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POLLUTION CONTROL RESEARCH INSTITUTE

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REPUBLIC OF INDIA

Report*

Environmental Simulation Models for Industrial Pollution Control

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

Based on the work of Dr. Kurt Fedra
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United Nations Industrial Development Organization
Vienna

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REPORT SUMMARY

During this third mission to the PCRI, Hardwar, India, the two main objectives were

- to present a key note paper at the International Conference on *Environmental Impact Assessment in Developing Countries* in Delhi (manuscript attached) and assist in the organization of the conference as co-chairman and rapporteur;
- to continue the training of the computer and mathematical modeling group at the PCRI, and prepare a working plan for 1989 and onwards in collaboration with the CTA and other experts present.

The training exercises of the mathematical modeling group were built on the previous work and assignments, and included, in addition to a number of lectures on various topics from ecological modeling to knowledge acquisition techniques, geographical information systems, and graphics programming, the continuing development of the ISC air pollution model and auxiliary software for TPS impact analysis on the Institute's PC AT. In particular, a simple map drawing routine based on a general topological data structure was developed and coupled with the air pollution model, thus allowing to represent the plume computed by the dispersion model as a color coded overlay over a map of the area under study. An application example for the Unchahar, UP, TPS was developed.

In addition, visits to the Regional Remote Sensing Service Center, the Survey of India, and the Indian Geological Survey, all located in Dehradun, helped to establish new contacts for PCRI and open new sources of training, expertise, and information.

Also, various possible collaborative research projects, involving PCRI and designed to provide clients, funding, and opportunities for on-the-job training for PCRI staff at foreign or Indian collaborating institutions, were elaborated, discussed, and proposals initiated where possible.

Finally, in preparation of the arrival of the new computer equipment, a detailed plan for the necessary logistics and environmental conditions for the computer rooms was formulated, and necessary repair and construction work as well as purchase procedures eg., for furniture and a vacuum cleaner, were initiated.

The following detailed papers or proposals are attached:

1. a summary of my recommendations
2. a working plan for 1989
3. a long-term working plan for 1990-1992
4. a copy of my paper presented at the Delhi Conference.

SUMMARY OF RECOMMENDATIONS:

The following recommendations also incorporate verbatim the recommendations made in my previous reports, dated November 15, 1987, and April 30, 1988. They are repeated here again because they obviously have not had any major or noticeable effects so far, but address essential preconditions for all further developments of computer applications at the PCRI.

COMPUTER CONFIGURATION (April 1988)

After several more rounds of discussions with PCRI executives and management, a final version fo the proposed hardware configuration and Local Area Network (LAN) layout was agreed upon. The configuration should include the following main components:

2 SUN 3/60C-8 color workstations, both with 8 MB RAM, 370 MB winchester disks and a 60 MB streamer tape each, with 19" and 16" color monitors, respectively.

The two workstation will be connected through Ethernet.

Attached to one of the workstations (the 19" model) should be a normal monochrome ANSI standard terminal, and a digitizing table of A1 format.

Attached to the second workstation should be a Laser Printer and a PC AT (under the XENIX operating system) for machine-to-machine connection. This PC should be configured with 4 MB RAM and an 80 MB disk, to serve as a multi-user gateway for the Institute's various PC's to the SUN system, and in particular the disks and the Laser Printer. This PC AT would therefore require an 8 channel communications board (RS 232C or RS 423). This gateway computer would then allow up to 8 additional PC's, to be located in the Institute's various laboratories, to access the gateway computer under the XENIX multi-user operating system, and, one at a time, the SUN network and its resources through the machine-to-machine connection between PC AT and the two networked SUN computers [1].

Since most if not all PC's in the Institute's laboratories and administration will, at least in the beginning, run under the DOS operating system, a substantial amount of DOS software support will have to be provided.

It is therefore strongly recommended to integrate at least one additional PC AT in the SUN Ethernet (under the SUN PC-NFS network file system) to allow a DOS machine direct access to the SUN network. This machine, to be located in the PCRI Computer Center, should primarily be used for DOS software development and could also serve as a model for a future expansion and upgrading of the local area network through the Ethernet, using local resources.

