paris	5	25
Seminar on Computer Graphics Software	London	2	10
Study tour of various firms and companies	Federal Republic of Germany	6	60
Study tour of various firms and companies	Japan	5	70
Total 1982		71	442
	1983		
13th International Symposium on Industrial Robots (ISIR), in conjunction with Robots 7	Chicago	3	48
2nd European Automated Manufacturing Conference (AUTOMAN '83)	Birmingham, United Kingdom	4	20
National Computer Conference, Computer Showcase Expo and International Printed Circuits Conference (PC '83)	Anaheim, Houston and New York	2	10
PEMEC	Birmingham, United Kingdom	5	25
Automated guided vehicle systems and 16th IPA Conference	Stuttgart, Federal Republic of Germany	2	10

continued

Annex V (continued)

Event	Place	Number of participants	Duration (man-days)
10th Annual International Symposium on Computer Architecture, conference and exhibition	Stockholm	3	18
Summer School on Combinatorial Optimization	Dublin	2	12
International Anti-pollution Safety and Security Exhibition '83	Tokyo	1	10
PDE Software: Modules, Interfaces, Systems	Söderköping, Sweden	4	20
3rd International Colloquium on Welding and Melting by Electrons and Laser Beams	Lyon, France	2	10
International PCI Motorcon Conference and Exhibition	Geneva	1	6
Systems '83	Munich	3	15
INTERKAMA '83	Munich	3	15
International Electronic Components Exhibition	Paris	6	24
Study tour of various firms and companies	Tokyo	1	14
Total 1983		42	257
	1984		
Technishow '84	Ultrecht, Netherlands	1	5
Hannover Fair	Hannover, Federal Republic of Germany	3	12
PCI Motorcon '84	United States	3	18

continued

Annex V (continued)

Event	Place	Number of participants	Duration (man-days)
6th International Conference and Exhibition on Computers in Design Engineering (CAD '84)	Brighton, United Kingdom	1	4
Security and Safety Conference and Exhibition	London	1	5
AWS Convention "Welding '84"	Dallas	1	6
BRA-7, Conference	Cambridge, United Kingdom	1	4
Machine Outil '84	Paris	4	16
Assembly Automation	Paris	3	12
Microcomputer Show '84	Tokyo	1	6
Welding and Testing Congress	Vienna	1	4
PC Expo '84	New York	1	6
MACH '84: International Machine Tool Conference	Birmingham, United Kingdom	4	16
Industrial Robots Symposium '84	Udine, Italy	1	5
37th Annual Assembly of the International Institute of Welding (IIW)	Boston	1	7
Computer Design	Vienna	1	7
EUROMICRO '84	Copenhagen	3	15
Microcomputers, study tour	Paris	1	4
6th International Congress of Cybernetics and Systems	Paris	1	5

continued

Annex V (continued)

Event	Place	Number of participants	Duration (man-days)
FMS '3	Stuttgart, Federal Republic of Germany	1	5
AUTOFACT '84 and study tour	Basel, Switzerland, and Munich	1	8
EUROCON '84	Brighton, United Kingdom	2	10
DES '84	Birmingham, United Kingdom	1	5
14th ISIR	Göteborg, Sweden	4	40
ITAME '84	London	2	10
Microcomputers, study tour	Vienna	1	4
Microcomputers, study tour	Tokyo	2	28
PERFORMANCE '84	Paris	3	21
Total 1984		50	288
	1985		
International Personal Robot Congress (IPRC '85) and Exposition	San Francisco	1	8
Schweissen und Schneiden and 11. Internationale Fachmesse	Essen, Federal Republic of Germany	1	7
ISO IC 184/2, ICAR '85 and Tsukuba EXPO '85	Nagoya and Tokyo	1	9
15th ISIR	Tokyo	1	11
ICAR '85 15th ISIR and Tsukuba EXPO '85	Tokyo	1	14
BYTE Computer Show	New York	1	7
ELEKTRONIK (exhibition on professional electronic equipment and components)	Copenhagen	2	14

continued

Annex V (continued)

Event	Place	Number of participants	Duration (man-days)
International Exhibition on Industrial Electronics (IE)	Vienna	1	5
SYSTEMS '85	Munich	1	6
Flexible Manufacturing Systems (FMS '85)	Nagoya, Japan	4	36
International Electronic Components Exhibition	Paris	2	12
SYROCO '85	Barcelona	1	4
International Conference on Machine Intelligence (MI-2) and exhibition	London	2	8
Study tour in Japan	Tokyo	1	12
Study tour in Greece	Athens	2	10
Total 1985		22	163
	1986		
Visit to companies	Tokyo	2	28
Conference on Lasers and Electro-optics (CLEO/IQEC '86)	San Francisco	1	6
Royal Agricultural Exhibition	Kenilworth, United Kingdom	1	6
6th IFAC	London	1	6
Personal Computer World (PCW) Show	London	2	12
INTERFACE '86 and study tour	Tokyo	1	10
FABRITEC, SWISSDATA	Basel, Switzerland	1	6

continued

Annex V (continued)

Event	Place	Number of participants	Duration (man-days)
SAMA, SWISSDATA	Basel, Switzerland	1	6
International Autumn Trade Fair	Vienna	1	6
SICOB '86	Paris	1	10
16th ISIR and post-symposium tour	Brussels	2	20
ISIR '86 - Robotex Exhibition	Brussels	1	5
INTERTOOL - International Machine Tool Fair	Vienna	1	6
INTERKAMA '86	Düsseldorf, Federal Republic of Germany	2	14
Total 1986		18	141
Total 1982-1986		203	1 291