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Project Number DP/IND/82/034/11-05/31.9.B

APPROPRIATE AUTOMATION PROMOTION PROGRAMME

DP/IND/82/034

INDIA

Technical Report

REVIEW OF THE APPROPRIATE AUTOMATION PROMOTION PROGRAMME AND RELATED AUTOMATION DEVELOPMENT ACTIVITIES IN INDIA

Prepared by

Theodore J. Williams
Consultant, UNIDO

Based on a Visit to India

June 22-29, 1985

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SUMMARY

At the request of the Department of Electronics of the Government of India through its Appropriate Automation Promotion Programme (AAPP) and with the approval of the United National Industrial Development Organization (UNIDO) and the United Nations Development Programme (UNDP) for India, the author spent the period of June 22-29 in India. The purpose of the visit was to review the progress of the project entitled Integrated Control System for Steel Plants (INCOS).

This project had been set up by the Government of India through the Steel Authority of India (SAIL), the Department of Steel, the Department of Electronics, and the Planning Commission at least partly as a result of discussions held during the December 1984 visit of the author to India (See Report, Reference 1).

A National Level Committee on Steel Plant Automation (Appendix AI) had been set up in February 1985 and in two meetings had endorsed a program similar to the example program worked out by Mr. G.S. Varadan, Chief Coordinator of AAPP and the author (Appendix II of Reference 1). The revised program is presented in Appendix A-II. The Bhilai Steel Plant, Bhilai, India, has been chosen as the site for the initial project. As a result of these meetings a Systems Engineering Group was set up at the Bhilai Steel Plant to develop the background information necessary to prepare a detailed proposal for INCOS. The division of the tasks of

Appendix AII to this Systems Engineering Group is given in Appendix AIII. Second a Study Group of members of the National Committee and Systems Engineering Group was sent abroad to review similar systems in Netherlands, American, and Japanese steel mills and to assess potential control systems. (See Appendix AIV for the composition of this study group and their itinerary).

The author was actively involved in arranging the visits of the Study Group and in accompanying them on their visits in the United States.

During the current trip to India a visit was made to the Bhilai Steel Plant to view the plant and review the work to date of the System Engineering Group. This Group is actively at work in carrying out the tasks of Appendix AII and are currently on schedule with these tasks.

No specific review of other aspects of the Appropriate Automation Promotion Programme beyond the INCOS Project were carried out during this visit.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions have been arrived at as a result of the visit to India during June 1985 and the review of the current status of the Integrated Control System for Steel Plants Project (INCOS).

1. The progress which has been made on the Integrated Control System for Steel Plants Project (INCOS) since the author's visit to India in December 1984 has been truly substantial and indicates the exceptional interest and backing that this project has generated in all who have been connected with it.

2. The Systems Engineering Group at the Bhilai Steel Plant has tackled its task of collecting the data for the proposal for project final approval with vigor and is currently on schedule in making this data available.

3. The Systems Engineering Group is only now reaching these points in the overall task where substantial decisions on future project direction must be made. However, they appear to be well equipped to make and substantiate these decisions where necessary.

4. The project enjoys the vigorous backing of the Managing Director of Bhilai Steel Plant (Mr. K. R. Sangameswaren) and his staff. It also is currently well received by the management of the Steel Authority of India (SAIL) and of the Department of Steel and of the Department of Electronics of the Government of India.

INTRODUCTION AND PURPOSE OF THE MISSION

The author visited India in November-December 1984 under the auspices of the United Nations Industrial Development Organization (UNIDO) and the United Nations Development Program (UNDP) for India to review the Appropriate Automation Promotion Programme (AAPP) of the Department of Electronics of the Government of India. The report of that visit is listed as Reference 1 of the List of References of this report.

While in India in December 1984 the author worked with Mr. G. S. Varadan, Chief Coordinator of AAPP to develop an initial proposal for a much larger project than AAPP to develop an overall hierarchical computer control system for one of India's integrated steel mills. That proposal is presented in Appendix II of Reference 1. That work is to be based on an earlier Purdue University study with the American Steel Industry (Reference 2).

Subsequent to that visit, the author was again invited to India during June 21-29, 1985 to review the status of the work on the steel mill project now officially entitled: Integrated Control System for Steel Plants Project (INCOS). Pertinent correspondence with the Government of India and the United Nations concerning this latter invitation is presented in Appendix AV. The itinerary for the trip itself is presented in Appendix AVI.

As noted, time in India during this visit was devoted to a review of the status of the INCOS Project, its accomplishments to date, and its plans and prospects for the future.

STATUS OF THE STEEL INDUSTRY PROJECT

Appendix AVII is a reprint of a paper presented at the Round Table on Steel Industry entitled, "Computerization and Automation in the Steel Industry." The Round Table was held in New Delhi at the Department of Electronics of the Government of India on February 18, 1985. This paper presents the Indian view of the state of steel plant automation in the industrial countries of the West and the standard against which the Indian steel plant automation project must be planned.

The basis for the conduct of the proposed project was the proposal developed by Mr. G. S. Varadan and the author and presented in Appendix II of the author's report of his visit to India in November-December 1984 (Reference 1).

The Government of India set up this project through the Steel Authority of India (SAIL), the Department of Steel, the Department of Electronics, and the Planning Commission. The initial action was the designation of a National Level Committee on Steel Plant Automation (see Appendix AI for membership) in February 1985. This committee has had two meetings (February 22 and March 22, 1985). They have established a formal project to be entitled, Integrated Control System for Steel Plants (INCOS) and have designated the Bhilai Steel Plant, Bhilai, Madhya Pradesh, as the experimental plant for the project. They also accepted a slightly modified version of the originally proposed project outline (Appendix AII) and designated a Systems Engineering Group at the Bhilai Steel Plant to begin the initial work of the project.

The Systems Engineering Group is composed of Bhilai Steel Plant personnel assisted by personnel of potential cooperating companies as follows: Bhilai Steel Plant; Metallurgical Consultants, Ltd. (MECON); Bharat Heavy Electricals, Ltd (BHEL); Computer Maintenance Corporation (CMC); Electronics Corporation of India, Ltd. (KELTRON) and Instrumentation, Ltd, (IL) of Kora, India. The group is under the direct supervision of Mr. K. R. Sangameswaren, Managing Director of the Bhilai Steel Plant. Thus it enjoys his vigorous backing in carrying out its tasks.

As of the time of the author's visit to the Bhilai Steel Plant (June 24-26, 1975) the Group had completed Items 1-3, 5 and 6 of Phase I of the Project Plan as listed in Appendix AII and had begun work on several others and thus is essentially on schedule as of this time.

The project also enjoys a very high visibility among the management of the Steel Authority of India, Ltd, of the Department of Steel and the Department of Electronics of the Government of India and of the Planning Commission, also of the Government of India. As noted in the itinerary meetings were held with high officials of each of these bodies during the author's visit to India. Each showed a very high interest in and knowledge of the INCOS project and a desire for it to proceed and succeed.

IMMEDIATE FUTURE PLANS FOR THE PROJECT

Immediate plans for the Integrated Control System for Steel Plants Project (INCOS) call for a continuation of the work on Phase I of the Project Plan (Appendix AII) with a scheduled completion of the automation specification of Item 4 of Phase I by early August. The author expects to return to India during the first week of September to aid in the review of this document before its final publication.

It should be noted that the immediate work of the Systems Engineering Group involves the determination of many decisions of vital importance to the future of the project as included in Items 7-12 of Phase I of the Project Plan. It is believed that the Group is equipped to make the necessary determinations.

REFERENCES

1. Williams, T. J., Review of the Appropriate Automation Promotion Programme and Related Automation Development Activities in India, Report to UNIDO (Project Number DP/IND/82/0341 11-03/31.9.B), November 25-December 23, 1984.

2. Steel Industry Advisory Committee and Steel Project Staff, Tasks and Functional Specifications of the Steel Plant Hierarchical Control System, Volumes I and II, Report Number 29, Purdue Laboratory for Applied Industrial Control, Purdue University, West Lafayette, Indiana (Revised, June 1984).