While the basic SUN computers have finally been ordered and an import certificate was granted during my last stay (DOE 0080/1988, dated December 5, 1988), the remaining PC's and network components are still to be purchased.

MANAGEMENT CONSIDERATIONS (April 1988)

Establishment of a Computer Services Group.

[1] Nota bene: none of these PC's or the gateway computer and its configuration requirements are included in the proposed UNDP/UNIDO funded computer equipment purchase. It must therefor be assumed that these microcomputers can be obtained using local funds

The overall computer system (planed to eventually include a total of 12 microcomputers and in particular the two 32-bit supermicro graphics workstations) will require a substantial amount of systems support, maintenance, and administration.

It is therefore strongly recommended that a Computer Services (CS) group of at least three engineers with the appropriate background (computer sciences or engineering) and experience is established.

This CS group would have the responsibility to ensure the proper continuing operation and appropriate use of the computer equipment.

Tasks should include:

- systems administration, including regular file saves, monitoring of resource allocation (disk space, access to the machines and various peripherals in the Computer Center (CC));
- installation and maintenance of system software, trouble shooting (including the rebooting/restoring of the system after power failures);
- installation, training, and supervision of new and novice users;
- administration and distribution of documentation and materials (such as floppy disks, tapes, printer paper etc.), distribution of printouts;
- providing application programming assistance for users within the framework of specific project assignments.

All common facilities and consumables will be arranged by this group. The CS group would also control the physical access to the CC machines, and ensure a proper working environment (see below). The PCRI Computer Center itself should be a "Restricted Access Area".

Unlimited access is only for CS. CS has personal accounts and super-user (SU) privileges on the UNIX/XENIX machines.

An experienced Users Core Group (e.g., from the Mathematical Modeling Group) has access to the CC machines (SUN network and the two PC AT's) on a project assignment basis and with temporary project user accounts only. Access is under a flexible schedule established by the CS and the User Group in consultation with the management. CS monitors the schedule.

Other users have direct access to the CC facilities only on a case-by-case basis, and only in direct collaboration and under supervision of a CS or User Core Group. They use temporary "guest" accounts installed on a short-term basis.

Without a clear commitment of dedicated personnel for the computer group, an effective maintenance and use of the computer equipment is hardly possible. However, until today, no such clear commitment of full-time staff was made, and most of the staff trained in the computer group is allocated to this group only at a part time basis (with additional responsibilities for the noise and air pollution labs, mostly). Under the current management and supervision conditions at PCRI, this seems to lead to a situation where always the other tasks (including administrative and clerical assistance of the management) are used as an excuse for not being able to complete a given assignment. As an example, from the seven assignments given during my last mission (see my report dated April 30, 1988) only one was completed within seven months. All other engineers cited other workload as the reason why they could not work on their assignments. The selection and clear dedication of a full-time core group with clearly defined responsibilities is therefor highly recommended.

This obviously will require additional new recruiting, since the current staff is simply not enough or efficient enough to fill all required positions in all the laboratories with all their equipment.

Finally, there is, to my understanding, a major unresolved problem in the motivation and incentive structure at the PCRI: good computer scientists, and in particular in India which boasts a very fast growing computer industry, have a considerable market value. It is therefore very difficult to attract and to keep good people, in particular after exposing them to foreign training and thus increasing their job options outside BHEL/PCRI. As a consequence, I strongly urge the PCRI management to implement creative and innovative incentive systems that will allow to attract and keep good and highly motivated people at the PCRI, using, to the extent possible, the UNIDO/UNDP project and proposed collaborative projects to provide academic and monetary incentives. The equipment is state-of-the-art, and therefor attractive to a good professional; the work, if interesting contracts can be secured and major collaborative projects with prestigious foreign or Indian institutions can be initiated, can be very attractive; career prospects and pay schemes, however, as well as the current use of foreign training as part of the UNDP project, which could be used as an effective instrument to provide incentives, are not at all attractive or used to their full potential.

Attracting and motivating good people, however, is an essential condition for successful operation in the future.

LOGISTIC CONSIDERATIONS (April 1988)

To allow the effective and uninterrupted use of the expensive computer equipment, it is extremely important to:

- Secure a hardware/software maintenance contract or equivalent with the Manufacturers representative in India (ICIM, New Delhi);
- Keep the machines working environment CLEAN.
  This involves:
  (a) strictest adherence to the limited access policy outlined above;
  (b) ABSOLUTELY NO SMOKING in the CC;
  (c) tea breaks are to be taken outside the CC;
  (d) dust proofing (sealing) of windows and air conditioner installations;
  (e) adding an additional (aluminum/glass) door and door mats in front of the CC entrance to create a buffer zone for dust protection;
  (f) regular daily use of a vacuum cleaner for the machine room;
  (g) keep the floor free of cables so that it can be washed properly (with ample water without splashing) regularly, at least weekly;
- Keep the working environment safe and orderly.
  This involves:
  (a) obtain appropriate furniture (stable and with easy-to-clean surfaces) for the workstations and peripherals; recommended size for a workstation table is 2 by 1 m, with no side drawers;
  (b) provide sufficient dust-proof storage space (file cabinets) for documentation and materials;
  (c) secure ALL cables only along the walls;
  (d) provide stable filtered (conditioned) power supply on a separate circuit for the computers.

- Noise reduction in the computer rooms, including curtains, drapes, sound-absorbing materials on free walls, soft partitions, is also strongly recommended.

During my last stay, repair and construction work to prepare the rooms for the computer equipment have been initiated. Several detailed work plans and requirements lists have been prepared and discussed with and approved by the PCRI management.

The procurement of a vacuum cleaner has finally been initiated.

The procurement of the furniture for the computer rooms has been prepared and initiated.

COMPUTER PERSONNEL TRAINING (April 1988)

Further training of CSCG and User Group members at appropriate institutions in India and abroad is an absolute necessity for the effective use of complex computer equipment. Collaborative projects with appropriate institutions could provide the necessary focus for such training.

It is highly recommended that specific projects are initiated, or appropriate sponsors and clients sought, to provide a framework for focused on-the-job training in collaboration with national and international institutions in the field that have experience in the use of computer based methods in environmental engineering and pollution control for efficient technology and know-how transfer.

Within the framework of such projects, PCRI staff should join, on a temporary basis, the research and development teams of the collaborating institutions for training; this personnel would then be in a position to transfer the necessary know-how to continue the development at PCRI.

Several main topics for training are listed in the following working plans for 1989 and 1990-1992, respectively. To provide the necessary framework of funded collaborative research, a number of research proposals for external funding or funding as BHEL R&D projects were prepared for and with PCRI staff. Any or all such projects could provide the framework and the resources for further training and the transfer of know how, software, and related skills to the PCRI modeling group.

PCRI 1989 Project Plan:

Mathematical Modeling and Computer Applications

OBJECTIVE:

- Implementation of one major interactive simulation model for TPS air pollution (SO_2, NO_x, particulates) and a minimum set of auxiliary software tools such as text processing and report generation, preparation of presentation graphics, and digitizing, on the new SUN computer equipment;
- train the staff in the use of computer based text processing and report generation, and the production of attractive presentation graphics including the digitizing and processing of cartographic background material as complementary activities for any model based consulting job, to enable the computer group to reliably operate the computer systems, software tools, and the model, and independently apply them to new case studies of commercial relevance;
- prepare with and for the group example case studies of TPSs (Bathinda, Unchahar, BHEL Ranipur) based on air quality modeling including digitized background maps and satellite data, and prepare one example report to serve as a reference for the groups capabilities, that can be distributed to potential clients.

MILESTONES:

April/May: SUN equipment fully operational; first version of the TPS air quality model and text processing tools implemented;

October/November: final version of TPS model operational; selected case study applications completed; auxiliary software tools implemented for report generation.