APPENDIX A I

NATIONAL LEVEL COMMITTEE ON STEEL PLANT AUTOMATION

1. Shri R.P. Khosla, Secretary
Department of Steel
Ministry of Steel & Mines
Udyog Bhawan, New Delhi-3 ......Chairman

2. Dr. N. Seshagiri, Additional Secretary
Department of Electronics
E-Wing, Pushpa Bhawan,
New Delhi-62 ......Vice Chairman

3. Shri K.R. Parameswar, Adviser (I&M)
Planning Commission
Yojana Bhawan,
New Delhi-1 ......Member

4. Shri Pradip Baijal, Jt. Secretary
Ministry of Steel & Mines
Udyog Bhawa,
New Delhi-3 ......Member

5. Shri S. Samarapungavan, Chairman
Steel Authority of India Ltd.
Ispat Bhawan, Lodi Estate,
New Delhi-3 ......Member

6. Dr. G. Mukherjee, Vice Chairman
Steel Authority of India Ltd.
Ispat Bhawan, Lodi Estate,
New Delhi-3 ......Member

7. Dr. S.C. Mehta
Chief Expert (Automation & Computerization)
Steel Authority of India Ltd.
Ispat Bhawan, Lodi Estate,
New Delhi-3 ......Member

8. Dr. S.K. Gupta, Director (R&D)
Research & Development Centre
for Iron & Steel
Steel Authority of India Ltd.
P.O. Hinoo, Ranchi-834 002 ......Member

APPENDIX A I (Cont.)

9. Shri P.C. Laha
Chairman & Managing Director
Metallurgical & Engineering
Consultants (India) Limited
Ranchi-834 002 ......Member

10. Shri M.S.S. Murthy
General Manager
Industrial Systems Group
Bharat Heavy Electricals Ltd.
25/1 Mahatma Gandhi Road
Bangalore-560 001 ......Member

11. Shri D.R. Ahuja
Chairman & Managing Director
Viskhapatnam Steel Plant Ltd.
P.O. Gujuwaka
Visakhapatnam-530 026 ......Member

12. Shri S.V. Kasargod
General Manager
Systems Group, ECIL
Electronics Corporation of India Ltd.
Cherlapalli
Hyderabad-500 762 ......Member

13. Dr. S. Parathasarathy
Computer Maintenance Corporation
Hyderabad ......Member

14. Prof. I.G. Sharma
Professor
School of Automation
Indian Institute of Science
Bangalore-560 012 ......Member

15. Shri G.S. Varadan
Chief Coordinator (AAPP)
Department of Electronics
E-Wing, Pushpa Bhawan,
New Delhi-110 062 ......Member-Secretary

APPENDIX A II

TASKS FOR PREPARATION OF PHASED IMPLEMENTATION PROGRAMME

The following paragraphs describe the suggested phases of the overall activity as worked out by Prof. Williams and Shri G.S. Varadan, Chief Coordinator AAPP along with inputs from Dr. S.C. Mehta, SAIL. The entire activity has been subdivided into five different phases and the important actions that are needed to be taken are indicated.

PHASE I

1. To conduct a survey of the current status of the plant that is selected in terms of

   a) Energy balance

   b) Materials balance and yield analysis

   c) Operational rules

   d) Complete plant specifications.

   This work needs to be carried by a full time task group located at the selected plant comprising specialists from among the concerned organizations.

   (March 31, 1985)

2. A definite goal for the entire project is to be proposed in the first instance. This may also call for a visit by a small group consisting of representatives of Steel Plant, MECON, SAIL and DOE to similar plants such as the Inland Steel, USA or NIPPON Steel, Japan and Hoogovens Steel Plant, Holland. This task is expected to be complete by April, 1985.

   (April 30, 1985)

APPENDIX A II (Cont.)

3. Preparation of an interim report. (June 1, 1985)

4. Develop an automation specification similar to the Purdue University Report No. 98 "Tasks and Functional Specification of the Steel Plant Hierarchical Control System" (Reference 2). (August 1, 1985)

5. An instrumentation audit, i.e., what is currently available and operational in the selected steel plant versus what is needed to be carried out. (April 30, 1985)

6. In order that the modernization is carried out starting at a definite basic level the manufacturing equipment which may need major maintenance and/or replacement is to be assessed. The additional equipment vital for a model plant for example-a continuous caster, etc., may be examined. (April 30, 1985)

7. Based on 2 to 5 above, a time based procurement and installation programme for the automation equipment desired needs to be prepared. (July 1, 1985)

8. Simultaneously the personnel required along with the skills, training requirement, the time of their availability, etc., are to be specified. (July 1, 1985)

APPENDIX A II (Cont.)

9. A listing of requirement of mathematical models, optimization and control algorithms, package programmes, etc., required to implement the proposed automation system is to be prepared. The sources of availability (Locally developed, purchased from abroad, etc.) and timing of the need for which are to be determined. (July 1, 1985)

10. The required standards for programming languages, plant internal communication systems, instrumentation systems, power systems, etc., are to be specified. If possible, steps should be taken to make these Indian National Standards. (July 1, 1985)

11. The requirements for assuring environmental safety, power supply stability and maintenance of computers and automation systems are to be assessed. (July 1, 1985)

12. The complete details of the succeeding phases along with a detailed budget for the total project are to be prepared. (September 1, 1985)

(Please see the bar chart enclosed)

PHASE II

1. Procurement of materials and equipment noted for Item 6 of Phase I. (October, 1985)

APPENDIX A II (Cont.)

2. Procurement of materials and equipment noted in Item 7 of Phase I. (October, 1985)

3. Initiation of training programmes and recruitment of personnel of Item 8 of Phase I. (February, 1985)

PHASE III

1. Necessary modelling of plant process listed in Item 9 of Phase I is to be carried out indigenously/or with the assistance of the Purdue University Group. (September, 1985)

2. The programming of computer systems required for the project is to be undertaken. (January, 1986)

PHASE IV

1. Check out of computer systems at the manufacturing plant. (December, 1987)

2. Shipment and installation of the computer systems after above check out. (March, 1988)

3. Hardware check out of computer systems at site. (June, 1988)

4. Installation and commissioning of various systems and programmes. (August, 1988)

APPENDIX A II (Cont.)

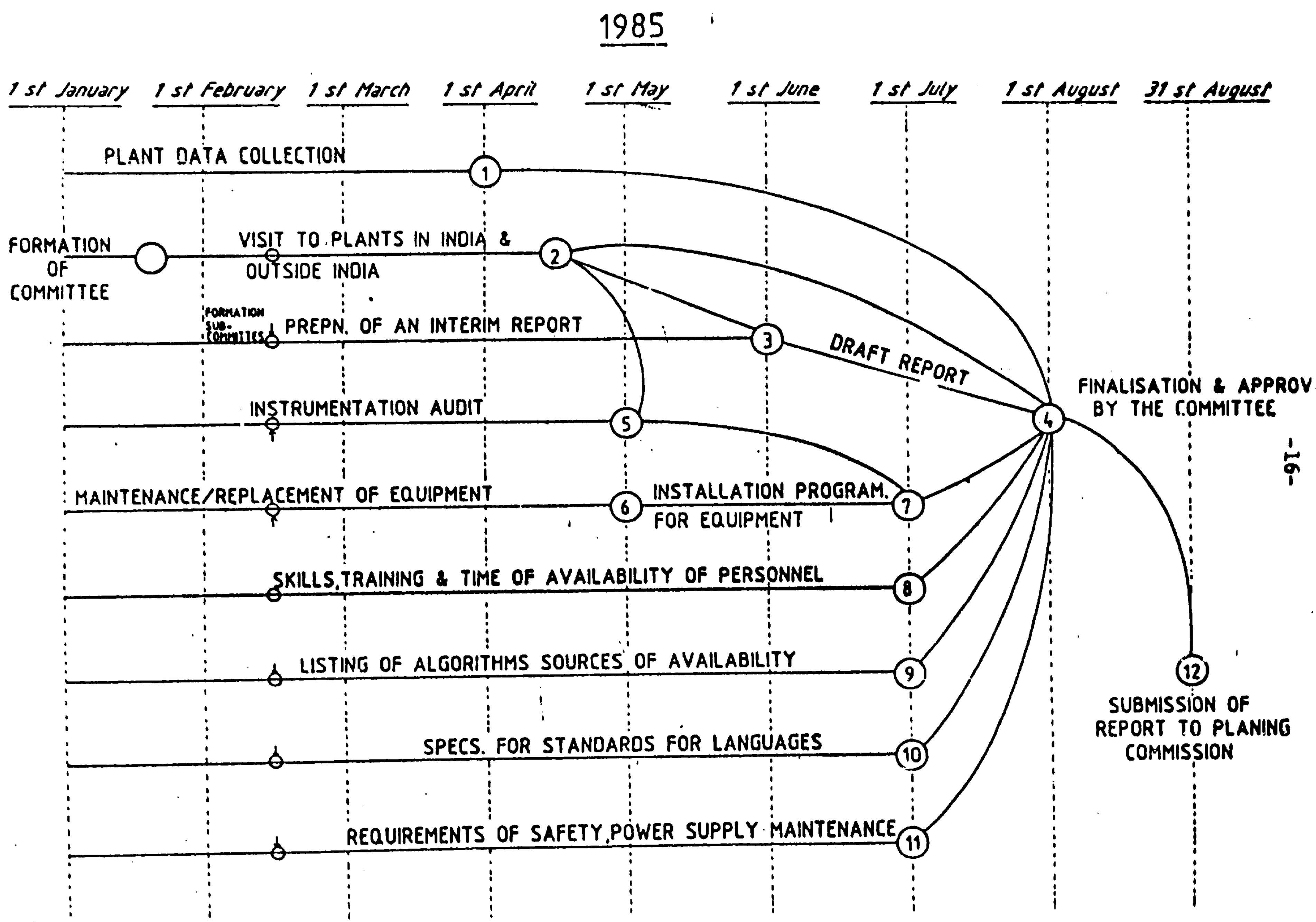
PHASE V

1. Phased operation of computer systems one by one until the entire system is operational. (November, 1988)

2. Operation of the full system for a certain period of time, i.e., about 3 months. (March, 1989)

3. The performance verification and success of the new systems versus the automation levels specified at Item 2 of Phase I is to be carried out. (June, 1989)

4. Any modifications of systems programme and equipment has necessary to achieve the goals committed on Item 2 of Phase I is to be carried out. (April, 1989)


1985
1 st January
1 st February
1 st March
1 st April
1 st May
1 st June
1 st July
1 st August
31 st August
PLANT DATA COLLECTION
FORMATION OF COMMITTEE
VISIT TO PLANTS IN INDIA & OUTSIDE INDIA
FORMATION SUB-COMMITTEES
PREPN. OF AN INTERIM REPORT
DRAFT REPORT
INSTRUMENTATION AUDIT
FINALISATION & APPROV BY THE COMMITTEE
MAINTENANCE/REPLACEMENT OF EQUIPMENT
INSTALLATION PROGRAM. FOR EQUIPMENT
SKILLS,TRAINING & TIME OF AVAILABILITY OF PERSONNEL
LISTING OF ALGORITHMS SOURCES OF AVAILABILITY
SUBMISSION OF REPORT TO PLANING COMMISSION
SPECS. FOR STANDARDS FOR LANGUAGES
REQUIREMENTS OF SAFETY,POWER SUPPLY MAINTENANCE
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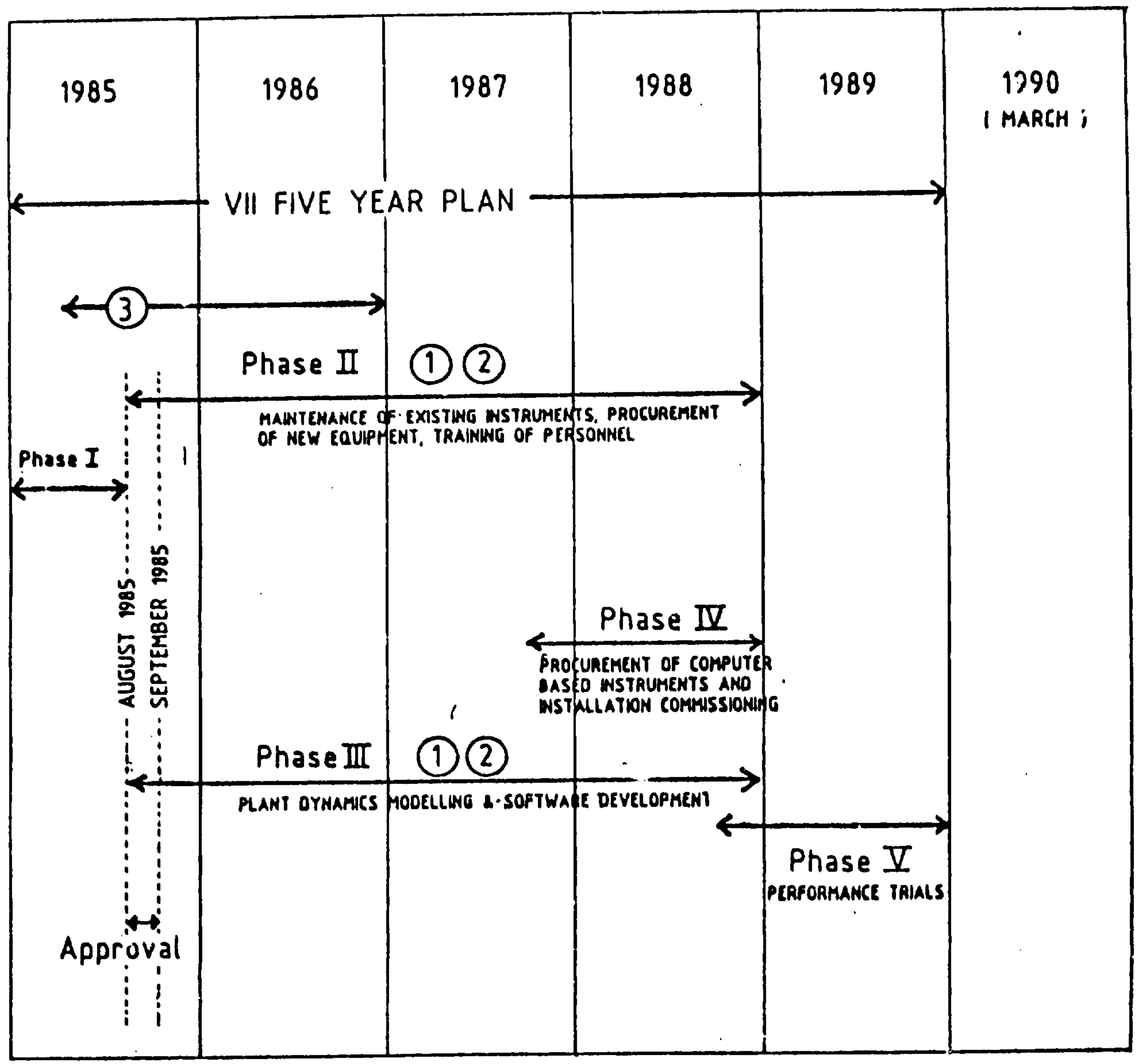

OVERALL IMPLEMENTATION OF THE PROGRAMME

APPENDIX A III

DIVISION OF THE TASKS OF APPENDIX AII AMONG THE MEMBERS OF THE SYSTEMS ENGINEERING COMMITTEE

Group No. 1: Instrumentation and Control Including PLCs.

Organizations to be involved: DOE/ECIL/IL/BHEL/SAIL/MECON

1. Take stock of the existing sensors, instruments, and control systems including PLCs. A format already exists with SAIL which had earlier prepared the report. The list may be updated indicating in each case its compatibility to other digital equipment.

2. New sensors/instruments which need to be installed to make the system/zone operational with the proposed control schemes.

3. Make schematic drawings of each system/zone which would indicate the location of sensors/instruments. This would need discussions with plant managers who may also need to guide the group from time to time.

4. Priorities and criticalities may also need to be indicated so that the finalization of schemes (depending upon resources) will be easier.

5. List out all sources and suppliers of sensors/instruments and control equipment keeping however certain criteria such as reliability, service support, easy availability,

APPENDIX A III (Cont.)

operational history, need for spares, technology/redundancy, communication facilities, front-panel maintenance, etc.

6. Suitability of process equipment for instrumentation and automation. Expansion and major replacements may be separately listed for the National Committee to decide the priorities.