EXPERT MISSIONS:

two expert visits of about 3 weeks each (with 4 weeks at home base e ch for the preparation of software and work on the case study) in conjunction with the above milestones.

STAFF TRAINING:

the following main topics are recommended for 1989:

- SUN/UNIX systems programming and administration
- SUN graphics programming, interactive modeling
- digitizing and geographical information systems (GRASS GIS)
- text processing (TEX, LATEX)
- preparation of presentation graphics (touchup, fig, raster, etc.)

Each of these topics would require a 2 to 3 months period for introductory level training.

In addition, basic SUN/UNIX user training in India (from the equipment supplier) is urgently recommended for the whole group.

Also, basic training in image processing at the RRSSC in Debra Dun is highly recommended for the entire group; one or two engineers should be selected for more extensive training in this field.

EQUIPMENT, MATERIAL, AND INFORMATION REQUIREMENTS:

New Equipment:

(a) 1 Mitsubishi Color Printer/Plotter G 650 (A3/A4 format) with RGB video interface to allow direct output of SUN graphics screens from the monitors video signal. with supplies (paper, color cartridges) for at least 1000 printouts.

Estimated cost: US$ 25-30K

Justification: the color printer will allow to produce immediate high-quality hard copy with the full resolution and colors of the SUN graphics system. It will therefore be an important element in any project reporting and documentation, as well as marketing efforts, adding cost-effective and professional high-resolution color graphics to make reports more useful and more attractive to clients and customers.

High-resolution color graphics are the only possible medium to convey the complex and detailed information the computer can generate directly to the user.

This printer technology is very new, and the machine was therefore not foreseen in the original equipment purchase proposal.

(b) 1 STD/FAX line (a dedicated telephone/fax line with international direct dialing) to improve communication with collaborating institutions and individuals, as well as for the direct communication with customers and clients.

MATERIALS:

(a) 40 1/4" tape cartridges (for SUN computers) high density, 60 MB, eg., 3M or CDC.
Estimated cost: US$ 3K

(b) 40 HP laser jet toner cartridges (for the laser printer)
Estimated cost: US$ 4K

Justification: the above consumables will be required to ensure uninterrupted operation for the first one or two years for the new computer and peripheral equipment. Without these materials, the equipment simply cannot be operated at all (toner cartridges) or safely (tapes for file backups).

SOFTWARE:

(a) TEXand LATEXtext processing software

from: Northwest Computing Support Center
DW-10, 208 Lewis Hall
University of Washington, Seattle
Washington 98195
USA

Estimated cost: US$ 500

(b) GRASS 3.0 Geographical Information System

from: DBA Systems,
11781 Lee Jackson Memorial Highway
Fairfax, VA 22033-3360
USA

Estimated cost: US$ 1000

DATA AND INFORMATION:

(a) Satellite data: SPOT tapes for the ares surrounding the two TPS case studies (Bathinda, Unchahar) to be ordered from NRSA, Hydcrabad.

(b) Cartographic information: physical maps (1:50,000 or bigger) for the Bathinda area (from Survey of India, Dehra Dun), land use and any other topical maps for both Bathinda and Unchahar, from the Geological Survey of India.

These data will be required in support of the two TPS case study applications for the air quality model, as well as for training purposes for the various software tools.

LITERATURE:

Purchasing a number of computer text books on topics such as the UNIX operating system, C, graphics programming, and environmental modeling is an absolute necessity. My previous report contains a list of such urgently recommended titles in the references.

PCRI Phase II (1990-1992) Proposals:

Mathematical Modeling and Computer Applications

As requested by the CTA, a list of suggested areas of concentration and further development for the computer based activities at PCRI was prepared together with subsequent proposals for implementation, training, and equipment; the sequence of topics implies approximate priorities.

In general, I do believe that the development of computer based analysis and consultancy capabilities, involving data bases and information systems, simulation modeling, expert systems technology, and in particular the extensive use of color graphics in reports as an innovative and highly attractive feature, can provide substantial research and business opportunities for PCRI.