7. Time-based procurement and installation programme may also be worked out.

8. Suggest maintenance and spares requirements to ensure reliability and availability.

Group No. 2: Computer Hardware/Software, Modelling, and Simulation

Organizations to be involved: DOE/BHEL/ECIL/SAIL/MECON/IISc./PURDUE

1. Make complete study of hierarchical, distributed systems including literature collection, current status at Bhilai and future requirements.

2. Make zone-wise or area-wise studies of existing schemes and propose schemes in consultation with Group 1 regarding requirement for control loops, etc.

APPENDIX A III (Cont.)

3. Suggest standard hardware and list out requirements for software viz mathematical models, algorithms, simulation package programmes, etc., sources of availability, i.e., locally developed/to be developed, purchase from abroad. List out clearly tasks and time targets for procurement and development; specify standards for communication systems, power supply requirements, etc.

4. Suggest measures for safety, maintenance of computers, requirements of computer installation such as building, flooring, cabling, etc.

5. Suggest training and experts requirements and identify clearly the capabilities and gap areas. Also indicate the timings of each.

Group No. 3: Management Integration Finance, Materials, Personnel

Organizations to be involved: BSP/SAIL/CMC/IIM/RDCIS

1. List out major areas that need computerization and integration keeping in view the economic benefits, time savings, inventory savings, etc.

2. Interact with other groups for raw material control, mining inventory control, production scheduling, etc.

APPENDIX A III (Cont.)

3. Suggest measures for information retrieval and documentation, also suggest priorities.

Group No. 4: Training Requirements, Facilities and Development

Organizations involved: DOE/BSP/CMC/IISc./SAIL

1. List out training requirement of Groups 1 and 2 with constant interaction. Various levels such as top executives, middle level executives and engineers, maintenance engineers should be considered.

2. Make requirements of comprehensive facilities for training-skills of trainers, trainees, experts from India and abroad. Also provide for certain basic minimum facilities for development work/demonstrations, etc.

3. List out training material such as audio-visuals, including films, slides, transparencies, etc.

Group No. 5: Plant Data Collection

Organizations to be involved: SAIL/MECON/BHEL

1. Audit of the state of the chosen plant as follows:
   a) Develop a plant energy balance similar to that of Table 21-IV, Purdue Report (Reference 2).
   b) Develop a material balance and yield analysis similar to Figs. 21-5, 6 and Table III of the Purdue Report.

APPENDIX A III (Cont.)

c) Prepare a set of operational rules for the current and proposed plant operations similar to that of Table 21-I, V of the Purdue Report.

d) Prepare a complete plant specifications similar to Table 21-I, II of the Purdue Report.

2. Propose a set of advanced but achievable goals for the project. Repeat Step 1 above with the numbers changed to reflect the gains expected from the automation project.

SYSTEMS ENGINEERING GROUP

Process Control

Instrumentation

- Process Parameters
  - Wt
  - Composition
  - Dimensions
  - Temp
  - Press
  - Flow
  - Speed
- Communication & Display
- Logging and Control
- PLCs

Process Models

- B.F.
- Steel making
- Rolling
- Raw material
- Sinter preparation
- Power generation
- Coke making
- By products
- Fertilisers
- Soaking pit
- Reheating furnaces

Scheduling Activities

- Power scheduling
- Gas "
- Wagon "
- Production Planning
- Shop activities
- Maintenance scheduling
- Services
  - Water
  - Compressed Air
  - Nitrogen
  - Oxygen
  - Welding gas
- Project Monitoring

Management Control

Finance Management

- Cash flow
- Monthly Consolidated Account
- Pay Roll
- Cost of production
- Capital budget
- Project cost Monitoring

Material Management

- Inventory Control
- Order Processing
- Payment Statistics
- Arrival Scheduling
- Supplier's History
- Production Data
- Despatch Information
- Stock Information

Personnel Management

- Career profile
- Personnel statistics and Labour cost
- Scheduling of DPC
- Data base for industrial relation group
- Housing allotments

APPENDIX A IV

MEMBERSHIP AND ITINERARY OF THE INDIAN STUDY GROUP ON STEEL PLANT AUTOMATION

1. Membership of the Group

a. Mr. G.S. Varadan
Chief Coordinator
Appropriate Automation Promotion Programme
Department of Electronics, Government of India
New Delhi

b. Dr. S.C. Mehta
Chief Expert (Automation and Computerization)
Steel Authority of India (SAIL)
New Delhi

c. Mr. M.G.R. Prasad
Deputy General Manager
Bhilai Steel Plant
Bhilai, India

d. Mr. A.K. Saigal
Deputy Chief (Technical Development)
Bhilai Steel Plant
Bhilai, India

e. Mr. R.L. Laddha
Manager-Projects
Instrumentation Limited
Kora, India

f. Mr. Nagaraja Rao
Manager-Projects
Bharat Heavy Electricals Limited (BHEL)
Bangalore, India

APPENDIX A IV (Cont.)

II. Itinerary for the Study Tour

1. Thursday, April 25 and Monday, April 29, 1985
   Electrical and Control Department and
   Information Systems Department
   Hoogovens Ijmuiden
   Ijmuiden
   THE NETHERLANDS
   Messrs Varadan, Mehta, Prasad

2. Tuesday, April 30, 1985
   Travel, Amsterdam to Chicago

3. Wednesday, May 1, 1985
   Gary Works
   United States Steel Corporation
   Gary, Indiana

4. Thursday and Friday, May 2-3, 1985
   Indiana Harbor Works and Research Dep[illegible]nt
   Inland Steel Company
   East Chicago, Indiana

5. Saturday, May 4 to Monday, May 6, 1985
   Purdue Laboratory for Applied Industrial Control
   Purdue University
   West Lafayette, Indiana

APPENDIX A IV (Cont.)

6. Tuesday, May 7, 1985
Fisher Control Company
Marshalltown, Iowa

7. Wednesday, May 8, 1985
Autech Data Systems
Pompano Beach, Florida

8. Thursday, May 9, 1985
Westinghouse Electric Company
Pittsburgh, Pennsylvania

9. Friday, May 10, 1985
Taylor Control Systems Division, Rochester, NY
and Engineered Systems Division, Stamford, CT
Combustion Engineering, Inc.

10. Saturday-Sunday, May 11-12, 1985
Travel, New York to Tokyo

11. Monday-Friday, May 13-17, 1985
Visits to Kawasaki and Kobe Steel Companies
and Industrial Exhibitions in Japan

12. Saturday, May 18, 1985
Return to India.

APPENDIX A V

CORRESPONDENCE CONCERNING VISIT TO INDIA OF JUNE 22-29, 1985

भारत सरकार
GOVERNMENT OF INDIA
इलेक्ट्रानिकी आयोग (सूचना, आयोजना एवं विश्लेषण दल)
ELECTRONICS COMMISSION (IPAG)
ई-खण्ड, पुष्प भवन, मदनगीर रोड,
E-Wing, Pushpa Bhavan, Madangir Road
नई दिल्ली-110 062
New Delhi-110 062
Grams : IPAGELCOM Telex : 031-4741 NICS IN
APPROPRIATE AUTOMATION PROMOTION PROGRAMME

सत्यमेव जयते

G.S. VARADAN
CHIEF COORDINATOR (AAPP)

DOE:CCI:AAPP:85(1)(1)

26th February, 1985.

Dear Prof. Williams,

I received your letter dated January 30, 1985 alongwith the copies of the letters which you had written to Inland Steel, USA and Hoogoven Steel Plant, Holland.

I am happy to inform you once again that the first meeting of the National Level Committee for introducing Automation in one of the public sector steel plant in India was held on 22nd February, 1985. Several conclusions were drawn and important discussions were made during the meeting. As for the tasks for preparation of the phase implementation programme are concerned, many are in line with the work that we did at Bombay. There is great interest generated at the various levels in implementing Hierarchical and Distributed Control schemes on an experimental basis in India.

The study tour of the group who will be involved in this project has also been agreed to and we would like to proceed as per the schedule in March/April that I had indicated. Very soon we will draw up an itinerary and communicate to the steel plants in USA, Holland and Japan. I shall also be informing you the same.

During the discussions in the meeting, it has been agreed that we would be seeking your help in implementing this project. While we are working out precisely what is expected from you, I should broadly indicate to you that your help would be required right from the initial stage including the preparation of the project document. We would perhaps be able to bring with us the inputs that would need to go into the documents so that we could discuss with you at your University. I, therefore, request you to think of sparing a couple of days of your valuable time in deciding guidelines for the preparation of the documents. As soon as we work out the itinerary, I shall send you the exact dates by telex. I would also appreciate if you kindly draw up a list of people who will be able to help us in the preparation of the detailed document, finalisation of schemes, participation by lecturing in our training programmes on this topic etc. This would enable me to draw up the various programmes for the next two years initially. I would also like you to confirm your trip to India in the second half of the June after your China trip. As a matter of fact, I am planning to organize the training programme at the steel plant itself which would greatly benefit a large number of participants. As regards meeting the expenses to and from India and the honorarium your terms are acceptable to us.

I am very conscious of your caution regarding doing things right rather than doing fast. However, considering the interest generated and the number of people that are likely to be involved in this project speeding up seems to me practicable.

I have received your letter enclosing the photographs and thank you for the same. I once again grately appreciate your interest in helping us with our project.

With best regards,

Sincerely yours,

(G.S.VARADAN)

Prof. Theodore J.Williams,
Professor of Engineering and
Director,
Purdue University,
Purdue Laboratory for
Applied Industrial Control,
AA Potter Engineering Center,
West Lafayette,
Indiana 4790 7,
USA

March 25, 1985

Mr. G. S. Varadan
Principal Scientific Officer
Electronics Commission (IPAG)
E-Wing, Pushpa Bhavan
Madangir Road
New Delhi 110 062
INDIA

Dear Mr. Varadan:

Thank you for your letter of February 26th concerning your proposed trip to Japan, USA and the Netherlands to discuss hierarchical computer schemes. I hope you received the telegrams from Inland Steel and ourselves concerning our problems with your chosen dates of early April. I hope the suggested date of early May will still be satisfactory for you in terms of your schedule.

I am tentatively planning to arrive in India on Saturday June 22nd at 12:45 a.m. on KLM Flight 834 from Singapore. I would plan to leave from Bombay at 05:00 a.m. on Saturday, June 29th on TWA Flight 883. This will give a full week in India as we had planned last December.

I will be happy to discuss my list of potential candidates for you to use to help further your program in India with you when you are here in May.

Best wishes for a very enjoyable and helpful trip.

Sincerely,

Theodore J. Williams

Theodore J. Williams

TJW:11

भारत सरकार
GOVERNMENT OF INDIA
इलेक्ट्रॉनिकी विभाग
DEPARTMENT OF ELECTRONICS
ई-खण्ड, पुष्प भवन
E-Wing, Pushpa Bhavan
मदनगीर मार्ग, नई दिल्ली-110 062
Madangir Road, New Delhi-110 062

दिनांक May 10, 1985
Dated

Prof. T. J. Williams
Director
Purdue Laboratory for Applied
Industrial Controls
Purdue University
West Lafayette, Indiana 47907

Dear Prof. Williams:

I would like you to kindly recall our earlier discussions regarding your short visit to India in June of this year. As per our plan, we expect to prepare a draft of the steel plant automation project by mid-June. It will be highly appropriate and desirable that we discuss with you before it is finalized for submission to our government for consideration for approval.

Besides this, I am also planning to promote a similar activity in the Indian-cement industry. M/S Associated Cement Company, Bombay, who are the pioneers in India have expressed their desire to have a presentation on some of the concepts of hierarchical and distributed control systems as developed by you. Perhaps this could be done at Bombay a day prior to your return to the U.S.A. We would also spend three days at the Bhilai Steel plant to review our project report and talk to the chief executives of the plant. At New Delhi, I am trying to arrange for appointments with secretaries to the government of India, Department of Electronics and Steel and a few other senior officials.

I am requesting the UNDP office in New Delhi to send the invitation to you and meet the travel expenditure from Hong Kong to the U.S.A. and other living expenditure in India. We are also recommending to the UNDP to pay you the consultancy fee for the duration of your visit to India. I shall arrange for your accommodation at the India International Centre during your stay at New Delhi.

I am short of words to appreciate your efforts in helping our programme of the Department of Electronics in promoting new technologies in our country.

Looking forward to meeting you in New Delhi on June 21st.

With best personal regards,

Yours sincerely,

GS Varadan

(G. S. Varadan)
Chief Coordinator (AAPP)

UNIDO ONUDI

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
ORGANISATION DES NATIONS UNIES POUR LE DEVELOPPEMENT INDUSTRIEL

VIENNA INTERNATIONAL CENTRE
P.O. BOX 300, A-1400 VIENNA, AUSTRIA
TELEPHONE: 26 310
TELEGRAPHIC ADDRESS: UNIDO VIENNA TELEX: 135612

CENTRE INTERNATIONAL DE VIENNE
B.P. 300, A-1400 VIENNE (AUTRICHE)
TELEPHONE : 26 310
ADRESSE TELEGRAPHIQUE : UNIDO VIENNE TELEX : 135612

REFERENCE: PRU85/PPRS/APP/VAT
DP/IND/82/034/11-05

DATE: 17 June 1985

Dear Mr. Williams,

As I understand you are stopping over in New Delhi from 21 to 29 June 1985 within the framework of a private business trip, I am pleased to enclose your Special Service Agreement covering your services for nine days. Please sign and date this document and complete your banking instructions in the space provided. The copies should be returned to this office for processing. The original is intended for your records.

Should you have had to pay for the deviation in your ticket, I am enclosing Voucher for Reimbursement of Expenses forms. These should be returned, together with ticket stubs to Experts Administration Unit, Attn. Mr. Seraydarian.

Thanking you for your co-operation and continued willingness to participate in UNIDO's programme of technical assistance, I remain,

Yours sincerely,

(for) R. Aguilar-Bolaños
Chief, Project Personnel Recruitment Section
Industrial Operations Division

Mr. Theodore J. Williams
Purdue Lab. for Applied Industrial Control
Room 334 - Purdue University
West Lafayette, IN 47907

UNIDO
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION F371106

VIENNA INTERNATIONAL CENTRE
P.O. BOX 300, A-1400 VIENNA, AUSTRIA
TELEPHONE: 26 310 TELEGRAPHIC ADDRESS: UNIDO VIENNA TELEX:

SPECIAL SERVICE AGREEMENT

EXPERT ON MISSION

INDEX NUMBER: E562144
PPRS/APP/No. 85- 367 /VAT

MEMORANDUM OF AGREEMENT made this 17 day of June 19 85 between the United Nations Industrial Development Organization (UNIDO) and Mr. Theodore J. WILLIAMS Purdue Lab. for applied Industrial (hereinafter referred to as the "subscriber"), whose address is Control, Room 334, Purdue University, West Lafayette, In. 47907, USA

WHEREAS UNIDO desires to engage the services of the subscriber on the terms and conditions hereinafter set forth, and

WHEREAS the subscriber is ready and willing to accept this engagement of service with UNIDO on the said terms and conditions,

NOW, THEREFORE, the parties hereto hereby agree as follows:

1. NATURE OF SERVICES Design of course matter

The subscriber shall perform the following services according to the following schedule:
advise on the syllabus and laboratory schedules for training in low-cost automation techniques; prepare course material along with project co-ordinator; arrange teaching sessions and laboratory programmes; suggest a suitable approach to the participants on the application of low-cost automation techniques in their respective countries; The subscirber will also prepare a final report setting out the findings of the mission and recommendations on further action which might be taken.

2. DURATION OF AGREEMENT 9 days(including preparation of the report)

This agreement shall commence on the 21 day of June 1985 and shall expire on the satisfactory completion of the services described above, but not later than the 29 day of June 1985 unless sooner terminated under the terms of this agreement. Either party may terminate this agreement at any time by giving the other party — days' notice in writing of its intention to do so.

In the event the duration of the agreement is terminated prior to or extended beyond its due expiration date, the subscriber shall be compensated for the actual amount of work performed and the actual time spent on the project on a *pro-rata* basis.