Other than all services based on field measurements or the analysis of samples only, information processing services require less logistics and are not limited to a rather small spatial radius for obvious problems of access and transportation.

Topics for Further Development:

(a) further extension of the **TPS air quality modeling** software:

- adding expert systems components for the selection and configuration of pollution control technologies and equipment including engineering cost estimates (emphasis should be on BHELs own product line of ESPs);
- inclusion of explicit ash management into the simulation system, ie., landfill leaching and groundwater contamination;
- addition of a multi-criteria decision support system for scenario/alternative option comparison, evaluation, and selection;

(b) development of **water quality** management tools for **industrial and domestic waste water**, following the basic pattern of the TPS system:

- expert system component for the selection and configuration of treatment technologies and steps depending on waste water composition. This could include a diagnostic ES component that identifies constituents of concern from circumstantial evidence, ie., sources of pollution (production technologies), or simple observation and measurements of the waste water;
- simulation of the treatment process, accounting of ORM costs;
- river water quality simulation models, including sediment transport and bioaccumulation of toxics or heavy metals;
- irrigation water simulation including accumulation of toxics and heavy metals in soils and crops.

These components could be extended into a regional management system including extensive data bases (pollution inventories) and optimization techniques (investment distribution and scheduling, technology and site selection) for a study of the River Ganga.

(c) **Industrial Waste Management** as a major and emerging theme also in developing countries could provide interesting and long-term opportunities for the PCRI:

- implementation of a US RCRA-type data base and information system on product and technology specific industrial waste streams;
- computer-based interactive treatability manuals, ie., expert systems versions of eg., the UNEP IRPTS manuals, EPAs WET/RCRA model, etc.;

- simulation models for selected waste management technologies and their environmental impacts, eg.,:
  - incineration of hazardous wastes (can use many of the TPS software components)
  - land disposal (can use the ground water part of the TPS ash management system)

(d) **Industrial Risk Analysis:** pollution control is not only concerned with routine operations, but should equally consider accidental spills or catastrophic failures in operating conditions. In particular the case of Bhopal should make the necessity of safety related analysis obvious. Again, following the patterns of development of environmental and risk awareness eg., in the OECD countries, this should be a topic with considerable potential for the long-term future.

- development and implementation of simple fault-tree and event-tree models for process industries, can use the consequence modeling components for air, surface and ground water from above;

Software Development and Staff Training:

Easy-to-use and reliable software, adapted to Indian conditions (resources, technologies, standards, IS required procedures) would have to be developed for and with PCRI staff on the basis of existing public domain software.

Ideally within the framework of application specific case studies to provide a realistic testing ground, these systems could be developed with institutions such as IIASA, providing at the same time ample opportunities for on-the-job training for PCRI staff. Such extensive training is an **absolute must** to enable the current group to responsibly use complex software tools.

Each of the above main areas and components would require several man-years of development effort for a fully tested, reliable easy-to-use package of commercial applicability. Research-level prototypes would probably require only about half that effort.

Hardware Requirements:

Top support the more compute intensive components of the 1989 and the proposed long-term activities such as image processing, geographical information systems, finite element modeling (eg., for groundwater models) fault-tree analysis, etc., and the AI components, one fully configured work station should be added in support fo the current network, eg.,

SUN 3/280C PAI with 32 MB RAM, large disk capacity (2 times 780 MB) and a 1/2" reel tape drive, essential for efficient storage and backup as well as for data transfer and communication with other institutions computers (eg., satellite data from NRSA),

estimated cost: US$ 150K.

In addition, one fast (20-25 MHZ) 386 based PC with the new IBM standard for color graphics (VGA) and a corresponding high-resolution color monitor should be included to maintain compatibility with new PC based developments and applications.

Software Requirements:

Two additional software packages, namely

SUN COMMON LISP (can be included in the PAI workstation configuration)

and QUINTUS Prolog for the SUN

should be obtained for the AI components of the above proposal.