US$1,480 total gross fee for 9 days

3. CONSIDERATION (based on $5,000 gross per month; 364.8 days per annum)

As full consideration for the services performed by the subscriber under the terms of this agreement, UNIDO shall pay the subscriber upon certification by:

Engineering Industries Branch (Mr. Putnam)
(Division)

that the services have been satisfactorily performed the sum of $ 1,480 as follows:

$1,480 upon completion of mission and submission/appraisal of final report by UNIDO.

Entitlements:

daily subsistence allowance at UN established rates

NOTE The subscriber will be responsible for any taxes due on the remuneration and as a consequence, no statement of

4. **STATUS OF THE SUBSCRIBER**

The subscriber shall be considered as having the legal status of an Expert on Mission for the purposes of the Convention on the Privileges and Immunities of the United Nations. The subscriber shall not be considered in any respect as being a staff member of UNIDO.

5. **RIGHTS AND OBLIGATIONS OF THE SUBSCRIBER**

The rights and obligations of the subscriber are strictly limited to the terms and conditions of this agreement. Accordingly, the subscriber shall not be entitled to any benefit, payment, subsidy, compensation or entitlement, except as expressly provided in this agreement. The entitlement to compensation in the event of service incurred death, injury or illness is subject to the said death, injury or illness having occurred while the subscriber was engaged in authorized travel at UNIDO expense or was working in an office of the Organization on official UNIDO business, and is equivalent to compensation payable to a staff member at level P-4, step V, according to the provisions of appendix D to the Staff Rules.

6. **TITLE RIGHTS**

The title rights, copyrights, and all other rights of whatsoever nature in any material produced under the provisions of this agreement shall be vested exclusively in UNIDO.

7. **UNPUBLISHED INFORMATION**

The subscriber shall not communicate to any person or other entity any unpublished information made known to him by UNIDO in the course of performing his obligations under the terms of this agreement except upon authorization by UNIDO.

IN WITNESS WHEREOF the parties hereto have executed this agreement.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

By [signature] 17 June 1985
(Authorized Officer)
Mr. E. Pospelov, FMS, FSS

By [signature]
(Office of Personnel)
Mr. R. Aguilar-Bolaños, Chief, PPR, DIO

[signature] Date: 5 July 1985
(Subscriber's Signature)
Theodore J. Williams

Banking Instructions: Purdue National Bank
Lafayette, IN 47902 USA
Acct#074900974 2-512-486-2
(Subscriber to Indicate)

M.O.D. Number: ________

Post Key Code: DP/IND/82/034/11-05/31.9.B

Allotment Account Number: DP/IND/82/034/11-05

Marital Status: married

Date of Birth: 2 September 1923

July 5, 1985

Mr. R. Aguilar-Bolaños
Chief, Project Personnel Recruitment Section
Industrial Operations Division
United Nations Industrial Development
Organization (UNIDO)
Vienna International Centre
'.O. Box 300, A-1400 Vienna
AUSTRIA

Reference: PRU85/PPRS/APP/VAT
DP/IND/821034/11-05

Dear Mr. Aguilar-Bolaños:

In response to your letter of June 17, 1985, I am herewith returning the executed Special Service Agreement, Expert on Mission, covering my visit to India under Index Number E562144, PPRS/APP/No. 85-3671VAT.

I have completed my visit to India and am now preparing the required report. I will send these plus my statement of expenses for the visit to UNIDO as soon as they are completed.

Thank you very much for your interest.

Best wishes.

Sincerely,

Theodore J. Williams
Professor of Engineering and
Director

TJW:11

Enclosure

APPENDIX A VI

PROGRAMME DURING THE MISSION OF PROFESSOR THEODORE J. WILLIAMS TO INDIA ON JUNE 22-29, 1985*

1. Leave Guangzhou, Peoples Republic of China by train for Hong Kong (HKG) at 10:40 AM, Thursday, June 20, 1985. Arrive Hong Kong at 12:00 M.

2. Leave Hong Kong (HKG) at 15:30 PM, Friday, June 21, 1985 on Singapore Airline Flight 51 (SQ51) for Singapore (SIN).

3. Arrive Singapore (SIN) on Friday, June 21, 1985 at 18:50 PM.

4. Leave Singapore (SIN) on Friday, June 21, 1985 at 21:50 PM on KLM Dutch Airlines Flight 834 (KL834) for New Delhi, India (DEL).

5. Arrive New Delhi (DEL) on Saturday, June 22, 1985 at 00:45 AM. Met by Mr. G. S. Varadan and Dr. S. C. Mehta and conveyed to India International Center for lodging. Afternoon spent in discussion of progress of Integrated Control System for Steel Plants Project (INCOS) with Mr. G. S. Varadan.

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*This trip to India was a continuation of a visit to the Peoples Republic of China (May 25-June 20, 1985) to take part in the International Conference on Industrial Process Modelling and Control held at Zhejiang University, Huangzhou, on June 6-9, 1985. The author was Vice-Chairman of the Conference.

APPENDIX A VI (Cont.)

6. Sunday, June 23, 1985, continued discussion of progress and future plans for INCOS project with Mr. Varadan.

7. Monday, June 24, 1985, left New Delhi at 07:00 AM on India Airways Flight 497 (IC497) to Raipur (RPR). Arrive Raipur at 09:30 AM. Drive by car to Bhilai. Arrive 12:00 M. Staying at Bhilai Hotel.

   Afternoon spent in discussions with the Systems Engineering Group of the INCOS Project reviewing their programme and the progress on each phase of their work.

8. Tuesday, June 25, 1985, presentation of lecture on, Hierarchical and Distributed Control System before the Bhilai Local Centre, The Institution of Engineers (India), 09:00-11:00 AM including discussion and questions. Met with Mr. K. R. Sangameswaren, Managing Director of the Bhilai Steel Plant, to discuss status, future progress and staffing of the INCOS Projects (11:00 AM-12:00 M).

   Afternoon spent in tour of the Bhilai Steel Plant facilities according to the schedule attached as Appendix A VI-1.

   In evening attended dinner given by all senior administrators of the Bhilai Steel Plant.

9. Wednesday, June 26, 1985, left Bhilai by car for Raipur (RPR). Left Raipur on Indian Airways Flight 498 (IC498)

APPENDIX A VI (Cont.)

for New Delhi (DEL) at 12:00 M. Arrived New Delhi at 14:00. Visited offices of United Nations Development Programme (UNDP) and discussed steel industry project and current visit with Mr. P. N. Pathok, UN Programme officer for the Appropriate Automation Promotion Programme.

10. Thursday, June 27, 1985 visited Mr. K. R. Paramesvar, Industrial Advisor for Industry and Minerals to National Planning Commission at the offices of the Planning Commission with Mr. G. S. Varadan to discuss progress and future plans for the INCOS Project (09:30 AM-10:30 AM).

Visited Dr. G. Mukherjee, Vice Chairman, Steel Authority of India, Ltd., (SAIL) with Mr. G. S. Varadan and Dr. S. C. Mehta, Chief Expert (Automation and Computerization) for SAIL to discuss the INCOS project and particularly its future staffing (11:00 AM-12:00 M).

Afternoon spent at the offices of the Appropriate Automation Promotion Programme to discuss the next day's lecture series with Mr. G. S. Varadan, Dr. Kushna Kant, Mr. M. R. Rajagopolan and others involved in that lecture series and the AAPP.

Visited with Dr. N. Seshagiri, Additional Secretary, Department of Electronics, in charge of the Computer-Communications and Instrumentation program of the Department to discuss the progress and future plans of the INCOS project (17:30 PM-18:30 PM).

APPENDIX A VI (Cont.)

11. Presented a series of lectures on Hierarchical Computer Control Systems for Industrial Plants to representatives of the steel and cement industries at the offices of the Appropriate Automation Promotion Programme. Assisted by Dr. Krishna Kant and Mr. M. R. Rajagopolan. Approximately 25 individuals attended these lectures. Content was similar to a related series of lectures given on Monday and Tuesday, December 17-18, 1984 at the same location during the previous visit to India.

    Met with Mr. R. P. Khosla, Secretary, Department of Steel, Ministry of Steel and Mines, to discuss the present progress and future plans of the INCOS project. Accompanied by Mr. G. S. Varadan (16:30 PM-17:00 PM).

    Met with Mr. E. Foster Pierpoint, US Steel Representative in India, to discuss their cooperation with the Systems Engineering Group at the Bhilai Steel Plant on the INCOS programme (17:30 PM-18:00 PM).

12. Leave Delhi at 20:30 PM on Indian Airways Flight 183 (IC183). Arrived Bombay (BOM) at 22:00 PM.

13. Leave Bombay, India (BOM) on Trans World Airways Flight 883 (TW883) 06:00 AM via Kuwait (KWI), Cairo (CAI) and Madrid (MAD) for New York (JFK). Arrived New York 19:30 PM.

APPENDIX A VI (Cont.)

14. Leave New York (JFK) on Trans World Airways Flight 311 (TW311) at 16:20 PM. Arrived Indianapolis, Indiana (IND) at 17:58 PM.

APPENDIX A VI-1

SCHEDULE FOR PROF TJ WILLIAMS FOR 25.6.85.

A PLANT VISIT

S.No.	Department	Timings	Persons to be present for taking him round.
1	BLAST FURNACE	11.30 - 12.15 Hrs	Shri BK Agrawal, CS(BFs)
2	ENERGY MANAGEMENT	12.15 - 12.30 Hrs	Shri I Jayaraman
3	CONVERTOR SHOP & CONTINUOUS CASTING	12.30 - 13.00 Hrs	Shri RC Gupta, AGM(Steel) Sri Palit.
4	PLATE MILL	13.00 - 13.30 Hrs	Sri KS Sastry.
	LUNCH 13.30 to 14.30 Hrs		
5	POWER PLANT II	14.30 - 15.00 Hrs	Sri Laxmana
6	B B M	15.00 - 15.30 Hrs	Sri Upadhyaya
7	FINISHING MILLS	15.30 - 16.00 Hrs	Resp.Supdts.
8	Discussion with system Engg.Group.	16.00 - 18.30 Hrs	EDP Conf.Hall

1 Acquaintance with on going systems.

2 Status of Technology.)
3 State of Art)

AGMs of various zones to be present.
DGMs to join at 6 PM

APPENDIX A VII

Computerisation and Automation in Steel Industry

Appropriate Automation Promotion Programme
CCI Wing, Department of Electronics, Govt. of India

Presented During
Round Table on Steel Industry

Organised By
DEPARTMENT OF STEEL, GOVERNMENT OF INDIA

NEW DELHI
18 February 1985

APPENDIX A VII (Cont.)

Computerisation and Automation in Steel Industry

Introduction

IN an industrial society, the strategic resource is capital. However, the present day society regards information as the most strategic resource. It is, therefore, inevitable that the information technology sector will gain ground over manufacturing and goods producing sector. Creation, processing and distribution of information will therefore be the predominant economic activity of the future. The information technology sector will in general include tools for doing the above. The identifiable parts are computers, communication and industrial controls.

The nature of both data and processing task is changing. Computing is moving from a sequential, centralised world to parallel, decentralised world in which a large number of systems must work together, thus calling for a new generation of general purpose computers. Technologically and socially the needs for future generation of computers is becoming increasingly demanding such as computer architecture which includes distributed architectures supporting computers networks such as Local Area Networks (LAN), Wide Area Networks (WAN), parallel architectures giving high speed computers for numerical calculations and VLSI architectures to make full use of the potential of VLSI technology.

The VLSI technology is making very rapid strides which has enabled the industrial applications of computers more and more viable. The processing architectures, the memory technology and the man-machine systems which are important for processing and distribution of information in industries are undergoing metamorphic changes. The computing power is facing an exponential growth while the cost per bit of information processing is rapidly falling. It is becoming clearly evident that the digital computer must form the basis for the industrial control system of the future and is also particularly time for steel mills. As a result, one of the most important recent trends in the development of automatic controls in all industries has been to start bringing whole plant under a unified coordination and control and to begin automating the entire operational supervision system using a hierarchy of computer with about 5 to 10 per cent of total plant cost being invested in computerised automation and management productivity improvement of the order of 10 per cent and energy savings of 5 per cent with a pay-back period of 2-3 years are realised in the steel industry abroad.

Industrial Computers and Their Applications

Process control and other industrial applications of computers have always been a relatively small fraction (approximately about 10 per cent) of the computer field, and thus it is a beneficiary but not a driver of this technology. Process control has indeed had an input into the requirement of computer systems (necessary speeds, word lengths, memory size, reliability, allowable cost, etc.) but as a second order effect; that is process control has influenced the characteristics of the systems which would have been built anyway but probably did not generate or spark their production in the first place. However, since it is believed that the needs of the process control field are not that much different from other applications, the general acceptable standards in the design of computer systems will not be detrimental to the needs of the industrial computer systems.

Automatic control of any modern industrial plant, whether achieved by a computer-based system or by conventional means, involves an extensive system for the automatic monitoring of a large number of different variables operating under a very wide range of process dynamics. It requires the development of a large number of functions, some of which might be quite complex, for the translation of the plant variable values into the required control correction commands. Finally these control corrections must be transmitted to another very large set of widely scattered actuation mechanisms of various types. Because of the nature of the manufacturing processes involved, these may, and often do, require the direction of the expenditure of very large amounts of material and energy. Also, plant personnel, both operating and management, must be kept aware of the current status of the plant and of each of its processes.

In addition, such an industrial plant is faced with the continual problem of adjusting its production schedule to match its customers' needs, as expressed by the new order stream being continually received, this while maintaining a high plant productivity and the lowest practical production costs. The production-scheduling problem is handled in most cases at present through a manual, although computer-aided, production-control system along with an in-process and finished goods inventory judged adequate by plant personnel.

It has also been repeatedly shown that one of the major benefits of the use of digital computer control systems in industrial plants has been in the role of a

APPENDIX A VII (Cont.)

"control systems enforcer." In this mode, the lower-level computer's main task is to continually assure that the control system equipment is actually carrying out the job that it was designed to do in keeping the units of the plant production system operating at some optimal level; that is, to be sure that the controllers have not been set on manual, that the optimal setpoints are being maintained, etc.

Often the tasks carried out by these control systems have been ones which a skilled and attentive operator could readily have done himself. The difference is the degree of attentiveness which can be achieved over the long run.

As stated earlier, all of this must be factored into the design and operation of the control system which will operate the plant, including the requirements for maximum productivity and minimum energy usage. As the overall requirements, both energy and productivity based, become more complex, more and more sophisticated and capable control systems are necessary. To achieve these, the field must gravitate more and more toward digital computer-based systems to carry out the needed work in order to achieve the needed complexity and sophistication.

Trends in Computer Control of Process Plants

In recent years digital systems have become the mainstream of instrumentation and control technology. The digital systems have not only created a variety of advanced control systems, which greatly improved process controllability and product quality, but also is revolutionising the philosophy of control system as a whole. Recent developments in the field of microelectronics based on VLSI technology has given a new dimension to the electronics revolution. This new dimension is manifesting itself in the form of microcomputer based systems.

It is worth while therefore to briefly mention the current technology trend in the field of computer based instrumentation and control. The current trend in sensors and transducers is towards integrating intelligence into them along with their primary functions. The silicon integrated circuit technology has spread into this field as well and sensors are already popular for all applications and the trend is to provide on-chip signal conversion and certain amount of intelligence for limit checking, etc. These are also reported to be directly compatible to be interfaced with control computers and other actuating elements. Fibre optics technology has made possible the development of sensors which provide electromagnetic noise immunity in the measurements. The Japanese iron and steel industry has already put them into practice and realised such benefits.

Programmable logic controllers are now designed around microprocessors. They facilitate the user to write the program in much easier and understandable language. New languages for programmable logic control are developed. The computer then generates the logic diagram on a CRT. PLCs are becoming available with powerful graphic facility to allow the user to change the relay logic diagram interactively. However, the conventional relay logic programming facility is also being provided for the user.

In the area of closed loop control, the microprocessor based PID controllers are already available. New control strategies such as adaptive control and control structures such as the hierarchical and distributed controls have been evolved and implemented in iron and steel industries abroad. It was the dream of every control engineer to go in for direct digital control, i.e., have the computer directly move the actuators in the process. Digital computers for direct control of processes were implemented in the early sixties in several industries including iron and steel making. Although, direct digital control system has always had a potential for an unlimited variety and complexity of the automatic control functions in each and every control loop, the vast number of them have been implemented as digital approximations to the conventional three mode analogue controller.

Centralised Computer Control System

However, the centralised computer concepts suffered many draw backs. In early years, computers were slow, unreliable, memory sizes were limited and programming had to be done in machine language. Further, to help justify higher cost, vendors incorporated all types of computer, computer functions including supervisory and DDC in one main frame as a central room located in the plant. Though computers become faster with greater memory size and added features, the centralisation led to further problems such as the need for vast plant communication system required to bring process signals to them and return the control signals to the field. Fear of failure of that one computer resulted in demands for a complete analogue back up system paralleling the DDC. The complexity in programming the computers tended to increase and thus worsen the difficulties.

Distributed Control Systems

With the advances in VLSI technology becoming very rapid and with the advent of single chip microcomputers with powerful processing capabilities which can be distributed physically, the distributed computer controls

APPENDIX A VII (Cont.)

emerged. A distributed system is one which has several microcomputers which can be physically spread all over and each assigned with a specific task and all mutually linked through a data highway which can be coaxial or fibre-optic. Each of these microcomputers perform its own task concurrently with and independently of the microcomputers in the system. Thus, this type of paralled processing provides excellent system response time and eliminates the possibility of any single point failure crashing the whole system. The courageous step of the Honeywell Company, USA starting in 1969 to design an alternative to the centralised computer control system was yet another development. The 'TDC 2000' system as it was called solved the problems of reliability by distributing the control functions to cover only few loops as well as providing a digital back-up capability. This high reliability has greatly contributed to the success of distributed control. Several key factors such as increased reliability, elimination of disks to execute control algorithms, redundancy and extensive error checking for communication highways, distributed display functions, redundant I/O capability, back-up control processors with automatic changeover are combined to achieve such a success. The MTBF for single loop controllers seem to be atleast more than 20 years, though this figure may drop for multiloop controllers. The advantage of distributed system however is the ability to upgrade as the technology improves without obsoleting the entire system. Computer languages such as Real-Time Fortran, PASCAL and ADA have become most popular with distributed computer control systems coupled with rapid strides in the developments in fibre-optics technology for wide-band communications between different computers in the system. Fibre-optic communication has enabled high data transmission rates of the order of 10 M bits/sec with a distance of about 2 km. between 2 stations for reliable communication in Japanese steel plants. Man-machine interfaces such as powerful interactive colour graphics systems enable the user to generate configure the various control loops, changing limits of any channel in any particular control loop 'on-line', and observe the performance of various control loops. The microprocessor based video terminals have made the task of human operators quite easy.

Hierarchical Control Systems

The development of the distributed digital control systems greatly simplified the computer's connection to the process. Combining the three levels of control each with distinct duties, namely, the dedicated digital controllers for process loops, direct digital control of certain process variables and supervisory control levels became a hierarchy computer system. The upper level computers depend on the lower level devices for process data and the lower level systems in turn depend upon the higher level systems for even more sophisticated control functions such as an overall plant optimization. One can immediately assume from this the ultimate in a computer control system structure by combining company's production scheduling and management information functions with the process control functions to develop a total plant hierarchy control system.

It must however be remembered that all of the elements in a hierarchy system can exist as individual elements. It should be noted that the different levels in a hierarchical system do not necessarily represent separate and distinct computer or hardware levels. One or more of these operational levels can be combined into one computer depending the size of the system.

Computers and Steel Industry

The first computer system in a steel mill was that of Great Lakes Steel Company, a National Steel subsidiary in Detroit, Michigan, USA in 1961. Since then the applications of process computers in steel industry has been innumerable areas in countries such as USA, Holland, Japan and Canada. It is reported by the Purdue group, USA that with the application of computers and using advanced control technologies in steel industry one can expect a minimum benefit of 5 per cent in increase of productivity and 10 per cent reduction in energy consumption. The Japanese iron and steel industry, among others, has actively introduced digital systems and has achieved remarkable results for energy conservation, improved product quality and efficient manufacturing processes. Japan has implemented computerisation in steel plants about 10 years ago with investments of the order of $100 million and 450 man years. As per the USA experience, a hypothetically automated steel plant would employ computers ranging between 110 mini computers and 360 micro computers to 90 mini computers and 900 micro computers depending upon the hierarchy and distribution of various formations. Improvements in man-machine systems for blast furnaces, the control of raw materials mixing, dead-time compensation in sintering plants, advanced feed-forward control in boiler plants are a few other examples of improvements due to applications of modern instrumentation and control using microcomputers and computers. There could be benefits at individual system level such as blast furnace control leading to 1-2 per cent savings in raw materials and 1 per cent increase in productivity, optionisation of coke rates leading to 1 to 2 per cent savings in coke consumption, stove optimisation leading to 5 per cent savings in gas etc.

APPENDIX A VII (Cont.)

A few applications of industrial computers in steel plants could be listed as follows:

1. Raw material preparations.
2. Computerising the coke making process.
3. Data logging and control system for blast furnace.
4. Computerising the LD process and teeming operations.
5. Computerising the scheduling of wagon movements, of soaking pits, of rolling programmes, of maintenance programmes, etc.
6. Computerising the energy and power distribution in the plant.
7. Computerising the rolling operations to reduce the wear and tear of rolls and to minimise cobbling.
8. Cutting operations computerisation to minimise the length of the last piece and increase the yield.
9. Computerisation of inventory and management information system for right decisions in time.

The list can be increased, but the aim is to show the potential areas where computers could be effectively utilised. The processes are so complete and depend upon large number of variables that without the help of modern tools it is impractical to operate them at their optimum level all the time.

Corporate Level Information

SAIL produces about 9.4 million tonnes of ingot steel in more than 2000 varieties of sections and qualities. While steel plants are located in the Eastern region, the products are mostly consumed in Western and Northern regions. SAIL has 7 zones, with branches and stock yards distributed throughout the country. For providing quick and satisfactory services to customers at a minimum of inventory at the stock yard and at the plant, it is essential to have an efficient information system between customer (sales point), railways and the plants. The manufacturing plant of each plant is drawn on the basis of orders booked.

The computerised short-term operating plans make it possible for management to be future-oriented rather than day-to-day crisis-management oriented. The management can solve calmly and in advance next week's bottleneck or next month's shortage as visualised through forecast models using the on-line computer system rather than merely cope frantically with yesterday's difficulties over the telephone or in meetings. Similarly, the up-to-date informatino gives branch manager more and better than organisational constraint oriented.

Information and Documentation

Information and documentation is the backbone of research institutes and industries. It is widely accepted in industrially advanced countries that information is one of the most vital forms of national resources. The results of research and development are published in a number of media. The primary sources of technical information are progress reports, technical reports on current research, professional journals, proceedings of conference and symposia and books. In addition to these, there is a mass of preprints, reprints, indexes, etc. Unless this proliferation of publications is properly organised, the information contained in them will be buried under megatons of paper. The technology is developing rapidly and there is a publication explosion. Large number of new journals are appearing. It is extremely difficult to keep track of the developments unless modern tools are used. Computerised current awareness, abstracts, profiles, etc., are available elsewhere. Design houses store Government contract clauses, commercial and technical term on computers and with minimum modifications can serve to new client in short time. Drawings and forms can be stored and reproduced in short time with varying sizes, using computers. The use of computers in all these above fields is possible because of the rapid development in computer technology.

Conclusion

An integrated steel plant is a complex system and is a highly capital intensive industry. The depreciation and the interest alone runs into lakhs of runpees per day. All resources have to be utilised to their optimum level every minute. Semiconductor technology has been developed so much in the last decade that the use of modern tools in steel plants is feasible. The Kimits works of the Nippon Steel Corporation in Japan with a production capacity of about 7.3 M.T. per year which is one of the most modernised steel plants have amply demonstrated the above fact by adopting an integrated production control system based on full utilization of the computer and advanced computer communication methods using optical fibre communication. In recent years the number of computer operators and maintenance personnel have increased conspicuously in direct proportion to the popular acceptance of computers in all sectors of production. In India too, other sectors such as Oil, Power, Fertilisers, Railways, Banking etc. have already either gone in for computerisation or in the process of doing so. The steel industry cannot lag behind and should realise the benefits of modern methods of computerisation and control which has significant impact on the national economy